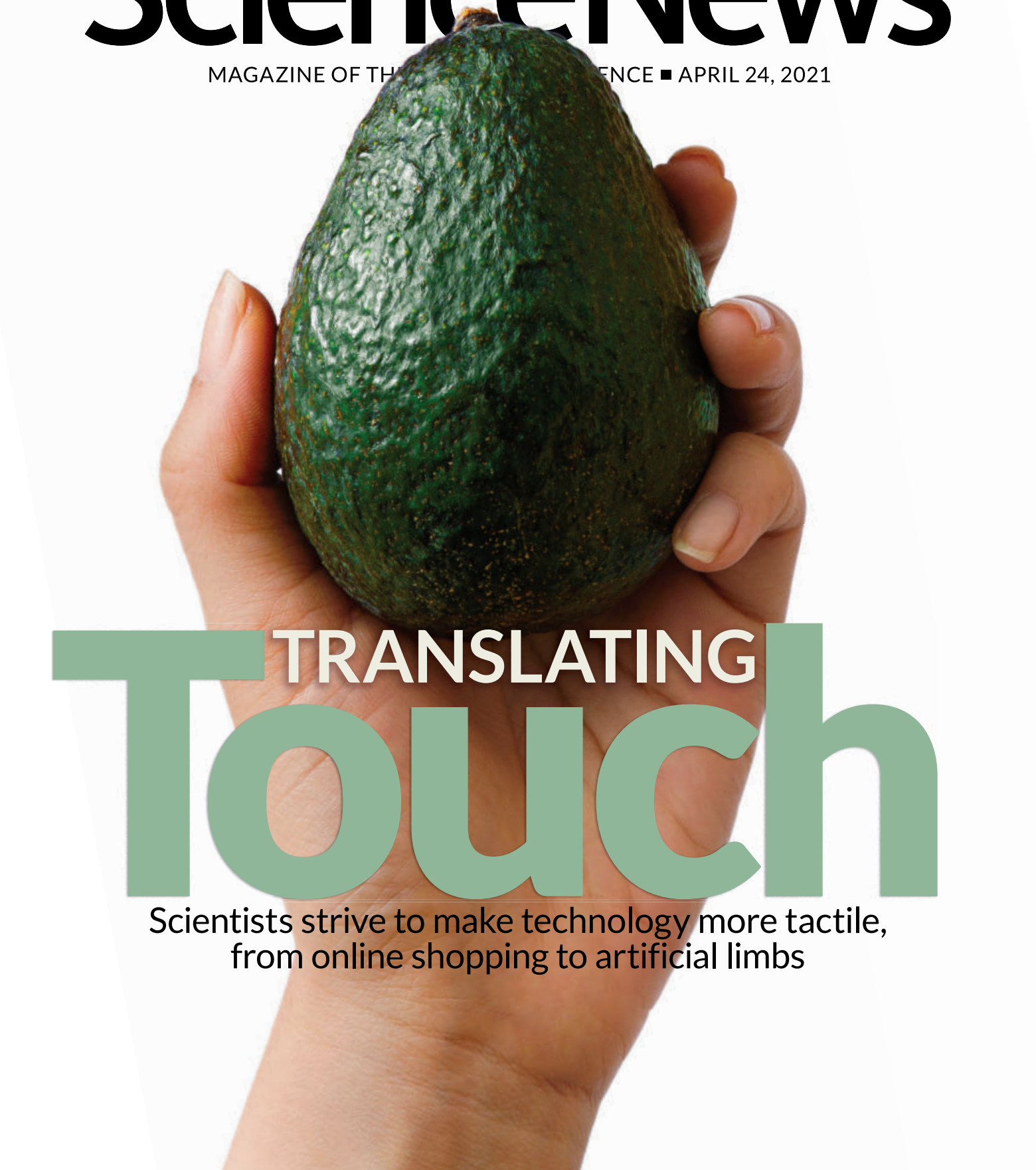
Xenobots From Frog Cells | Why Rabbits Do Handstands

ScienceNews

MAGAZINE OF TH ENCE ■ APRIL 24, 2021



TRANSLATING Touch

Scientists strive to make technology more tactile, from online shopping to artificial limbs

THINK SMALL

To solve BIG problems

UChicago's molecular engineers are ushering in a new era of discovery in quantum science and engineering, developing advanced molecular technologies to address global issues like cancer treatment, quantum computing, and regenerative medicine. With an emphasis on critical thinking and creative problem-solving, the University of Chicago has been a global leader in scientific advancement for generations. Students share in this legacy of discovery; they participate in research on campus, contribute directly to the advancement of knowledge, and graduate prepared for a wide variety of careers and leadership roles in STEM-related fields.

Visit collegeadmissions.uchicago.edu to learn more!

*While supplies last.

VOL. 199 | NO. 8

ScienceNews


22

Features

News


10


4

Departments

COVER A lot goes into feeling the ripeness of an avocado and surveying the texture of its skin. *bbtree/Alamy Stock Photo*

FROM TOP: EVERETT COLLECTION HISTORICAL/ALAMY STOCK PHOTO; R. VULLO *ET AL*./*SCIENCE* 2021; T. HODGSON/ICRAR/CURTIN UNIV.

Enchanted by black holes? We are, too

The first-ever image of a black hole dazzled people worldwide when it was unveiled in April 2019, the result of a scientific feat involving scientists and observatories around the globe.

Now we've got a new snapshot of the elusive beast at the center of galaxy M87, and it's just as alluring as the first. This new image reveals magnetic fields swirling around the black hole's accretion disk, the superhot gas encircling the black hole's center. Those magnetic fields are thought to play key roles in black hole behavior, as staff writer Maria Temming reports in this issue (Page 6).

We here at *Science News* are all in for black holes — we've been covering them extensively since we first used the term in the magazine in 1964, when their existence was still a big question mark. Decades of work by scientists has revealed not just that black holes are real, but that they sit at the center of most galaxies and influence the creation of stars. And even though they're huge, strange and very far away, they seem to reflect human experience. "They are a go-to metaphor for any unknowable space, any deep abyss, any endeavor that consumes all our efforts while giving little in return," *Science News* special projects editor Elizabeth Quill wrote in our ongoing series of stories marking our 100-year anniversary (*SN: 2/13/21, p. 16*). Ah, but they give so much.

"Black holes were instrumental in getting me interested in science," Temming says, and she's not alone in that. "If you talk to many science writers or many astronomers, black holes are one of those shared experiences: They're so mysterious and mind-boggling, you can't help but get sucked in," she says. Temming first got interested in astronomy in high school, when she was captivated by a poster of galaxies in her physics classroom. Her teacher, Mrs. Girkin, took the poster off the wall and gave it to Temming; it's been hanging in every place she's lived since. Along the way, she also acquired undergraduate degrees in physics and English, then a master's degree in science writing from MIT.

Temming was part of our team coverage of the April 10, 2019 announcement of the first image of a black hole. She attended the news conference in Washington, D.C., and filed notes and quotes to our editors via Slack so we could publish the image within minutes of the big reveal. Temming followed up with a story explaining how astronomers captured the image by combining observations from seven stations around the globe, known as the Event Horizon Telescope network (*SN: 4/27/19, p. 7*). Her explanations of this exceedingly complex and precise process, which involved so many terabytes of data that they had to be shipped from the various observatories around the world by snail mail, are compelling and clear.

"Covering the 2019 black hole picture felt like a great culmination of many, many decades of science," Temming says, going all the way back to Einstein's general theory of relativity. "I feel very lucky to have come on the scene as a science writer just as this was starting to happen." She's excited to be covering this new era of astrophysics, and we're glad she's on the beat.

— Nancy Shute, Editor in Chief

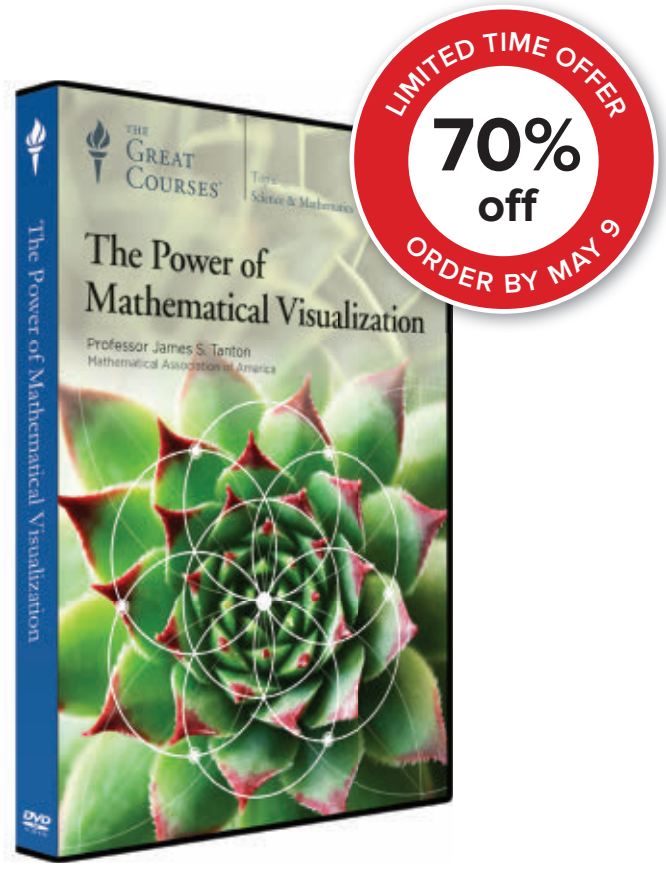
Science News
1719 N Street NW, Washington, DC 20036
(202) 785-2255

Subscriber services:
E-mail subscriptions@sciencenews.org
Phone (800) 552-4412 in the U.S. or (937) 610-0240 outside of the U.S.
Web www.sciencenews.org/join
For renewals, www.sciencenews.org/renew
Mail *Science News*, PO Box 292255, Kettering, OH 45429-0255

Alliance for Audited Media

Editorial/Letters: feedback@sciencenews.org
***Science News* in High Schools:** snhs@societyforscience.org
Advertising/Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published 22 times per year, bi-weekly except the first week only in May and October and the first and last weeks only in July by the Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.
Subscribe to *Science News*: Subscriptions include 22 issues of *Science News* and full access to www.sciencenews.org and cost $50 for one year (international rate of $68 includes extra shipping charge).
Subscribe www.sciencenews.org/subscription
Single copies are $3.99 (plus $1.01 shipping and handling).
Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Postmaster: Send address changes to *Science News*, PO Box 292255, Kettering, OH 45429-0255. Two to six weeks' notice is required. Old and new addresses, including zip codes, must be provided.

THE GREAT COURSES®



Discover an Illuminating New Way to Learn Math

Many people believe they aren't good at math, but mathematics is accessible to all if problems are approached visually. Working on the principle that a picture can spawn a thousand ideas, world-renowned math educator Dr. James Tanton—a teacher of math teachers—shows how you can skip rules and formulas if you see the underlying logic of a mathematical operation. In 24 half-hour lectures, he covers topics in arithmetic, algebra, geometry, number theory, probability, statistics, and other fields—all presented visually and all united by connections that you literally see in graphics that he designed, as well as through fun examples using poker chips, marbles, strips of paper, and other props. Dr. Tanton uncovers surprising links and novel ways of looking at problems that will give you many "*Eureka!*" moments, proving that you are much better at math than you ever imagined.

Offer expires 05/09/21

THEGREATCOURSES.COM/6SN

1-800-832-2412

The Power of Mathematical Visualization

Taught by Professor James S. Tanton
MATHEMATICAL ASSOCIATION OF AMERICA

LECTURE TITLES

1. The Power of a Mathematical Picture
2. Visualizing Negative Numbers
3. Visualizing Ratio Word Problems
4. Visualizing Extraordinary Ways to Multiply
5. Visualizing Area Formulas
6. The Power of Place Value
7. Pushing Long Division to New Heights
8. Pushing Long Division to Infinity
9. Visualizing Decimals
10. Pushing the Picture of Fractions
11. Visualizing Mathematical Infinities
12. Surprise! The Fractions Take Up No Space
13. Visualizing Probability
14. Visualizing Combinatorics: Art of Counting
15. Visualizing Pascal's Triangle
16. Visualizing Random Movement, Orderly Effect
17. Visualizing Orderly Movement, Random Effect
18. Visualizing the Fibonacci Numbers
19. The Visuals of Graphs
20. Symmetry: Revitalizing Quadratics Graphing
21. Symmetry: Revitalizing Quadratics Algebra
22. Visualizing Balance Points in Statistics
23. Visualizing Fixed Points
24. Bringing Visual Mathematics Together

The Power of Mathematical Visualization
Course no. 1443 | 24 lectures (30 minutes/lecture)

SAVE UP TO $200

DVD	~~$269.95~~	NOW $69.95
Instant Video	~~$234.95~~	NOW $49.95

+$10 Shipping & Processing (DVD only)
and Lifetime Satisfaction Guarantee

Catalog Code: 193182

For over 30 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free apps for iPad, iPhone, Android, Kindle Fire, or Roku. Over 800 courses available at www.TheGreatCourses.com.

Excerpt from the April 24, 1971 issue of *Science News*

50 YEARS AGO

The continuing battle over pot

The White House Conference on Youth voted to legalize the sale of grass (with restrictions). On the same day, the *Journal of the American Medical Association* published an article condemning the use of marijuana by the young.... The researchers conclude that marijuana smoking is particularly harmful to the adolescent. It adds unnecessary anxieties to the already disturbing problems of physical and psychological maturation.

UPDATE: Fifty years after the recommendation to legalize the recreational use of marijuana, at least 15 U.S. states have done so. In that time, a growing body of research has strengthened the link between teen marijuana use and mental health effects, including an increased risk of depression later in life. Such health concerns partly explain why people younger than 21 are prohibited from recreationally using pot. But pot use is prevalent among U.S. middle and high school students: About 25 percent of students in grades 8, 10 and 12 disclosed using the drug in 2020, scientists report.

Most bandages are tinted to match white skin. Popularizing brown bandages could help unravel medical racism, experts argue.

SOAPBOX

Redefining 'flesh-colored' makes medicine inclusive

As a child, Linda Oyesiku skinned her knee on her school's playground. The school nurse covered the wound with a peach-tinted bandage, which stuck out on Oyesiku's dark skin. So Oyesiku colored it with a brown marker. Years later, Oyesiku, now a medical student at the University of Miami Miller School of Medicine in Florida, needed to conceal a wound on her face after having surgery. Aware that the surgeon was unlikely to have brown bandages, she brought her own. Those episodes left her wondering: Why were such bandages not widely available?

Linda Oyesiku argues for normalizing brown bandages in medicine.

The ubiquity of peach, so-called "flesh-colored," bandages provides a stark reminder that medicine remains centered on white patients, says Oyesiku, who calls for brown bandages to become mainstream. That would symbolize that patients of color no longer represent "deviations from the norm," she writes in an October commentary in *Pediatric Dermatology*.

First made by U.S. pharmaceutical company Johnson & Johnson in the 1920s, peach-tinted bandages have been the standard for a century. Normalizing peach as the default flesh color has had knock-on effects: Nicotine and birth control adhesive patches are also tinted peach, Oyesiku notes. Over the last several decades, smaller companies have introduced bandages for multiple skin tones, but those remain harder to come by than peach-tinted ones.

The issue goes deeper than a bandage, Oyesiku says. Treating whiteness as the default in medicine has led to biases in machine learning programs that U.S. hospitals use to prioritize patient care (*SN: 11/23/19, p. 6*), for instance.

Dermatology is a clear starting point for dismantling structural racism in medicine, says dermatologist Jules Lipoff of the University of Pennsylvania. "Dermatology is racist only inasmuch as all of medicine and all of society is. But because we are at the surface, that racism is easier to recognize."

Consider "COVID toes," a symptom of COVID-19 characterized by swollen and discolored toes. A review of 130 images of skin conditions associated with COVID-19 found that almost all the images depicted people with white skin, researchers reported in 2020 in the *British Journal of Dermatology*. Because COVID-19 has disproportionately impacted Black people in the United States and the United Kingdom, photos of this population are crucial to proper diagnosis, the team says. This scarcity of medical images is pervasive: Only 4.5 percent of images in common medical textbooks depict dark skin, Lipoff and colleagues reported in the Jan. 1 *Journal of the American Academy of Dermatology*.

When it comes to bandages, change might be afoot. Last June, Johnson & Johnson pledged to roll out bandages for multiple skin tones. Whether health care providers and stores routinely stock such bandages remains to be seen.

Brown bandages won't solve racism in medicine, but they would symbolize that everyone's flesh color matters, Oyesiku says. "Small things like this are a gateway to ... other changes." — *Sujata Gupta*

FROM TOP: FATCAMERA/E+/GETTY IMAGES; REBECCA TANENBAUM

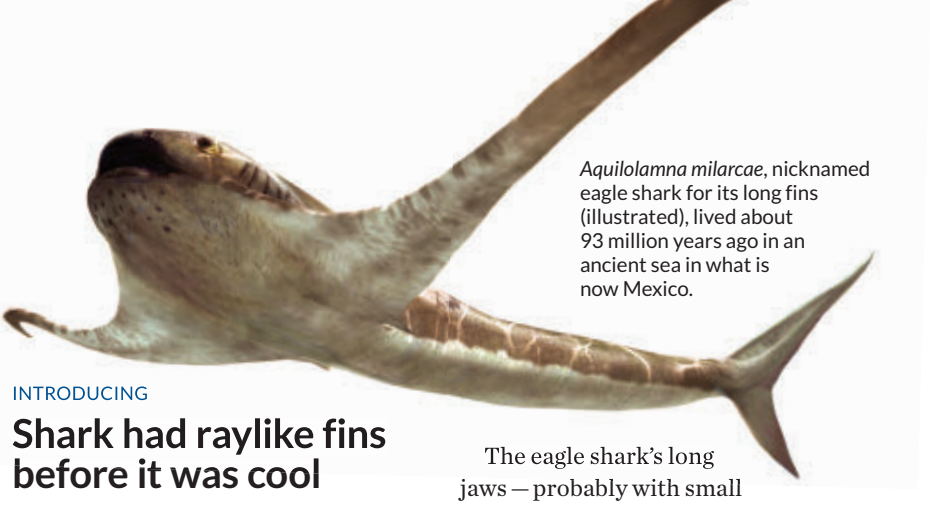
HOW BIZARRE

Uranium 'snowflakes' might spark supernovas

Tiny crystals of uranium could set off massive explosions within a dead star, physicists propose, making for a cosmic version of a thermonuclear weapon.

Expired stars called white dwarfs slowly cool as they age. In the process, heavy elements such as uranium crystallize, forming "snowflakes" in the stars' cores. If enough uranium clumps together — about the mass of a grain of sand — it could initiate a chain of nuclear reactions, raising a star's internal temperature and generating a star-destroying explosion, physicists calculate in the April 2 *Physical Review Letters*. The effect is akin to a hydrogen bomb, says Matt Caplan of Illinois State University in Normal. More research is needed to see if uranium snowflakes could really spur stellar detonations, Caplan says.

White dwarfs are known to be explosive: They're the source of type 1a supernovas. Typically, these blasts happen when a white dwarf pulls matter off a companion star. The snowflake proposal might explain a small fraction of the blasts, without the need for another star. — *Emily Conover*



Aquilolamna milarcae, nicknamed eagle shark for its long fins (illustrated), lived about 93 million years ago in an ancient sea in what is now Mexico.

INTRODUCING

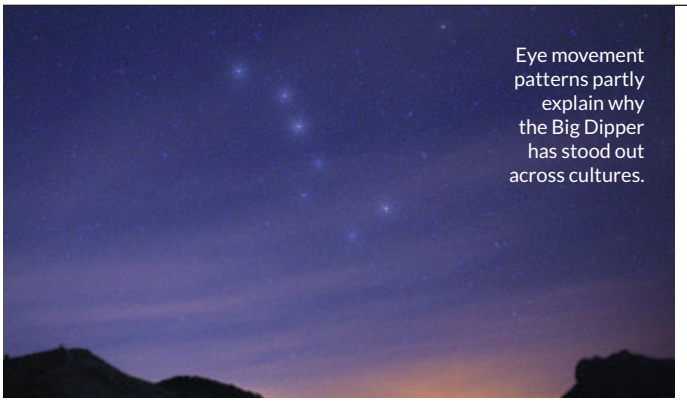
Shark had raylike fins before it was cool

More than 30 million years before manta rays began gracefully gliding through ocean waters, a shark with fantastically elongated fins gave such underwater flight a go, researchers report in the March 19 *Science*.

A quarry worker unearthed a fossil of the strange shark, now dubbed *Aquilolamna milarcae*, in 2012 from a rock layer in northeastern Mexico dating to about 93 million years ago. The shark's most distinctive feature is the long curving fins that swoop out from its sides. Spanning nearly 2 meters from tip to tip, the fins' length rivals the wingspan of bald eagles. Nicknamed eagle shark by the scientists, *A. milarcae* may have used the fins to stabilize itself or propel itself in a manta ray–like fashion.

The eagle shark's long jaws — probably with small teeth — and broad, rounded head hint that it may have been a filter feeder, sucking in floating plankton from seawater. Its torpedo-shaped body and powerful tail suggest the shark was an active swimmer, though not a particularly fast one, say vertebrate paleontologist Romain Vullo of the University of Rennes in France and colleagues.

A. milarcae may have been a member of a highly diverse group of sharks that includes extinct megalodons as well as modern great whites and filter-feeding basking sharks. Although that group once dominated the seas, many of its members became extinct after an asteroid struck Earth about 66 million years ago. — *Carolyn Gramling*



Eye movement patterns partly explain why the Big Dipper has stood out across cultures.

THE EVERYDAY EXPLAINED

How human eyes spy star patterns

The Big Dipper's stars make up a conspicuous landmark in the sky of the Northern Hemisphere. Even novice stargazers can easily pick out the shape, part of the Ursa Major constellation. Now, scientists have shown that three factors can explain why certain groups of stars form such recognizable patterns.

To replicate how humans perceive the celestial sphere, a team of researchers considered how the eye might randomly scan the night sky. Human eyes tend to move in discrete jumps, called saccades, from one point of interest to another. The team created a simulation that incorporated the range of lengths of those saccades, as well as basic details of the night sky as seen from Earth — namely the apparent distances between neighboring stars and their brightnesses.

The technique reproduced individual constellations, such as Dorado, the dolphinfish. And when used to map the whole sky, the simulation generated groupings of stars that tended to align with the 88 modern constellations recognized by the International Astronomical Union, Sophia David and colleagues reported March 18 at an online meeting of the American Physical Society.

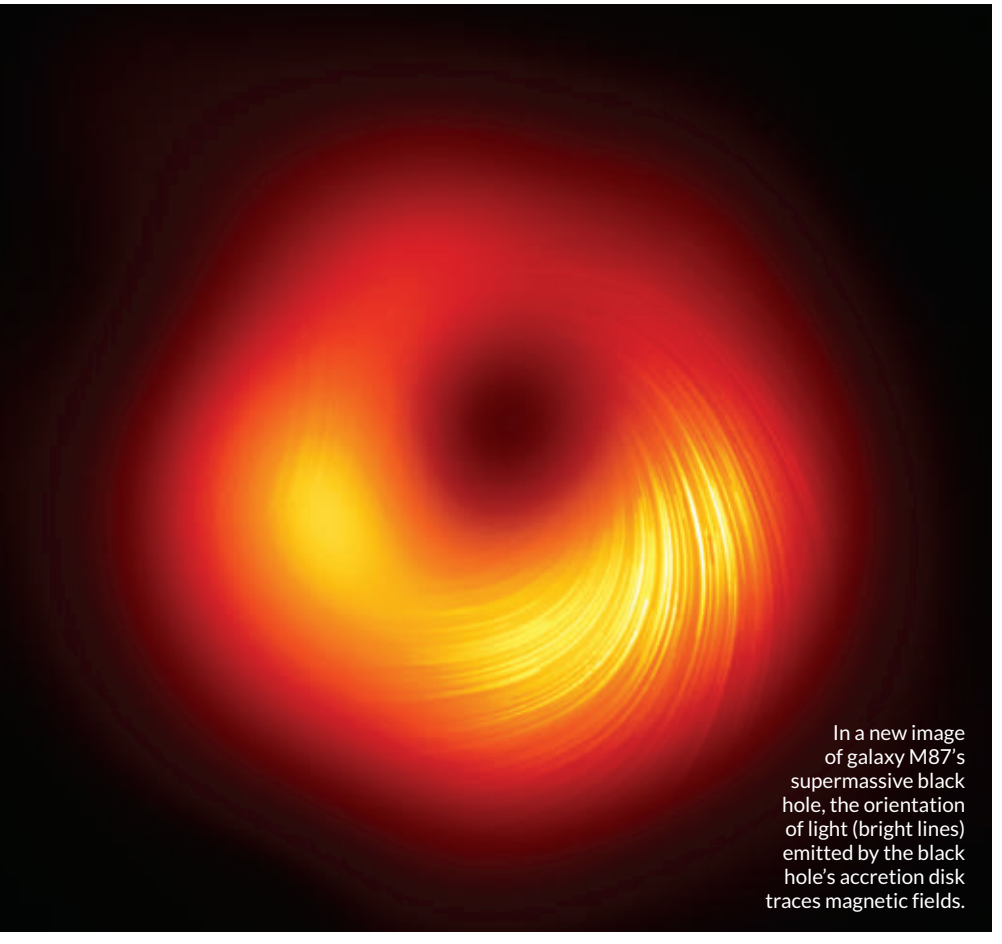
"Ancient people from various cultures connected similar groupings of stars independently of each other," said David, a high school student at Friends' Central School in Wynnewood, Pa., who worked with network scientists at the University of Pennsylvania. "And this indicates that there are some fundamental aspects of human learning ... that influence the ways in which we organize information." — *Emily Conover*

FROM TOP: R. VULLO *ET AL*/*SCIENCE* 2021; SHIM YOUNGBO/500PX/GETTY IMAGES

ATOM & COSMOS

Black hole's magnetic fields revealed

Strong fields may help launch powerful plasma jets into space



In a new image of galaxy M87's supermassive black hole, the orientation of light (bright lines) emitted by the black hole's accretion disk traces magnetic fields.

EHT COLLABORATION

BY MARIA TEMMING

Astronomers have gotten their first glimpse of the magnetic fields tangled around a black hole.

The Event Horizon Telescope has unveiled the magnetism of the hot, glowing gas around the supermassive black hole at the heart of galaxy M87, researchers report in two studies published in the March 20 *Astrophysical Journal Letters*. These magnetic fields are thought to play a crucial role in how the black hole scarfs down matter and launches powerful plasma jets thousands of light-years into space.

"We've known for decades that jets are in some sense powered by accretion onto supermassive black holes, and that the in-spiraling gas and the outflowing plasma are highly magnetized — but there was a lot of uncertainty in the exact details," says Eileen Meyer, an astrophysicist at the University of Maryland, Baltimore County who was not involved in the work. "The magnetic field structure of the plasma near the event horizon [of a black hole] is a completely new piece of information."

M87's supermassive black hole was the first, and so far only, to get its picture taken (*SN: 4/27/19, p. 6*). That image showed the black hole's shadow against its accretion disk — the bright eddy of superhot gas spiraling around the black hole's dark center. Observations taken in April 2017 by a global network of observatories, which collectively form one virtual, Earth-sized radio dish called the Event Horizon Telescope (*SN: 4/27/19, p. 7*), were used to create the image.

The new analysis uses the same observations. But unlike the black hole's initial portrait, the new image accounts for the polarization of the light waves emitted by gas around the black hole. Polarization measures a light wave's orientation — whether it wiggles up and down, left and right or at an angle — and can be affected by the magnetic field where the light originated. So by mapping the polarization of light around the edge of M87's black hole, researchers were able to trace the structure of the underlying magnetic fields.

The team found evidence that some magnetic fields loop around the black hole along with the disk of material swirling into it. That's to be expected because "when gas is rotating, it's basically able to carry along the magnetic field with it," says Jason Dexter, an astrophysicist at the University of Colorado Boulder.

But, he says, "there's some interesting component of this magnetic field which is not just following the motion of the gas." At least some of the magnetic field lines are sticking up or down perpendicularly from the accretion disk, or pointing directly toward or away from the black hole, Dexter and colleagues found. These magnetic fields must be very strong to resist being dragged around by the whirl of infalling gas, he says.

Such strong magnetic fields may actually push back against some of the material spiraling in toward the black hole, helping it resist gravity's pull, says study coauthor Monika Mościbrodzka, an astrophysicist at Radboud University in Nijmegen, Netherlands. Magnetic fields pointed up and down from the accretion disk could also help launch the black hole's plasma jets by channeling material toward the black hole's poles and giving it a boost in speed, she says. ■

LIFE & EVOLUTION

Elusive killer in eagle die-offs ID'd

A weed leaks a compound that turns bacteria deadly

BY SUSAN MILIUS

Mysterious deaths of bald eagles, mallards and other lake life in the southeastern United States have puzzled scientists for more than 25 years. After a long slog exploring cyanobacteria that glue themselves to an invasive water weed, researchers have found a toxin. And it's an odd one, the team reports in the March 26 *Science*.

Nicknamed AETX, the toxin has an unusual chemical structure requiring building blocks rich in the element bromine, says Susan Wilde, an aquatic ecologist at the University of Georgia in Athens. Yet those bromide building blocks are not routinely abundant in southern lake water. That's where the life story of a particular water weed comes in.

The mystery of the unknown toxin began at an Arkansas lake during the winter of 1994–95 with the nation's largest unexplained die-off of bald eagles. Then biologists saw more eagles, coots and some other birds losing motor coordination, struggling to fly or even walk, and having seizures. Affected animals' brains had swaths of unnatural microscopic holes, or vacuoles. By 1998, six states had confirmed bird die-offs from the same disease, now called vacuolar myelinopathy, or VM for short.

Wilde noticed that lakes with die-offs grew dense expanses of the green bottlebrush-shaped invasive water plant called *Hydrilla verticillata*. In 2001, she and collaborators began a long journey of exploring whether the plants and their ride-along cyanobacteria might somehow destroy brains.

"It's not a safe topic for a dissertation," she warned prospective grad students. There wasn't much money or any certainty of success. But "it's so cool," she remembers them saying.

One clue came from looking at this *Hydrilla* under microscope lighting that can make certain substances fluoresce. That revealed splats of cyanobacteria gripping the undersides of leaves and protecting their colonies with goo. Some other cyanobacteria, which slosh around as soup in water, release great flushes of toxins that kill fish and threaten human swimmers, but leaf-clingers weren't known as menaces.

These cyanobacteria turned out to be a new species (*Aetokthonos hydrillicola*). They also turned out to be hard to grow in the lab. Two years after collecting samples from a reservoir, the team raised enough cyanobacteria to dose test birds. The bacteria, however, didn't bother chickens. Microscopic analysis found no tiny holes in their brains.

Wondering if something weird was going on with the lab culture setup, the researchers collected wild weeds glopped with cyanobacteria from places with confirmed VM outbreaks. The team set up a system to detect any unusual chemical compounds the bacteria were making. Lurking in bacterial colonies was a previously unknown compound with abundant bromine. Colonies like these yield substances that do cause VM. And providing a bromide compound to lab colonies turned the bacteria toxic too.

Bromine can get into lakes from various sources, some natural and some not, such as power plants. Researchers discovered that the invasive *Hydrilla* builds up concentrations of bromine 20 times greater than the concentrations in lake bottom mud and 500 to 1,000 times greater than in lake water. In late fall, the weedy *Hydrilla* probably leaks bromine-rich compounds. That's when the cyanobacteria have the ingredients to make the deadly toxin.

The newly discovered exotic chemistry of these toxin-makers doesn't surprise Jason Stajich of the University of California, Riverside, who studies microbial evolution. Free-floating cyanobacteria cause toxic blooms in both marine and freshwater settings (*SN: 9/29/18, p. 14*). But this bacterial group also includes ecologically crucial species. The desert crusts that Stajich studies (like "bread crust" but on desert surfaces, he says) take years to form and depend on networks of cyanobacteria (*SN Online: 12/10/19*).

In this case, now that the suspect has been nabbed, there's even more reason to get rid of the *Hydrilla* invaders that facilitate the making of toxins. Water birds gorge on the *Hydrilla* and its ride-along bacteria and thus get a deadly dose of toxin. Predators such as eagles and owls that feast on those water birds also get poisoned. In the lab, the toxin affects other vertebrates such as amphibians and snakes. Knowing the makeup of the toxin will now let the lab check for effects on mammals. With such a wide range of potentially susceptible creatures, solving the mystery couldn't have come soon enough. ■

Bald eagles inspired a decades-long quest to find the cause of avian die-offs at southeastern U.S. lakes. Now scientists think they've got the killer: a toxin made by cyanobacteria that colonize an invasive water weed (*Hydrilla verticillata*, above right) that birds eat.

FROM LEFT: JAYSTOUT/FLICKR (CC BY 2.0); LESLIE J. MEHRHOFF/UNIV. OF CONNECTICUT/BUGWOOD.ORG (CC BY 3.0 US)

GENES & CELLS

Frog cells turn into 'living machines'

Self-healing xenobots swim and move particles in the lab

BY LAURA SANDERS

Using blobs of skin cells from frog embryos, scientists have grown creatures unlike anything else on Earth. These microscopic "living machines" can swim, sweep up debris and heal themselves after a gash.

Scientists often strive to understand the world as it exists, says Jacob Foster, a collective intelligence researcher at UCLA who was not involved with this research. But the new feat, published March 31 in *Science Robotics*, is part of a "liberating moment in the history of science," Foster says. "A reorientation towards what is possible."

In a way, the bots were self-made. Scientists removed small clumps of skin stem cells from frog embryos to see what these cells would do on their own. Separated from their usual spots in a growing frog embryo, the cells organized themselves into balls and grew. About three days later, the clusters, dubbed xenobots, began to swim.

Normally, hairlike structures called cilia on frog skin repel pathogens and spread mucus around. But on the xenobots, cilia allowed them to motor around. That surprising development "is a great example of life reusing what's at hand," says study coauthor Michael Levin, a biologist at Tufts University in Medford, Mass.

And that process happens fast. "This isn't some sort of effect where evolution has found a new use over hundreds of thousands of years," Levin says. "This happens in front of your eyes within two or three days."

Xenobots have no nerve cells and no brains. Yet xenobots — each about half a millimeter wide — can swim through very thin tubes and traverse curvy mazes. When put into an arena littered with small particles of iron oxide, the xenobots can sweep the debris into piles. Xenobots can even heal themselves; after being cut, the bots zipper themselves back into their spherical shapes.

Small clusters of skin cells taken from frog embryos organized themselves into roughly 500-micrometer-wide living machines that scientists call xenobots (one shown).

Scientists are still working out the basics of xenobot life. The creatures

EARTH & ENVIRONMENT

Urchins plague California kelp forests

Surveys of damage hint at how to restore the marine habitats

BY ANUSHREE DAVE

Ecologist Joshua Smith has been diving in kelp forests in Monterey Bay along the central coast of California since 2012. Back then, Smith says, being underwater was like being in a redwood forest, where kelp were like "towering tall cathedrals."

No longer. The kelp forests are now a mosaic of thin thickets interspersed with barrens colonized by sea urchins. And those sea urchins have so little to eat that they aren't worth the effort of hungry sea otters that feed on urchins and thus help keep forests healthy, report Smith, of the University of California, Santa Cruz, and colleagues in the March 16 *Proceedings of the National Academy of Sciences*.

A similar scene is playing out farther north along the coast. More than 95 percent of a thick kelp forest that stretched 350 kilometers has vanished since 2014, satellite images show. The forest shrank from an average of about 210 hectares to just 10 hectares, marine biologist Meredith McPherson, also at UC Santa Cruz, and colleagues report March 5 in *Communications Biology*. Urchins also blanket this forest's barrens.

Though the findings reveal devastation of these once resilient ecosystems, they may hint at how some forests can bounce back, says ecologist Marissa Baskett of the University of California, Davis, who was not involved in either study.

California's kelp forests, which provide a rich habitat for marine organisms, were hit by two ecological disasters in the last decade, says UC Santa Cruz ecologist Mark Carr, a coauthor of the study in *Communications Biology*.

First, sea star wasting disease wiped out local populations of sunflower sea stars, which typically feed on urchins that feed on kelp. Then "the Blob" (*SN: 1/20/18, p. 6*), a persistent marine heat wave, slowed kelp growth. As less kelp drifted into reef crevices where sea urchins lurk, and with a key predator gone, urchins expanded their domain to feast on the remaining kelp.

More frequent marine heat waves and unchecked sea urchins are making it harder for kelp to bounce back, especially in northern forests where the dominant kelp species dies each winter and returns in the spring. In comparison, a main species in Monterey Bay is a giant kelp that lives for several years, making it more resilient than kelp in northern forests.

What's left of Monterey Bay's kelp forests is getting a helping hand from sea otters, which are eating three times

D. BLACKISTON

can live for about 10 days without food. When fed sugar, xenobots can live longer (though they don't get bigger). "We've grown them for over four months in the lab," says developmental biologist Doug Blackiston, also at Tufts. "They do really interesting things if you grow them," such as forming strange balloonlike shapes.

It's not yet clear what sorts of jobs these xenobots might do, if any. Cleaning waterways, arteries or other small spaces comes to mind, the team says. More broadly, xenobots may hold lessons about how bodies are built, Levin says.

With the advent of new organisms comes ethical issues, cautions Kobi Leins, a digital ethics researcher at the University of Melbourne in Australia. "Scientists like to make things, and don't necessarily think about what the repercussions are," she says. More conversations about unintended consequences are needed, she says.

Levin agrees. The small xenobots are fascinating in their own rights, he says, but they raise bigger questions, and bigger possibilities. "It's finding a whole galaxy of weird new things." ■

as many sea urchins as they did before 2014, Smith's team found. But the predators feast on urchins only in patches of kelp. That's because barren-dwelling urchins subsist on scraps, leaving them hollow "zombies," Smith says. Urchins living among healthy kelp make a far better snack. By zeroing in on those urchins, the otters keep the population in check.

Simply transferring sea otters to northern kelp forests may create new challenges. For instance, otters brought in to help kelp forests off the Pacific coast of Canada competed with humans, especially Indigenous communities, for the same food sources. And there's a lot of work to do to bring back sunflower sea stars. Identifying the cause of the wasting disease is crucial (*SN: 2/13/21, p. 13*).

The new findings improve scientists' understanding of these interactions, Baskett says, which also "can inform restoration efforts aimed at ... anticipating the effects of future marine heat waves." ■

HUMANS & SOCIETY

Stone Age culture bloomed inland

Ancient site in Africa's interior may include symbolic crystals

BY BRUCE BOWER

Africa's southern Kalahari Desert is not typically regarded as a hotbed of Stone Age innovations. Yet human culture blossomed there around 105,000 years ago, back when it was green, researchers say.

Calcite crystals and other finds at a South African rock-shelter more than 600 kilometers from the nearest shoreline reflect cultural behaviors on par with those previously reported for ancient humans living on or near South Africa's coast, archaeologist Jayne Wilkins and colleagues report online March 31 in *Nature*. Those coastal sites date to between roughly 125,000 and 70,000 years ago, including one where locals used tools to make paint out of pigment around 100,000 years ago.

Given the scarcity of human sites from that time period, it's hard to know whether cultural innovations emerged independently in groups spread across southern Africa or originated in one region before being adopted elsewhere. But the new discoveries fit a scenario in which "the emergence of *Homo sapiens* involved the interaction of many different populations across Africa," says Wilkins, of Griffith University in Nathan, Australia. "That included the Kalahari."

A stone tool unearthed at an inland African site belongs to a set of artifacts pointing to ancient cultural advances among humans who lived far from resource-rich coastlines.

J. WILKINS

Excavations at Ga-Mohana Hill North Rockshelter, or GHN, uncovered a sediment layer containing 42 ostrich eggshell fragments, many of them burned, and 22 palm-sized or smaller calcite crystals, the team reports.

Like some modern African hunter-gatherer groups, ancient people at GHN may have cut holes in ostrich eggshells to create water containers, the researchers say. Geologic studies indicate that enough rain once fell over the southern Kalahari Desert to have produced year-round water sources for ancient people.

Many eggshell pieces showed discoloration from burning. Eggshells lay among animal bones, some of which had possible butchery marks and signs of burning.

The calcite crystals probably came from local rock sources, the team says. Excavated crystals hadn't been modified and had no apparent practical use, hinting that the items held ritual or symbolic significance, Wilkins suspects. Other GHN finds included stone tools, rock chunks from which tools were struck and a piece of red pigment with scrape marks.

Ritualistic use of the GHN crystals is difficult to demonstrate, says archaeologist Manuel Will of the University of Tübingen in Germany. And the eggshells could have been discarded after a meal, he says. Still, the new study adds to growing skepticism of claims that human cultural advances started along African coasts, Will says. It's possible, though, that bountiful coastal habitats fostered a broader range of innovations, he suggests. Coastal sites have yielded items not found at GHN, such as beads, bone tools and engraved ostrich eggshells. ■

ATOM & COSMOS

Life precursors found in outer space

Hydrocarbon cache sparks rethink of how the molecules form

BY LISA GROSSMAN

Complex carbon-bearing molecules that could help explain how life got started have been identified in space for the first time.

These molecules, called polycyclic aromatic hydrocarbons, or PAHs, consist of several linked hexagonal rings of carbon with hydrogen atoms at the edges. Astronomers have suspected for decades that these molecules are abundant in space, and simpler molecules with a single ring of carbon have been seen before. But "we're now excited to see that we're able to detect these larger PAHs for the first time in space," says astrochemist Brett McGuire of MIT, whose team reports the discovery in the March 19 *Science*.

Studying these molecules and others like them could help scientists understand how the chemical precursors to life might get started in space. "Carbon is such a fundamental part of chemical reactions, especially reactions leading to life's essential molecules," McGuire says. "This is our window into a huge reservoir of them."

Since the 1980s, astronomers have seen a mysterious infrared glow coming from spots within our galaxy and other galaxies. Many astronomers suspected that the glow comes from PAHs, but could not identify a specific source. The signals from several different PAHs overlap too much to tease any one of them apart, like a choir blending so well that the ear can't pick out individual voices.

Instead of searching the infrared signals for a single voice, McGuire and colleagues turned to radio waves, where different PAHs sing different songs. The team pointed the powerful Green Bank Telescope in West Virginia at TMC-1, a dark cloud about 450 light-years from Earth near the constellation Taurus.

Since McGuire previously had discovered that the cloud contains benzonitrile, a molecule made of a single carbon ring (*SN: 10/12/19 & 10/26/19, p. 28*), he thought TMC-1 was a good place to look for more complicated molecules.

The team detected 1- and 2-cyanonaphthalene, two-ringed molecules with 11 carbons, seven hydrogens and a nitrogen atom. The concentration is fairly diffuse, McGuire says: "If you filled the inside of your average compact car with [gas from] TMC-1, you'd have less than 10 molecules of each PAH we detected."

But it was a lot more than the team expected. The cloud contains between 100,000 and 1 million times more PAHs than theoretical models predict it should. "It's insane. That's way too much," McGuire says.

There are two ways that PAHs are thought to form in space: out of the ashes of dead stars or by direct chemical reactions in interstellar space. Since TMC-1 is just beginning to form stars, McGuire expected that any PAHs it contains ought to have been built by direct chemical reactions. But that scenario can't account for all the PAH molecules the team found. There's too much to be explained easily by stellar ash, too. That means something is probably missing from astrochemists' theories of how PAHs can form in space.

"We're working in uncharted territory here," McGuire says, "which is exciting."

Identifying PAHs in space is "a big thing," says Alessandra Ricca, an astrochemist at the SETI Institute in Mountain View, Calif., who was not involved in the new study. The work "is the first one that has shown that these PAH molecules actually do exist in space," she says. "Before, it was just a hypothesis."

Ricca's group is working on a database of infrared PAH signals that the James Webb Space Telescope, slated to launch in October, can look for. "All this is going to be very helpful for JWST and the research on carbon in the universe," she says. ■

ATOM & COSMOS

'USS Jellyfish' is a cosmic oddball

Faraway entity emits a strange radio wave pattern

BY KEN CROSWELL

Something's fishy in the southern constellation Phoenix.

Strange radio emissions from a distant galaxy cluster take the shape of a gigantic jellyfish, complete with head and tentacles. Moreover, the cosmic jellyfish emits only the lowest radio frequencies and can't be detected at higher frequencies. The unusual shape and radio spectrum tell a tale of intergalactic gas washing over galaxies and gently revving up electrons spewed out by gargantuan black holes long ago, researchers report in the March 10 *Astrophysical Journal*.

Spanning 1.2 million light-years, the strange entity lies in Abell 2877, a cluster of galaxies 340 million light-years from Earth. Researchers have dubbed the object the USS Jellyfish, because of its ultrasteep spectrum, or USS, from low to high radio frequencies.

"This is a source which is invisible to most of the radio telescopes that we have been using for the last 40 years," says astrophysicist Melanie Johnston-Hollitt of Curtin University in Perth, Australia. "It holds the record for dropping off the fastest" with increasing radio frequency.

Johnston-Hollitt's colleague Torrance Hodgson, a graduate student at Curtin, discovered the USS Jellyfish while analyzing data from Australia's Murchison Widefield Array, a complex of telescopes that detect low-frequency radio waves. These radio waves are more than a meter long and correspond to photons, or particles of light, with the lowest energies. Remarkably, the USS Jellyfish is about 30 times brighter at 87.5 megahertz — a frequency similar to that of an FM radio station — than at 185.5 MHz.

"That is quite spectacular," says Reinout van Weeren, an astronomer at Leiden University in the Netherlands who was not involved with the work.

Low-frequency radio waves of various strengths (red, orange, yellow, white) outline a huge cosmic "jellyfish" 1.2 million light-years across in galaxy cluster Abell 2877, whose center emits X-rays (magenta).

T. HODGSON/ICRAR/CURTIN UNIV.

"It is quite a neat result, because this is really extreme."

The USS Jellyfish bears no relation to previously discovered jellyfish galaxies. "This is absolutely enormous compared to those other things," Johnston-Hollitt says. Indeed, jellyfish galaxies are a very different kettle of celestial fish. Although they also inhabit galaxy clusters, they are individual galaxies passing through hot gas in a cluster. The hot gas tears out the galaxy's own gas, creating a wake of tentacles. The much larger USS Jellyfish, on the other hand, appears to have formed when intergalactic gas and electrons interacted.

Johnston-Hollitt, Hodgson and colleagues note that two galaxies in the Abell 2877 cluster coincide with the brightest patches of radio waves in the USS Jellyfish's head. These galaxies probably have supermassive black holes at their centers, the researchers say. The team ran computer simulations and found that the black holes were probably accreting material some 2 billion years ago. As they did so, the simulations suggest, disks of hot gas formed around each of them, spewing huge jets of material into the surrounding galaxy cluster.

This ejected material had electrons that whirled around magnetic fields at nearly the speed of light, and the electrons emitted radio waves. Over time, the electrons lost energy. The most energetic electrons, which had been emitting the highest radio frequencies, faded the most. Then a wave of gas sloshed through the cluster, reaccelerating the electrons around the two galaxies.

"It's a very gentle process," Johnston-Hollitt says. "The electrons don't get that much energy, which means they don't light up at high frequencies." Instead, the gentle gas wave caused electrons to emit radio waves with the lowest energies and frequencies, giving the USS Jellyfish the extreme spectrum it has today. ■

LIFE & EVOLUTION

Octopus sleep is remarkably active

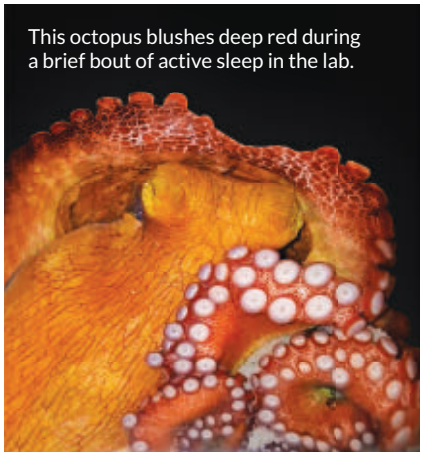
The cephalopods snooze in bursts of REM-like activity

BY LAURA SANDERS

Octopuses cycle through two stages of slumber, a new study reports.

First comes quiet sleep, and then a shift to a twitchy, active sleep in which vibrant colors flash across the animals' skin. These details, gleaned from four snoozing cephalopods in a lab in Brazil, may provide clues to a big scientific mystery: Why do animals sleep?

Sleep is so important that every animal seems to have a version of it, says Philippe Mourrain, a neurobiologist at Stanford University who recently described the sleep stages of fish (*SN: 8/3/19, p. 9*). Scientists have also cataloged sleep in



This octopus blushes deep red during a brief bout of active sleep in the lab.

reptiles, birds, amphibians, bees, mammals and jellyfish, to name a few. "So far, we have not found a single species that does not sleep," says Mourrain, who was not involved in the new study.

Cephalopod neuroscientist and diver Sylvia Medeiros caught four wild octopuses, *Octopus insularis*, and brought them into a lab at the Brain Institute of the Federal University of Rio Grande do Norte in Natal, Brazil. After tucking the animals away in a quiet area, she began to carefully record their behavior during the day, when octopuses are more likely to rest.

Two distinct states usually emerge, she and colleagues report online March 25 in *iScience*. In the first, called quiet sleep, the octopuses are pale and mostly motionless with the pupils of their eyes narrowed to slits. Active sleep comes next. Eyes dart around, suckers contract, muscles twitch, skin textures change and bright colors race across the body. This wild sleep is rhythmic and brief, lasting about 40 seconds every half an hour or so. Active sleep is also rare; the octopuses spent less than 1 percent of their days in active sleep, the team found.

Active sleep in octopuses is somewhat like REM sleep in people, Medeiros says. But because octopuses' active sleep is so short, their sleep cycles more

GENES & CELLS

Pilfered plant gene made insect a pest

The DNA lets whiteflies neutralize plants' defensive toxins

BY JONATHAN LAMBERT

At some point 35 million to 80 million years ago, a whitefly landed on a leaf and sucked its sweet sap. That fateful meal provided more than sugar. A gene from the plant wound its way into the whitefly's genome, a new study suggests, and may have helped the fly's descendants become notorious agricultural pests.

The gene helps plants neutralize and safely store certain toxic molecules they use to deter herbivores. In whiteflies, it allows the insects to feed on flora undeterred by one of the plant world's best chemical weapons, researchers report in the April 1 *Cell*. This plant-to-insect gene swap is the second ever documented and the clearest example of an insect commandeering the genetic toolkit of their "prey" to use it against them.

"Ten or 20 years ago, no one thought that this kind of gene transfer was possible," says Roy Kirsch, a chemical ecologist at the Max Planck Institute for Chemical Ecology in Jena, Germany, who was not involved in the study. "There are so many barriers a gene must overcome to move from a plant to an insect, but this study clearly shows that it happened, and that the gene provides a benefit to whiteflies."

Gene swapping is common among bacteria and occasionally happens between gut microbes and their animal hosts. Known as horizontal gene transfer, this process allows organisms to bypass parent-to-offspring inheritance and instantly acquire genes shaped by generations of natural selection. But a genetic jump from plants to insects, lineages separated by at least a billion years of evolution, has been documented only once before, also in whiteflies.

Whiteflies are aphidlike insects that feed on over 600 different plants around the globe. The pernicious pests' wide-ranging diet stems in part from their ability to evade many common plant defenses. While looking for genes that underlie this ability, researchers in China stumbled upon something strange in three closely related whitefly species — a gene, called *BtPMaT1*, not known to exist outside of plants.

The gene allows plants to neutralize a class of defensive chemicals called phenolic glycosides until herbivores start munching. "Phenolic glycosides are very toxic to insects," says chemical ecologist and entomologist Ted Turlings of the University of Neuchâtel in Switzerland. The possibility that whiteflies might use a plant detoxification gene to tolerate plant toxins tantalized his colleagues in China.

The researchers inserted a bit of RNA designed to disable the whitefly *BtPMaT1* gene into tomato plants in the lab. After a week of feeding on five genetically altered tomato plants, nearly all of roughly 2,500 *Bemisia tabaci* whiteflies died, compared with only about 20 percent of those that fed on unaltered plants. Such a drastic effect suggests this gene plays an important role in helping whiteflies bypass plant defenses, Turlings says.

S. MEDEIROS

Watch a video of a sleeping octopus at **bit.ly/SN_OctopusNap**

closely resemble the sleep of reptiles and birds, says study coauthor Sidarta Ribeiro, a neuroscientist also at the Brain Institute.

In people, sleep is thought to allow the brain to organize itself, getting rid of useless information and strengthening helpful memories (*SN: 6/11/16, p. 15*). "It comes to mind immediately that the octopus is very smart," Ribeiro says. Perhaps a similar sorting process happens in the sleeping octopus brain, he says.

For people, REM sleep is packed with dreams. "It is tempting to try to read octopuses' dreams on their skin," Ribeiro says. But as fun as it is to speculate, no one knows what the octopuses experience during these active sessions of vibrant, flickering color. Researchers have a lot more work to do before they can say that octopuses dream, Ribeiro says. And even if it turns out that they do, those dreams might not make much sense to a human. ■

How exactly a plant *BtPMaT1* ended up in whiteflies remains a mystery. Turlings suspects that a virus shuttled bits of DNA between the plant and insect. Horizontal gene transfer might be "an important mechanism for pests to gain abilities to deal with plant defenses," he says. The three species Turlings' team examined split some 35 million years ago, suggesting they got the gene before then. But close relatives that diverged 80 million years ago lack the gene, suggesting the transfer happened within that window.

The first documented plant-to-insect gene swap, reported September 23 in *Scientific Reports*, also occurred in whiteflies, though the function of the gene in that swap is less clear. But it may not be a coincidence that the two known examples of such an event occurred in the same insect. "The lives of whiteflies and their plant hosts are closely intertwined," says Shannon Soucy, an evolutionary microbiologist at Dartmouth College. That consistent exposure prepares the system for this kind of event, allowing whiteflies to use the plant defense gene against its maker. ■

GENES & CELLS

Why rabbits handstand instead of hop

A gene defect may stop some bunnies from syncing hind legs

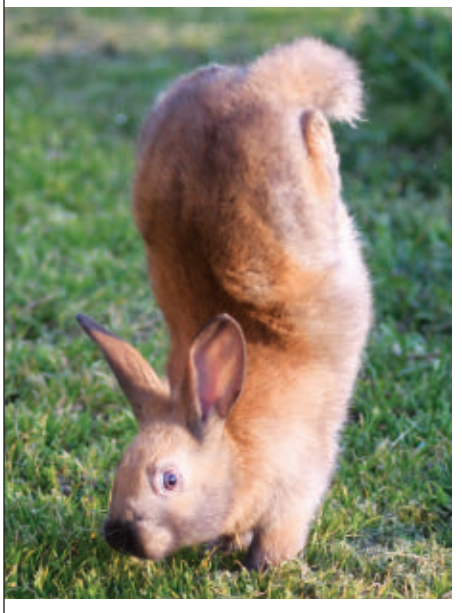
BY ERIN GARCIA DE JESÚS

One defective gene might turn some bunnies' hops into handstands. To move quickly, a breed of domesticated rabbit called sauteur d'Alfort sends its back legs sky high and walks on its front paws. That strange gait may be the result of a mutation in a gene tied to limb movement, scientists report March 25 in *PLOS Genetics*.

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

Andersson and colleagues bred hopless male sauteur d'Alfort rabbits with female white New Zealand rabbits that can hop. The team then searched the genetic blueprints of the offspring that couldn't hop for mutations that didn't appear in offspring that could.

A mutation in the *RORB* gene popped up as a likely candidate for the rabbits' handstands. That change creates faulty versions of the genetic instructions that cells use to make proteins, the team found. As a result, rabbits that have the mutation appear to have less RORB protein in specialized nerve cells than do rabbits that don't have the mutation.



SAMUEL BOUCHER

Some rabbits walk on their front paws, perhaps due to a mutation in a gene that coordinates limb movement.

Those spinal cord nerve cells, called interneurons, help coordinate the left and right side of the body and are crucial for a normal gait, Andersson says. Without RORB protein in interneurons, the rabbits may be unable to coordinate their hind limbs, restricting their ability to hop.

While moving slowly from place to place, rabbits with the defective gene can walk normally, alternating their front and hind legs. But to move fast or travel long distances, rabbits normally hop, which requires synchronized hind legs to jump at the same time, says study coauthor Miguel Carneiro, a molecular geneticist at the University of Porto in Vairão, Portugal. Without that coordination, rabbits with a mutation in *RORB* use their front paws to move quickly, Carneiro says. But some hop-less bunnies might do a more drastic handstand than others.

Though the finding is interesting, the study doesn't reveal how interneurons lacking RORB protein spur the rabbits' handstands, says Stephanie Koch, a neuroscientist at University College London who was not involved with the work.

Uncovering how that genetic defect affects the body could be important for understanding the way all animals move. Even people can't run very fast without all limbs moving in harmony. "If you look at the 100-meter sprint — 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." These handstand rabbits wouldn't grab any golds either. But they could help researchers develop ways to repair the body when defects in *RORB* cause disease, Koch says. ■

Watch a video of acrobatic rabbits at **bit.ly/SN_RabbitWalk**

BODY & BRAIN

New COVID-19 vaccines in the works

Unique inoculation tactics may help hasten the pandemic's end

BY TINA HESMAN SAEY

Barely a year after the World Health Organization declared the coronavirus outbreak a pandemic, 11 vaccines are now in use worldwide.

Yet those 11 vaccines "will not be enough to fulfill the global need in the short term," says Esther Krofah, executive director of FasterCures, part of the Milken Institute think tank in Washington, D.C. As of April 5, only about 1.9 percent of the world's more than 7 billion people had been fully vaccinated against the coronavirus. "We need as many vaccines over the finish line as can get through the scientific process," she says.

Help may be on the way. Another 251 COVID-19 vaccines are at some stage of development, with 60 far enough along to be tested in people, says Carly Gasca, senior associate at FasterCures.

Some vaccines are close to the finish line. Novavax of Gaithersburg, Md., may soon request emergency use authorization for its vaccine in the United States and other countries. But vaccines in the pipeline can fail at any stage.

Among the hurdles: COVID-19 vaccines already in use have set a high bar. For instance, mRNA vaccines from Moderna and Pfizer have proved to be about 90 percent effective in real-world situations (*SN Online: 3/30/21*). And finding people willing to participate in clinical trials in which they might get a placebo instead of a vaccine could be tough, especially in countries where other authorized vaccines are available.

"You have to have something super-über-duper special about your product to survive in this environment," says Onyema Ogbuagu, a virologist who heads COVID-19 clinical trials at Yale School of Medicine.

That edge could come from logistics. To be effective, vaccines have to get into people's bodies. So unlike the Pfizer and Moderna shots, vaccines that don't have to be frozen have a better chance of being used in rural or remote areas and places that don't have resources to buy and maintain freezers, Gasca says.

Or an edge could come from an ability to handle emerging variants of the coronavirus that may be more infectious, more deadly or both (*SN Online: 2/5/21*). "The variants emerging are changing the landscape of the kind of virus we're fighting now versus the virus that we were fighting in the fall and in the summer," Krofah says. New vaccines may need to combat even more variants.

Here's a closer look at some of the novel ways vaccine makers are approaching these challenges.

A potential COVID-19 vaccine in pill form (shown) from the pharmaceutical company Vaxart might be an easy way to get inoculations and boosters to people even in hard-to-reach places.

VAXART INC.

Vaxxinity

Vaxxinity, formerly COVAXX, used several proteins from SARS-CoV-2, the virus that causes COVID-19, to design peptides that look like pieces of those proteins. Those peptides mimic important structures within the coronavirus proteins, including a part of the spike protein that the virus uses to latch onto cells. When injected into the body, the lab-made peptides prod the immune system to build antibodies and gear up other immune cells to attack the coronavirus should the vaccinated person encounter it later.

While other vaccines, including Novavax's candidate, use the entire spike protein, Dallas-based Vaxxinity homed in on portions of coronavirus proteins that are important for function and are likely to provoke a reaction from the immune system. The vaccine is stable at refrigerator temperature.

The company completed Phase I testing for safety and the ability to rev up the immune system in 60 adults. All of the volunteers made antibodies and had immune cells known as T cells trained to recognize the coronavirus in the event of future encounters. Participants had mostly mild side effects, with few people reporting symptoms such as fever and fatigue.

Vaxxinity is doing Phase II testing in Taiwan to learn more about the immune response and side effects. Phase II and III testing will begin soon in Brazil to determine the vaccine's efficacy.

The company is already working on a second generation of the vaccine that could work against multiple variants, says Mei Mei Hu, CEO of Vaxxinity.

Vaxart

San Francisco–based Vaxart engineered a common cold virus called an adenovirus to carry into human cells instructions for making two coronavirus proteins. There, the proteins can be made to prime the immune system to later fend off the coronavirus.

Vaxart's oral vaccine is a pill, which can be stored at room temperature and doesn't need trained medical workers

or equipment to administer. So the vaccine could be ideal for sending booster doses through the mail or using in hard-to-reach places where keeping vaccines cold is difficult. And people who are afraid of needles might like a tablet alternative.

Animal research suggests that taking the vaccine orally also may produce more of an immune response in the mucous membranes that line the nose, mouth, throat and digestive tract than injected vaccines do, says Sean Tucker, Vaxart's founder and chief scientific officer.

Other vaccines already in use, including from Johnson & Johnson and AstraZeneca, also contain engineered adenoviruses. But those vaccines have instructions for making just one coronavirus protein, the spike protein. Vaxart's vaccine contains instructions for making the spike protein and the nucleocapsid, or N, protein, which is important for replication and assembly of the coronavirus. It provides another target for antibodies that can shut the virus down.

Because the vaccine works in airways and the digestive tract, it is difficult to directly compare with injected vaccines, Tucker says. But the vaccine appears to generate antibodies against both the spike and N proteins and revs up T cells to combat the virus, according to preliminary results from a small Phase I trial.

The company will soon begin a Phase II study to determine the optimal dose of the vaccine, and Tucker says the team hopes to start an efficacy study later this year.

Even though the spike protein has undergone many changes resulting in some concerning variants that may be partially able to evade vaccines, the N protein hasn't altered much. For instance, the difference between the N proteins in the B.1.351 variant first identified in South Africa and the original SARS-CoV-2 is just one amino acid. Hopefully that will mean antibodies and T cells against the N protein can neutralize variants as well as they do the original virus, Tucker says. Meanwhile, he says, "we are looking at new versions of the vaccines in research and will test preclinically [in animals or cells] to see if there are advantages to making new matched vaccines."

Valneva

Valneva's vaccine is an inactivated, or "killed," version of SARS-CoV-2. The virus used in the vaccine was isolated from a patient in Italy. The vaccine virus is grown in monkey cells and then chemically inactivated and mixed with two adjuvants, substances that enhance the body's immune response.

Several inactivated COVID-19 vaccines, including ones made by the Chinese companies Sinopharm and Sinovac and by Bharat Biotech in India, are already in use. But those vaccines don't have the extra boost from the dual adjuvants in Valneva's vaccine.

Because the vaccine contains the whole virus, variants that have tweaks in their spike protein may not be as big a problem for Valneva's vaccine as for other vaccines. There are a lot of other parts of the virus for the immune system to recognize. Results from a Phase I/II study are expected soon. Meanwhile, the France-based company is working on creating versions of the vaccine based on strains circulating in people.

Inovio

In Inovio's vaccine, DNA instructions for building the coronavirus spike protein are injected just under the skin with multiple tiny needles and then zapped into cells in the body via a handheld device that releases a split-second pulse of electricity. From there, cells produce the spike protein and cue the immune defenses.

No other vaccine has this delivery method. Some people report that the procedure is less painful than a traditional needlestick. And the vaccine may produce fewer side effects than some already in use. J. Joseph Kim, Inovio's CEO, speculates it may be because the vaccine contains only DNA and saline, or because different types of cells may take up the DNA than are affected by injected vaccines. Five of 40 people tested in a Phase I study reported any side effects, and all of those were mild, researchers reported December 23 in *EClinicalMedicine*.

Inovio will use a handheld device (shown) to zap its DNA vaccine into people's cells with a pulse of electricity.

INOVIO

Additionally, the vaccine can be stored for a year at room temperature and for five years in a refrigerator.

Results from the Phase I study indicate that people given the Inovio vaccine make antibodies against the coronavirus at higher levels, on average, than people given vaccines that use adenoviruses to deliver DNA instructions for building the spike protein, Kim says. It's unclear why. And while antibody levels were lower than those produced by the mRNA vaccines, Inovio's DNA vaccine does a good job of revving up T cells to fight the coronavirus.

Inovio has started Phase II testing, with early results expected soon. A Phase III trial will start once the U.S. Food and Drug Administration clears a commercial version of the DNA delivery device to be used in the trial.

The company is testing whether antibodies made against the vaccine can still fight off the variants. In addition, Inovio, headquartered in Plymouth Meeting, Pa., hopes to engineer a universal vaccine that could fight off known and unknown versions of SARS-CoV-2. ■

Get the *sensation*

Haptics research aims to add touch to virtual reality, online shopping and artificial limbs

By Kathiann M. Kowalski

On most mornings, Jeremy D. Brown eats an avocado. But first, he gives it a little squeeze. A ripe avocado will yield to that pressure, but not too much. Brown also gauges the fruit's weight in his hand and feels the waxy skin, with its bumps and ridges.

"I can't imagine not having the sense of touch to be able to do something as simple as judging the ripeness of that avocado," says Brown, a mechanical engineer who studies haptic feedback — how information is gained or transmitted through touch — at Johns Hopkins University.

Many of us have thought about touch more than usual during the COVID-19 pandemic. Hugs and high fives rarely happen outside of the immediate household these days. A surge in online shopping has meant fewer chances to touch things before buying. And many people have skipped travel, such as visits to the beach where they might sift sand through their fingers. A lot goes into each of those actions.

"Anytime we touch anything, our perceptual experience is the product of the activity of thousands of nerve fibers and millions of neurons in the brain," says neuroscientist Sliman Bensmaia of the University of Chicago. The body's natural sense of touch is remarkably complex. Nerve receptors detect cues about pressure, shape, motion, texture, temperature and more. Those cues cause patterns of neural activity, which the central nervous system interprets so we can tell if something is smooth or rough, wet or dry, moving or still.

Neuroscience is at the heart of research on touch. Yet mechanical engineers like Brown and others, along with experts in math and materials science,

Scientists at the University of Chicago attached strips of different materials to a rotating drum to measure vibrations produced in the skin as a variety of textures move across a person's fingertips.

OPPOSITE: HAND: IMAGE SOURCE/GETTY IMAGES PLUS; SWEATERS: CEREBROCREATIVE/ISTOCK/GETTY IMAGES PLUS; PHONE: ISSARAWAT TATTONG/GETTY IMAGES PLUS; T. TIBBITTS; THIS PAGE: MATT WOOD/UNIV. OF CHICAGO

are studying touch with an eye toward translating the science into helpful applications. Researchers hope their work will lead to new and improved technologies that mimic tactile sensations.

As scientists and engineers learn more about how our nervous system responds to touch stimuli, they're also studying how our skin interacts with different materials. And they'll need ways for people to send and receive simulated touch sensations. All these efforts present challenges, but progress is happening. In the near term, people who have lost limbs might recover some sense of touch through their artificial limbs. Longer term, haptics research might add touch to online shopping, enable new forms of remote medicine and expand the world of virtual reality.

> "Anytime you're interacting with an object, your skin deforms," or squishes a bit.
>
> SLIMAN BENSMAIA

Good vibrations

Virtual reality programs already give users a sense of what it's like to wander through the International Space Station or trek around a natural gas well. For touch to be part of such experiences, researchers will need to reproduce the signals that trigger haptic sensations.

Our bodies are covered in nerve endings that respond to touch, and our hands are really loaded up, especially our fingertips. Some receptors tell where parts of us are in relation to the rest of the body. Others sense pain and temperature. One goal for haptics researchers is to mimic sensations resulting from force and movement, such as pressure, sliding or rubbing.

"Anytime you're interacting with an object, your skin deforms," or squishes a bit, Bensmaia explains. Press on the raised dots of a braille letter, and the dots will poke your skin. A soapy glass slipping through your fingers produces a shearing force — and possibly a crash. Rub fabric between your fingers, and the action produces vibrations.

Four main categories of touch receptors respond to those and other mechanical stimuli. There's some overlap among the types. And a single contact with an object can affect multiple types of receptors, Bensmaia notes.

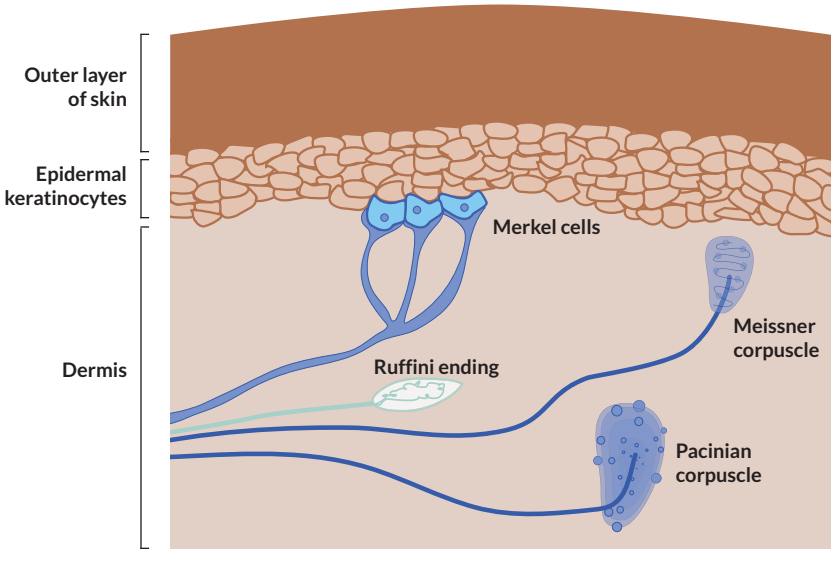
One type, called Pacinian corpuscles, sits deep in the skin. They are especially good at detecting vibrations created when we interact with different textures. When stimulated, the receptors produce sequences of signals that travel to the brain over a period of time. Our brains interpret the signals as a particular texture. Bensmaia compares it to the way we hear a series of notes and recognize a tune.

"Corduroy will produce one set of vibrations. Organza will produce another set," Bensmaia says. Each texture produces "a different set of vibrations in your skin that we can measure." Such measurements are a first step toward trying to reproduce the feel of different textures.

Additionally, any stimulus meant to mimic a texture sensation must be strong enough to trigger responses in the nervous system's touch receptors. That's where work by researchers at the University of Birmingham in England comes in. The vibrations from contact with various textures create different kinds of wave energy. Rolling-type waves called Rayleigh waves go deep enough to reach the Pacinian receptors, the team reported last October in *Science Advances*. Much larger versions of the same types of waves cause much of the damage from earthquakes.

Not all touches are forceful enough to trigger a response from the Pacinian receptors. To gain more insight into which interactions will stimulate those receptors, the team looked at studies that have collected data on touches to the limbs, head or neck of dogs, dolphins, rhinos, elephants and other mammals. A pattern emerged. The group calls it a "universal scaling law" of touch for mammals.

Deep feelings Four main types of touch receptors respond to mechanical stimulation of the skin: Meissner corpuscles, Merkel cells, Ruffini endings and Pacinian corpuscles. Some respond better to certain kinds of stimuli than others. Recent studies have focused on the deep-skin Pacinian corpuscles, which respond to vibrations created when fingers rub against textured materials. SOURCE: SCHOLARPEDIA.ORG



T. TIBBITTS

Retired U.S. Army Sgt. Garrett Anderson shakes hands with researcher Aadeel Akhtar, CEO of Psyonic, a prosthesis developer (left). A wireless skin patch on Anderson's upper arm gives him sensory feedback when grasping an object. Inside the patch are circular actuators that vibrate in response to signals. The prototype device (right) might give the sensation of touch pressure in artificial limbs, in virtual reality and telemedicine.

For the most part, a touch at the surface will trigger a response in a Pacinian receptor deep in the skin if the ratio is 5-to-2 between the length of the Rayleigh waves resulting from the touch and the depth of the receptor. At that ratio or higher, a person and most other mammals will feel the sensation, says mathematician James Andrews, lead author of the study.

Also, the amount of skin displacement needed to cause wavelengths long enough to trigger a sensation by the Pacinian receptors will be the same across most mammal species, the group found. Different species will need more or less force to cause that displacement, however, which may depend on skin composition or other factors. Rodents did not fit the 5–2 ratio, perhaps because their paws and limbs are so small compared with the wavelengths created when they touch things, Andrews notes.

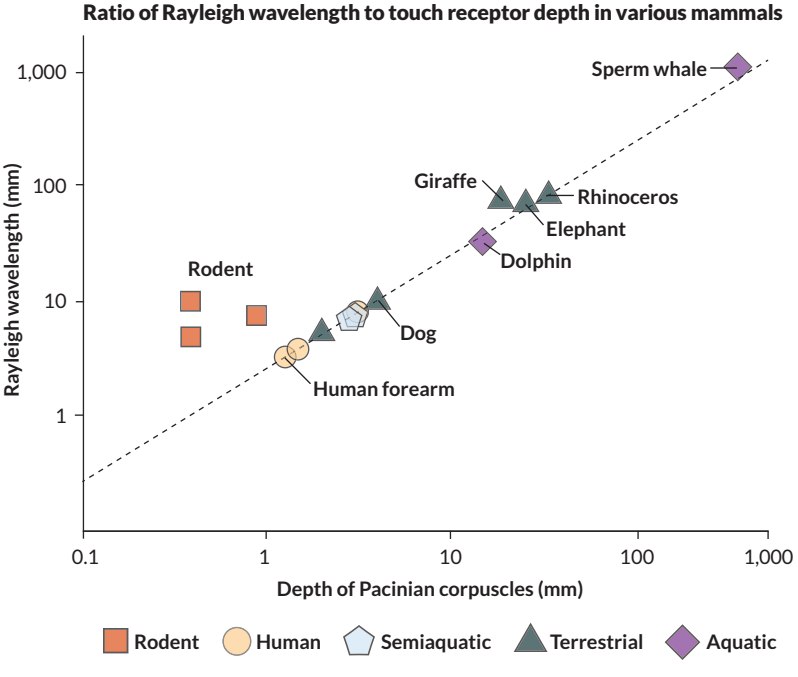
Beyond that, the work sheds light on "what types of information you'd need to realistically capture the haptic experience — the touch experience — and send that digitally anywhere," Andrews says. People could then feel sensations with a device or perhaps with ultrasonic waves. Someday the research might help provide a wide range of virtual reality experiences, including virtual hugs.

Online tactile shopping

Mechanical engineer Cynthia Hipwell of Texas A&M University in College Station moved into a new house before the pandemic. She looked at some couches online but couldn't bring herself to buy one from a website. "I didn't want to choose couch fabric without feeling it," Hipwell says.

"Ideally, in the long run, if you're shopping on Amazon, you could feel fabric," she says. Web pages' computer codes would make certain areas on a screen mimic different textures, perhaps with shifts in electrical charge, vibration signals, ultrasound or other methods. Touching the screen would clue you in to whether a sweater is soft or scratchy, or if a couch's fabric feels bumpy or smooth. Before that can happen, researchers need to understand conditions

Universality of touch A pattern in the ratio of length of Rayleigh waves moving through skin while touching an object and the depth of Pacinian touch receptors suggests that the same amount of deformation in the skin of several different mammals, except rodents, will produce similar sensations. SOURCE: J. ANDREWS *ET AL*/*SCIENCE ADVANCES* 2020



PHOTOS: NORTHWESTERN UNIV; GRAPH: T. TIBBITTS

that affect our perception of how a computer screen feels.

Surface features at the nanometer scale (billionths of a meter) can affect how we perceive the texture of a piece of glass, Hipwell says. Likewise, we may not consciously feel any wetness as humidity in the air mixes with our skin's oil and sweat. But tiny changes in that moisture can alter the friction our fingers encounter as they move on a screen, she says. And that friction can influence how we perceive the screen's texture.

Shifts in electric charge also can change the attraction between a finger and a touch screen. That attraction is called electroadhesion, and it affects our tactile experience as we touch a screen. Hipwell's group recently developed a computer model that accounts for the effects of electroadhesion, moisture and the deformation of skin pressing against glass. The team reported on the work in March 2020 in *IEEE Transactions on Haptics*.

Hipwell hopes the model can help product designers develop haptic touch screens that go beyond online shopping. A car's computerized dashboard might have sections that change texture for each menu, she suggests. A driver could change temperature or radio settings by touch while keeping eyes on the road.

> "Ideally, in the long run, if you're shopping on Amazon, you could feel fabric."
>
> CYNTHIA HIPWELL

Wireless touch patches

Telemedicine visits rose dramatically during the early days of the COVID-19 pandemic. But video doesn't let doctors feel for swollen glands or press an abdomen to check for lumps. Remote medicine with a sense of touch might help during pandemics like this one — and long after for people in remote areas with few doctors.

People in those places might eventually have remote sensing equipment in their own homes or at a pharmacy or workplace. If that becomes feasible, a robot, glove or other equipment with sensors could touch parts of a patient's body. The information would be relayed to a device somewhere else. A doctor at that other location could then experience the sensations of touching the patient.

Researchers are already working on materials that can translate digital information about touch into sensations people — in this case, doctors — can feel. The same materials could communicate information for virtual reality applications. One possibility is a skin patch developed by physical chemist John Rogers of Northwestern University in Evanston, Ill., and others.

One layer of the flexible patch sticks to a person's skin. Other layers include a stretchable circuit board and tiny actuators that create vibrations as current flows around them. Wireless signals tell the actuators to turn on or off. Energy to run the patch also comes in wirelessly. The team described the patch in *Nature* in 2019.

Since then, Rogers' group has reduced the patch's thickness and weight. The patch now also provides more detailed information to a wearer. "We have scaled the systems into a modular form to allow custom sizes [and] shapes in a kind of plug-and-play scheme," Rogers notes. So far, up to six separate patches can work at the same time on different parts of the body.

The group also wants to make its technology work with electronics that many consumers have, such as smartphones. Toward that end, Rogers and colleagues have developed a pressure-sensitive touch screen interface for sending information to the device. The interface lets someone provide haptic sensations by moving their fingers on a smartphone or touch screen–based computer screen. A person wearing the patch then feels stroking, tapping or other touch sensations.

Pressure points

Additionally, Rogers' team has developed a way to use the patch system to pick up signals from pressure on a prosthetic arm's fingertips. Those signals can then be relayed to a patch worn by the person with the artificial limb. Other researchers also are testing ways to add tactile feedback to prostheses. European researchers reported in 2019 that adding feedback for pressure and motion helped people with an artificial leg walk with more confidence (*SN: 10/12/19, p. 8*). The device reduced phantom limb pain as well.

Brown, the mechanical engineer at Johns Hopkins, hopes to help people control the force of their artificial limbs. Nondisabled people adjust their hands' force instinctively, he notes. He often takes his young daughter's hand when they're in a parking lot. If she starts to pull away, he gently squeezes. But he might easily hurt her if he couldn't sense the stiffness of her flesh and bones.

Two types of prosthetic limbs can let people who lost an arm do certain movements again. Hands on "body-controlled" limbs open or

close when the user moves other muscle groups. The movement works a cable on a harness that connects to the hand. Force on those other muscles tells the person if the hand is open or closed. Myoelectric prosthetic limbs, in contrast, are directly controlled by the muscles on the residual limb. Those muscle-controlled electronic limbs generally don't give any feedback about touch. Compared with the body-controlled options, however, they allow a greater range of motion and can offer other advantages.

In one study, Brown's group tested two ways to add feedback about the force that a muscle-controlled electronic limb exerts on an object. One method used an exoskeleton that applied force around a person's elbow. The other technique used a device strapped near the wrist. The stiffer an object is, the stronger the vibrations on someone's wrist. Volunteers without limb loss tried using each setup to judge the stiffness of blocks.

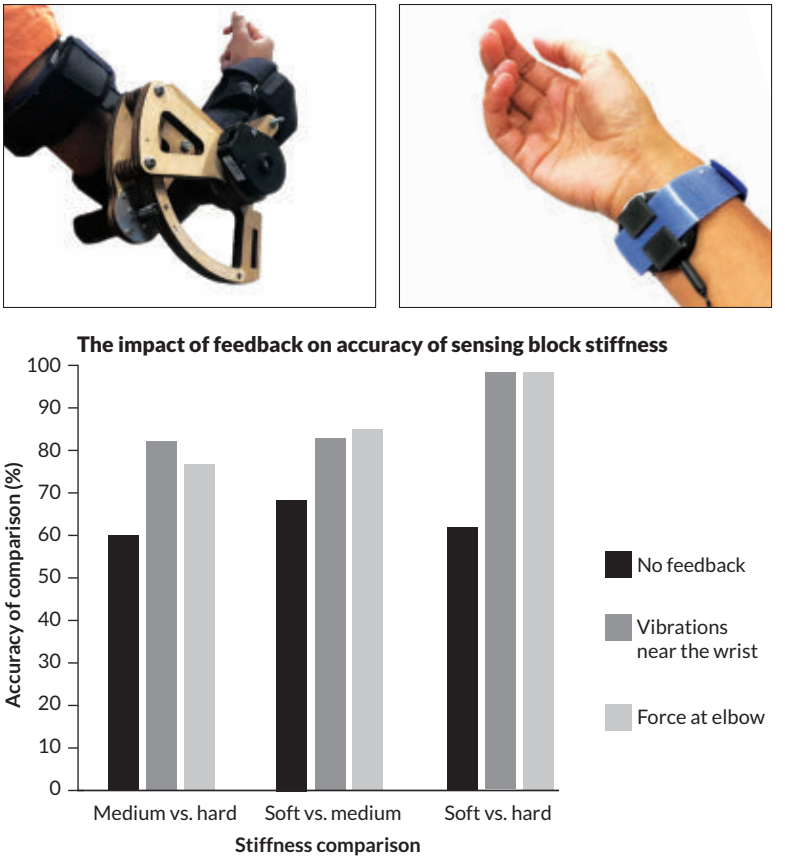
Both methods worked better than no feedback. And compared with each other, the two types of feedback "worked equally well," Brown says. "We think that is because, in the end, what the human user is doing is creating a map." Basically, people match up how much force corresponds to the intensity of each type of feedback. The work suggests ways to improve muscle-controlled electronic limbs, Brown and colleagues reported in 2019 in the *Journal of NeuroEngineering and Rehabilitation*.

Still, people's brains may not be able to match up all types of feedback for touch sensations. Bensmaia's group at the University of Chicago has worked with colleagues in Sweden who built tactile sensors into bionic hands: Signals from a sensor on the thumb went to an electrode implanted around the ulnar nerve on people's arms. Three people who had lost a hand tested the bionic hands and felt a touch when the thumb was prodded, but the touch felt as if it came from somewhere else on the hand.

Doctors can choose which nerve an electrode will stimulate. But they don't know in advance which bundle of fibers it will affect within the nerve, Bensmaia explains. And different bundles receive and supply sensations to different parts of the hand. Even after the people had used the prosthesis for more than a year, the mismatch didn't improve. The brain didn't adapt to correct the sensation. The team shared its findings last December in *Cell Reports*.

Despite that, in previous studies, those same people using the bionic hands had better precision and more control over their force when grasping objects, compared with those using versions without direct stimulation of the nerve. People getting the direct nerve stimulation also reported feeling as if the hand was more a part of them.

As with the bionic hands, advances in haptic technology probably won't start out working perfectly. Indeed, virtual hugs and other simulated touch experiences may never be as good as the real thing. Yet haptics may help us get a feel for the future, with new ways to explore our world and stay in touch with those we love. ■



Helpful feedback Volunteers without limb loss wore an artificial lower arm with and without different types of haptic feedback. One system applied force near the elbow (top, left image). The other provided vibrations near the wrist (top, right). Participants compared the softness or hardness of different blocks. Both types of feedback improved participants' accuracy in judging stiffness over the tests with no feedback.
SOURCE: N. THOMAS *ET AL/J. NEUROENG. REHAB.* 2019

Explore more

- Xinge Yu *et al.* "Skin-integrated wireless haptic interfaces for virtual and augmented reality." *Nature*. November 20, 2019.

Kathiann M. Kowalski is a freelance journalist based in northeast Ohio.

PHOTOS: N. THOMAS *ET AL/J. NEUROENG. REHAB.* 2019; GRAPH: T. TIBBITTS

What took the **videophone** so long to catch on?

Decades of attempts preceded Zoom's success

By Anushree Dave

Eileen Donovan, an 89-year-old mother of seven living in a Boston suburb, loved watching her daughter teach class on Zoom during the coronavirus pandemic. She never imagined Zoom would be how her family eventually attended her funeral.

Donovan died of Parkinson's disease on June 30, 2020, leaving behind her children, 10 grandchildren and six great-grandchildren. She always wanted a raucous Irish wake. But only five of her children plus some local family could be there in person, and no extended family or friends, due to coronavirus concerns. This was not the way they had expected to mourn.

For online attendees, the ceremony didn't end with hugs or handshakes. It ended with a click on a red "leave meeting" button, appropriately named for business meetings, but not much else.

LUIS ALVAREZ/GETTY IMAGES

It's the same button that Eileen Donovan-Kranz, Donovan's daughter, clicks when she finishes an English lecture for her class of undergraduate students at Boston College. And it's the same way she and I ended our conversation on an unseasonably warm November day: Donovan-Kranz sitting in front of a window in her dining room in Ayer, Mass., and me in my bedroom in Manhattan.

"I'm not going to hold the phone during my mother's burial," she remembers thinking. Just a little over a year ago, it would have seemed absurd to have to ask someone to hold up a smartphone so that others could "attend" such a personal event. Donovan-Kranz asked her daughter's fiancé to do it.

The COVID-19 pandemic has profoundly changed the way people interact with each other and with technology. Screens were for reminiscing over cherished memories, like watching VHS tapes or, more recently, YouTube videos of weddings and birthdays that have already happened. But now, we're not just watching memories. We're creating them on screens in real time.

As social distancing measures forced everyone to stay indoors and interact online, multibillion-dollar industries have had to rapidly adjust to create experiences in a 2-D world. And although this concept of living our lives online — from mundane work calls to memorable weddings or concerts — seems novel, both scientists and science fiction writers have seen this reality coming for decades.

In David Foster Wallace's 1996 novel *Infinite Jest*, videotelephony enjoys a brief but frenzied popularity in a future America. Entire industries emerge to address people's self-consciousness on camera. But eventually, the industry collapses when people realize they prefer the familiar voice-only telephone.

Despite multiple efforts by inventors and entrepreneurs to convince us that videoconferencing had arrived, that reality didn't play out. Time after time, people rejected it for the humble telephone or for other innovations like texting. But in 2020, live video meetings finally found their moment.

It took more than just a pandemic to get us here, some researchers say. Technological advances over the decades together with the ubiquity of the technology got everyone on board. But it wasn't easy.

Initial attempts

On June 30, 1970 — exactly half a century before Donovan's death — AT&T launched what it called the nation's first commercial videoconferencing service in Pittsburgh with a call from Peter Flaherty, the city's mayor, to John Harper, chairman and CEO of Alcoa Corporation, one of the world's largest producers of aluminum. Alcoa had already been using the Alcoa Picturephone Remote Information System for retrieving information from a database using buttons on a telephone. The data would be presented on the videophone display. This was before desktop computers were ubiquitous.

AT&T President Walter Sherman Gifford (third from right) makes a videocall at Bell Telephone Laboratories in New York City on April 7, 1927. The call went to U.S. Secretary of Commerce Herbert Hoover in Washington, D.C., via 300 miles of long-distance wire.

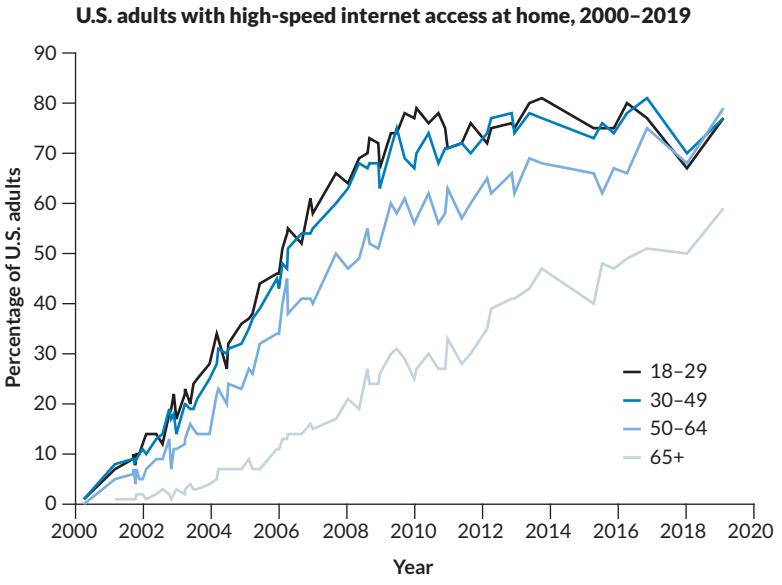
FEDERAL COMMUNICATIONS COMMISSION/PHOTOQUEST/GETTY IMAGES

This was not AT&T's first videophone, however. In 1927, U.S. Secretary of Commerce Herbert Hoover had demonstrated a prototype developed by the company. But by 1972, AT&T had a mere 32 units in service in Pittsburgh. The only other city offering commercial service, Chicago, hit its peak sales in 1973, with 453 units. AT&T discontinued the service in the late 1970s, concluding that the videophone was "a concept looking for a market."

About a decade after AT&T's first attempt at commercialization, a band called the Buggles released the single "Video Killed the Radio Star," the first music video to air on MTV. The song reminded people of the technological change that occurred in the 1950s and '60s, when U.S. households transitioned away from radio as televisions became more accessible to the masses.

The way television achieved market dominance kept videophone developers bullish about their technology's future. In 1993, optimistic AT&T researchers predicted "the 1990s will be the video communication decade." Video would change from something we passively consumed to something we interacted with in real time. That was the hope.

When AT&T launched its VideoPhone 2500 in



Broad reach Access to high-speed, broadband internet has risen among U.S. adults, across all age groups. The data above are for at-home use, excluding internet access via smartphone.
SOURCE: PEW RESEARCH CENTER 2019

1992, prices started at a hefty $1,500 (about $2,800 in today's dollars) — later dropping to $1,000. The phone had compressed color and a slow frame rate of 10 frames per second (Zoom calls today are 30 frames per second), so images were choppy.

Though the company tried to enchant potential customers with visions of the future, people weren't buying it. Fewer than 20,000 units sold in the five months after the launch. Rejection again.

Building capacity

Last June, to commemorate the 50th anniversary of AT&T's first videophone launch, William Peduto, Pittsburgh's mayor, and Michael G. Morris, Alcoa's chairman at the time, spoke over videophone, just as their predecessors had done.

Several scholars, including Andrew Meade McGee, a historian of technology and society at Carnegie Mellon University in Pittsburgh, joined for an online panel to discuss the rocky history of the videophone and its 2020 success. McGee told me a few months later that two things are crucial for a product's actual adoption: "capacity and circumstance." Capacity is all about the technology that makes a product easy to use and affordable. For videophones, it's taken a while to get there.

When the Picturephone, which was launched by AT&T and Bell Telephone Laboratories, premiered at the 1964 World's Fair in New York City, a three-minute call cost $16 to $27 (that's about $135 to $230 in 2021). It was available only in booths in New York City, Chicago and Washington, D.C. (*SN: 8/1/64, p. 73*). Using the product required planning, effort and money — for low reward. The connection required multiple phone lines and the picture appeared on a black-and-white screen about the size of today's iPhone screens.

These challenges made the Picturephone a tough sell. Marketing researchers Steve Schnaars and Cliff Wymbs of Baruch College at the City University of New York theorized why videophones hadn't taken off decades before in *Technological Forecasting and Social Change* in 2004. Along with capacity and circumstance, they argued, critical mass is key.

For a technology to become popular, the researchers wrote, everybody needs the money and motivation to adopt it. And potential users need to know that others also have the device — that's the critical mass. But when everyone uses this logic, no one ends up buying the new product. Social networking platforms and dating apps face the same hurdle when they launch, which is why the apps create incentive programs to hook those all-important initial users.

Internet access

Even in the early 2000s, when Skype made a splash with its Voice over Internet Protocol, or VoIP, enabling internet-based calls that left landlines free, people weren't as connected to the internet as they are today. In 2000, only 3 percent of U.S. adults had high-speed internet, and 34 percent had a dial-up connection, according to the Pew Research Center.

By 2019, the story had changed: Seventy-three percent of all U.S. adults had high-speed internet at home; with 63 percent coverage in rural areas. Globally, the number of internet users also increased, from about 397 million in 2000, to about 2 billion in 2010 and 3.9 billion in 2019.

But even after capacity was established, we weren't glued to our videophones as we are today, or as inventors predicted years ago. Although Skype claimed to have 300 million users in 2019, Skype was a service that people typically used on occasion, for international calls or as something that took advance planning.

One long-time barrier that the Baruch College researchers cite from an informal survey is the aversion to always being "on." Some people would have paid extra to *not* be on camera in their home, the same way people would pay extra to have their phone numbers left out of telephone books.

"Once people experienced [the 1970s] videophone, there was this realization that maybe you don't always want to be on a physical call with someone else," McGee says. Videocalling developers had predicted these challenges early

C. CHANG

on. In 1969, Julius Molnar, vice president at Bell Telephone Labs, wrote that people will be "much concerned with how they will appear on the screen of the called party."

A scene from the 1960s cartoon *The Jetsons* illustrates this concern: George Jetson answers a videophone call. When he tells his wife Jane that her friend Gloria is on the phone, Jane responds, "Gloria! Oh dear, I can't let her see me looking like this." Jane grabs her "morning mask" — for the perfect hair and face — before taking the call.

That aversion to face time is one of the factors that kept people away from videocalling.

It took the pandemic, a change in circumstance, to force our hand. "What's remarkable," McGee says, "is the way in which large sectors of U.S. society have all of a sudden been thrust into being able to use videocalls on a daily basis."

Circumstance shift

Starting in March 2020, mandatory stay-at-home orders around the world forced us to carry on an abridged form of our pre-pandemic lives, but from a distance. And one company beat the competition and rose to the top within a matter of months.

Soon after lockdown, Zoom became a verb. It was the go-to choice for all types of events. The perfect storm of capacity and circumstance led to the critical mass needed to create the Zoom boom.

Before Zoom, a handful of companies had been trying to fill the space that AT&T's videophone could not. Skype became the sixth most downloaded mobile app of the decade from 2010 to 2019. FaceTime, WhatsApp, Instagram, Facebook Messenger and Google's videochatting applications were and still are among the most popular platforms for videocalls.

Then 2020 happened.

Zoom beat its well-established competitors to quickly become a household name globally. It gained critical mass over other platforms by being easy to use.

"The fact that it's been modeled around this virtual room that you come into and out of really simplifies the connection process," says Carman Neustaedter of the School of Communication, Art and Technology at Simon Fraser University in Burnaby, Canada, where his team has researched being present on videocalls for work, home and health.

Zoom reflects our actions in real life — where we all walk into a room and everyone is just there. Casual users don't need to have an account or connect ahead of time with those we want to talk to.

Beyond design, there were likely some market factors at play as well. Zoom connected early with universities, claiming by 2016 to be at 88 percent of "the top U.S. universities." And just as K–12 schools worldwide started closing last March, Zoom offered free unlimited meeting minutes.

In December 2019, Zoom statistics put its maximum number of daily meeting participants (both paid and free) at about 10 million. In March 2020, that number had risen to 200 million, and the following month it was up to 300 million. The way Zoom counts those users is a point of contention.

But these numbers still provide some insight: If the product wasn't easy and helpful, we wouldn't have kept using it. That's not to say that Zoom is the perfect platform, Neustaedter says. It has some obvious shortcomings.

"It's almost too rigid," he says.

It doesn't allow for natural conversation; participants have to take turns talking, toggling the mute button to let others take a turn. Even with the ability to send private and direct messages to anyone in the room, the natural way we form groups and make small talk in real life is lost with Zoom.

It's also not the best for parties — it's awkward to attend a birthday party online when only one out of 30 friends can talk at a time. That's why some people have been enticed to switch to other videocalling platforms to host larger online events, like graduations.

For example, Remo, founded in 2018, uses visual virtual rooms. Everyone gets an avatar and can choose a table after seeing who else is there, to talk in smaller groups. Instead of Zoom breakout sessions where you're assigned a room and can't enter another one on your own, a platform like

Lady Bird Johnson, who was then first lady of the United States, is visible on the screen of a prototype AT&T videophone in 1964.

EVERETT COLLECTION HISTORICAL/ALAMY STOCK PHOTO

Zoom peak daily meeting participants

10
million
December 2019

200
million
March 2020

300
million
April 2020

Remo allows you to virtually see all the rooms and pick one, exit it and go to another one all without the help of a host.

The rigidity also results in Zoom fatigue, that feeling of burnout associated with overusing virtual platforms to communicate. Videocalling doesn't allow us to use direct eye contact or easily pick up nonverbal cues from body language — things we do during in-person conversations.

The psychological rewards of videocalling — the chance to be social — don't always outweigh the costs.

Jeremy Bailenson, director of the Virtual Human Interaction Lab at Stanford University, laid out four features that lead to Zoom fatigue in the Feb. 23 *Technology, Mind and Behavior*. Along with cognitive load and reduced mobility, he blames the long stretches of closeup eye gazing and the "all-day mirror." When you constantly see yourself on camera interacting with others, self-consciousness and exhaustion set in.

Bailenson has since changed his relationship with Zoom: He now hides the box that lets him view himself, and he shrinks the size of the Zoom screen to make gazing faces less imposing. Bailenson expects minor changes to the platform will help reduce the psychological heaviness we feel.

Other challenges with Zoom have revolved around security. In April 2020, the term "Zoom-bombing" arose as teleconferencing calls on the platform were hijacked by uninvited people. Companies that could afford to switch quickly moved away from Zoom and paid for services elsewhere. For everyone else who stayed on the platform, Zoom added close to 100 new privacy, safety and security features by July 2020. These changes included the addition of end-to-end encryption for all users and meeting passcodes.

Anybody's guess

In *Metropolis,* the 1927 sci-fi silent film, a master of an industrial city in the dystopian future uses four separate dials on a videophone to put a call through. Thankfully, placing a videocall is much easier than it was predicted to be. But how much will we use this far-from-perfect technology once the pandemic is over?

In the book *Productivity and the Pandemic*, released in January, behavioral economist Stuart Mills discusses why consumers might keep using videocalling. This pandemic may establish habits and preferences that will not disappear once the crisis is over, Mills, of the London School of Economics, and coauthors write. When people are forced to experiment with new behaviors, as we did with the videophone during this pandemic, the result can be permanent behavioral changes. Collaboration through videocalling may remain popular even after shutdowns lift now that we know how it works.

Events that require real-life interactions, such as funerals and some conferences, may not change much from what we were used to pre-pandemic.

For other industries, videocalling may change certain processes. For example, Reverend Annie Lawrence of New York City predicts permanent changes for parts of the wedding industry. People like the ease of getting a marriage license online, and she's been surprisingly in demand doing video weddings since the pandemic started. Before, getting booked for officiating a wedding would require notice months in advance. "Now, I've been getting calls on Friday to ask if I can officiate a wedding on Saturday," she says.

But other sectors of society may realize that videocalling isn't for them, and will leave just a few processes to be done online. Jamie Dimon, CEO of JPMorgan Chase, for example, stated in a March 1 interview with Bloomberg Markets and Finance that he thinks a large portion of his staff will permanently work in the office when that becomes possible again. Culture is hard to build on Zoom, relationships are hard to strengthen and spontaneous collaboration is difficult, he said. And there's research that backs this.

But none of these changes or reversions to our previous normal are a sure bet. We may find, just like in Wallace's satirical storyline, that videocalls are just too much stress, and the world will revert back to phone calls and face-to-face time. We may realize that even when the technology gets better, the lifting of shutdowns and return to in-person life may mean fewer people are available for videocalls.

It's hard to say which scenario is the most likely to play out in the long run. We've been terribly wrong about these things before. ■

Explore more

- Jeremy N. Bailenson. "Nonverbal overload: A theoretical argument for the causes of Zoom fatigue." *Technology, Mind and Behavior*. February 23, 2021.
- Steve Schnaars and Cliff Wymbs. "On the persistence of lackluster demand — the history of the video telephone." *Technological Forecasting and Social Change*. March 2004.

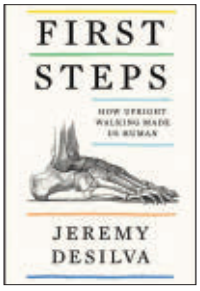
REAL-WORLD RESEARCH

At **Virginia Commonwealth University College of Engineering**, graduate students and fellows work alongside our diverse faculty on projects that will shape the future of medicine. From cellular mechanobiology to systems-level mechanics and imaging, our research is propelling ideas from the lab to the larger community.

#EngineersMakeItReal

egr.vcu.edu

VCU College of Engineering



First Steps
Jeremy DeSilva
HARPER, $27.99

BOOKSHELF

A strange stroll made a strange species

No other animal moves the way we do. That's awfully strange. Even among other two-legged species, none amble about with a straight back and a gait that, technically, is just a form of controlled falling. Our bipedalism doesn't just set us apart, paleoanthropologist Jeremy DeSilva posits; it's what makes us human.

There's no shortage of books that propose this or that feature — tool use or self-awareness, for example — as the very definition of humankind. But much of our supposed uniqueness doesn't stand up to this tradition. In *First Steps*, DeSilva takes a slightly different approach. Our way of walking, he argues, set off an array of consequences that inform our peculiar evolutionary history.

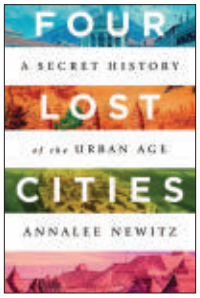
DeSilva starts his tour through the annals of bipedalism with other upright organisms. *Tyrannosaurus* and ancient crocodile relatives are trotted out to show how they moved on two legs, thanks to long, counterbalancing tails. DeSilva stumbles a little here, like arguing that "bipedalism was not a successful locomotion for many dinosaur lineages." An entire group — the theropods — walked on two legs and still do in their avian guises. But the comparison with dinosaurs is still worthwhile. With no tail, the way we walk is even stranger. "Let's face it," DeSilva writes, "humans are weird."

Each following chapter gets more surefooted as DeSilva guides readers through what we've come to know about how our ancestors came to be bipedal. This is breezy popular science at its best, interweaving anecdotes from the field and lab with scientific findings and the occasional pop culture reference. DeSilva gets extra credit for naming oft-overlooked experts who made key discoveries.

Instead of presenting a march of progress toward ever-greater bipedal perfection, DeSilva highlights how our ancestors had varied forms of upright walking, such as the somewhat knock-kneed gait of *Australopithecus sediba* (*SN: 8/10/13, p. 26*). The way we now walk, he argues, was one evolutionary pathway among many possibilities.

But walking upright opened up unique evolutionary avenues, DeSilva notes. Freed from locomotion, our arms and hands could become defter at creating and manipulating tools. Our ancestors also evolved a bowl-shaped pelvis to comfortably cradle our viscera. But this arrangement made giving birth more complicated, especially as human infants began to have larger heads that needed to pass through a narrowed birth canal created by this anatomical shift.

Such trade-offs, including how debilitating twisted ankles and broken bones can be to humans, may have required our ancestors to care for each other, DeSilva concludes. While that may be a step too far into speculation, he nevertheless makes a compelling case overall. "Our bipedal locomotion was a gateway to many of the unique traits that make us human," he writes, an evolutionary happenstance that formed the context for how we came to be. — *Riley Black*



Four Lost Cities
Annalee Newitz
W.W. NORTON & CO., $26.95

BOOKSHELF

What urbanites can learn from ancient cities

It's a familiar trope in movies and books: A bright-eyed protagonist moves to the big city where all hopes and dreams come true. But why do we cling to this cliché? In *Four Lost Cities*, author Annalee Newitz explores four ancient settlements to find out why people flock to big cities — and why they leave.

The book is divided into four snack-sized sections, one for each city. Newitz makes a special effort to highlight oddities and innovations unique to each place. Take Çatalhöyük, which thrived from 7500 to 5700 B.C. in what is now Turkey. This city persisted despite a dearth of things we might consider necessary, such as roads, dedicated public spaces and shopping areas.

Newitz also explores Pompeii (700 B.C. to A.D. 79). When paired with Çatalhöyük, the Roman city offers insights into how humans developed the distinction between public and private spaces and activities — ideas that would not have made sense before humans began living in large settled groups. Cahokia (A.D. 1050 to 1350), located in what is now Illinois, offers an unexpected reason for a city's emergence. Many people link cities with trade centers, but Cahokia suggests that spiritual revival can also build a metropolis. Cahokia and Angkor (A.D. 800 to 1431) in Cambodia show how cities can form when a few influential people concentrate power.

Each city eventually fell, and Newitz reveals that it wasn't floods or volcanoes that always spelled the end. Collapsing infrastructure often provided the final push that kept people away. Here we glimpse our potential future, as climate crises and political instability threaten our urban networks. But Newitz's bright prose and boundless enthusiasm keep the tone optimistic. These cities ended, but their citizens lived on. Even in Pompeii, many people escaped the eruption of Mount Vesuvius and went to new places and spurred new growth.

Four Lost Cities is about how cities collapse. But it's also about what makes a city succeed. It's not glamour or Wall Street. It's people, infrastructure and opportunities for residents to better their lot. "Our forebears' eroded palaces and villas warn us about how communities can go wrong," Newitz writes. "But their streets and plazas testify to all the times we built something meaningful together." — *Bethany Brookshire*

THE COOPER UNION

ALBERT NERKEN SCHOOL OF ENGINEERING

Bachelor of Engineering in Chemical, Civil, Electrical, and Mechanical; Bachelor of Science in General Engineering.

cooper.edu

Teen scientists win $1.8M at virtual Regeneron Science Talent Search 2021

REGENERON SCIENCE TALENT SEARCH
A program of SOCIETY FOR SCIENCE & THE PUBLIC
Since 1942

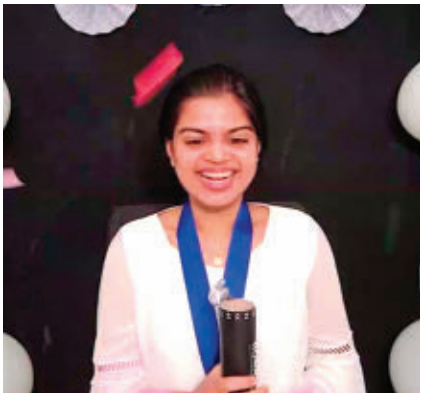
Society for Science and Regeneron announced the top winners of the Regeneron Science Talent Search, the United States' oldest and most prestigious science and math competition for high school seniors. The competition provides a national stage for future leaders in STEM, bringing together the best and brightest young minds to present their original research ideas to leading scientists.

△

Yunseo Choi, 18, of Exeter, N.H., won the top award of $250,000 for her project, which allowed her to play theoretical "matchmaker" for an infinite number of things or people.

△

Second place and $175,000 went to **Noah Getz**, 17, of New York, N.Y., for his research in which he adjusted the way computer models identify promising pharmaceutical compounds. This could make the discovery of new drugs faster and less expensive.



△

Third place and $150,000 went to **Eshani Jha**, 17, of San Jose, Calif., for her development of a biochar filtration system that removes microplastics, pharmaceuticals, pesticides and heavy metals (such as arsenic, cadmium, lead and mercury) from drinking water.

Historically held in person in Washington, D.C., the competition took place virtually for the second year in its 80-year history to keep the finalists and their families safe during the ongoing pandemic.

MARCH 13, 2021

Big mouths to feed

The oldest animal DNA yet recovered comes from a mammoth that lived over 1 million years ago, ***Erin Garcia de Jesús*** *reported in "Million-year-old mammoth DNA found"* (SN: 3/13/21, p. 6). Considering that a modern elephant can consume hundreds of kilograms of plant food per day, what could the mammoth have eaten in the frozen tundra, reader **Peter Nissenson** asked.

Researchers don't know for sure what the ancient animal may have eaten. But like other mammoths, its menu may have included flowers and grasses (*SN: 3/22/14, p. 13*). Recent studies suggest that dwindling food sources contributed to the demise of most mammoths about 10,000 years ago, **Garcia de Jesús** says. "So as the flowers disappeared, so too, perhaps, did the mammoths."

A wild escape

Escaped genes from modified cotton crops are disrupting wild cotton's interactions with insects, causing irreversible ecological effects, ***Emiliano Rodríguez Mega*** *reported in "Modified genes may harm wild cotton"* (SN: 3/13/21, p. 10).

Reader **Marc Sapir** wondered why the effects are irreversible if wild cotton plants with the escaped genes struggled more to survive than those without.

Once the genes escape, we can no longer control how they behave or where they go, **Rodríguez Mega** says. That doesn't necessarily mean the genes will devastate wild cotton populations. But there currently isn't a way for scientists to rid those populations of the genes.

The genes could disappear if they are selected against by natural forces, **Rodríguez Mega** says, but we don't know that that will happen. More studies are needed to understand the long-term effects the escaped genes could have in the wild.

What makes a plant?

A parasitic plant, Sapria himalayana, *has lost genes for stems, roots and photosynthetic tissue to live within its hosts,* ***Jake Buehler*** *reported in "A parasitic plant is missing many genes"* (SN: 3/13/21, p. 13).

Given all that *S. himalayana* has lost, "is it even still a plant?" reader **Jeff Fisher** asked. Could it be something entirely new?

Biologists group organisms based on their shared evolutionary history, so *S. himalayana* is still considered a plant, **Buehler** says. But taxonomists and other researchers have long debated at what point an organism deviates enough from its ancestral line to earn a unique taxonomic rank. There currently isn't a standard that scientists use to determine these bounds, **Buehler** says.

Researchers found that the parasite has taken a lot of DNA from its hosts, though much of it doesn't encode any genes, **Buehler** reported. Reader **D.C. Randle** questioned why the plant would bother pilfering this genetic material.

Some of the stolen DNA do encode genes. And those genes may be useful, **Buehler** says. Some are involved in the parasite's defense and stress responses, and another is instrumental in making pyrimidine, a crucial building block of nucleic acids like DNA.

Flying high

Microfliers powered by sunlight could fly in conditions like those high in Earth's atmosphere, ***Emily Conover*** *reported in "Tiny aircraft that fly by light could soar beyond airplanes' reach"* (SN: 3/13/21, p. 5).

Reader **William S. Darter** wondered how scalable these microfliers might be.

"The lift forces produced in this case are quite small, so the aircraft and its instruments have to be extremely light," **Conover** says. That makes the aircraft a challenge to scale up. "One idea would be to create arrays of microfliers connected by thin carbon fibers. That would allow the microfliers to carry more massive payloads, though still only in the range of grams."

Correction

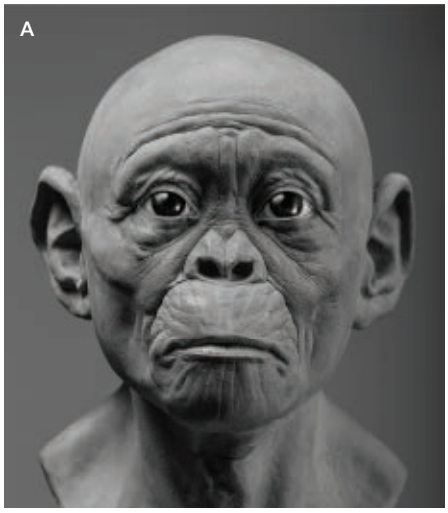
"Two new books search for the meaning of life" (*SN: 3/27/21, p. 28*) incorrectly stated that a person's metabolism increases to about 0.5 times its resting rate after eating. Metabolism increases to about 1.5 times the resting rate.

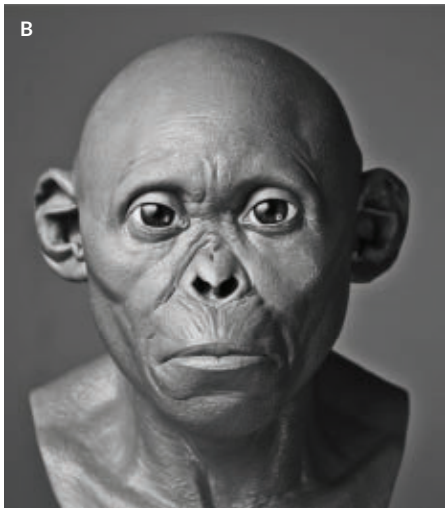
Join the conversation

E-MAIL feedback@sciencenews.org

MAIL Attn: Feedback
1719 N St., NW
Washington, DC 20036

Connect with us





Ousting bias in hominid depictions

Portrayals of extinct hominids are often more art than science. Consider two reconstructions of the Taung child, a 2.8-million-year-old *Australopithecus africanus*, based on a scan of the skull (below). One version (A, above), made using a sculptor's intuition, appears more apelike. A second version (B and C), made while working alongside a scientist, appears more humanlike.

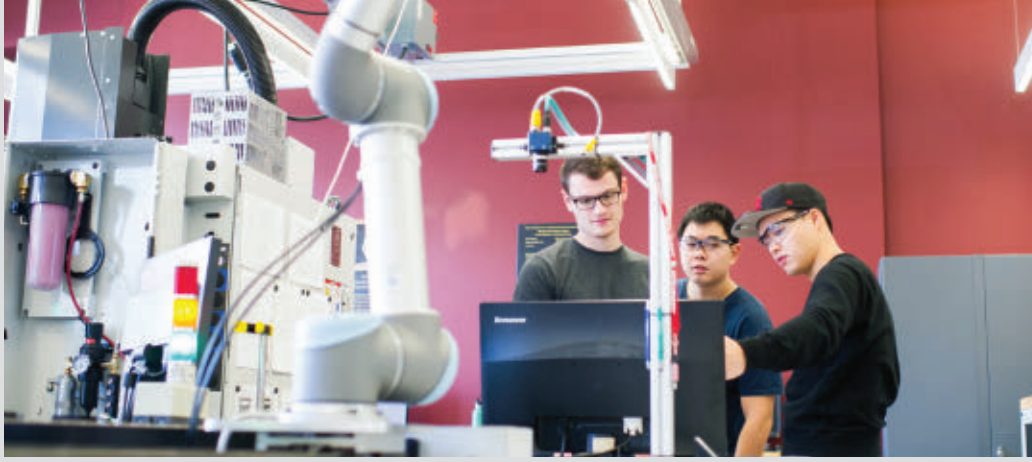
Now, the researchers who produced these dueling views are trying to remove some of this subjectivity. They have created reference databases (visibleapeproject.com) to help create more accurate, reproducible portraits of species. The team points out some flaws in facial reconstructions of ancient hominids — and the social and ethical implications of misleading portraits — February 26 in *Frontiers in Ecology and Evolution*.

Getting depictions right matters, says Rui Diogo, a biological anthropologist at Howard University in Washington, D.C. When museumgoers see renditions of extinct hominids, visitors may not realize how much bias creeps into the work, he says, and that can skew people's views and reinforce prejudices of present-day people. For instance, reconstructions in the Smithsonian National Museum of Natural History in Washington, D.C., portray — without evidence — skin getting lighter as hominids became more bipedal. Such a depiction, Diogo says, might give the mistaken impression that people with lighter skin are more evolved.

Depictions can also give erroneous views of extinct species' intelligence and behavior, says Ryan Campbell, an anthropologist at the University of Adelaide in Australia. "It's as if there is a bias toward portraying our ancestors as if they were stupid and didn't have hygiene." Neandertals are often shown with matted, dirty hair, but there is no reason to think they were any different from the many animals that groom themselves.

"The reconstructions of the past, most of them did not have a scientific basis," Diogo says. "Our goal is to change the methods and to change the biases" to give a more accurate view of human evolution. — *Tina Hesman Saey*

ALL: G. VINAS, R. CAMPBELL, M. HENNEBERG, R. DIOGO



bu.edu/admissions

Take the next step to learn why Boston University is ranked #42 among Best Colleges by *U.S. News & World Report.*

BOSTON UNIVERSITY

An equal opportunity, affirmative action institution

AT BOSTON UNIVERSITY, YOUR BRAIN IS AT ITS BEST. WHY?

- **Join the best:** BU is ranked #21 in the U.S. and #3 in Massachusetts for "Best Universities for Excellence, Equity, and Employability."
- **Learn from the best:** Thanks to our student-to-faculty ratio of just 10:1 and 300+ programs of study.
- **Intern at the best:** Like BU's own premier medical facilities, GE, Massachusetts General Hospital, Pfizer, and more.
- **Graduate among the best:** Employers recognize the value of a BU degree. BU is ranked #14 among US Universities for the employability of its graduates.

DECATUR, ILLINOIS

MILLIKIN UNIVERSITY®

39.8431° N, 88.9748° W

STEM

SCIENCE • TECHNOLOGY • ENGINEERING • MATH

BIOLOGY • CHEMISTRY • COMPUTER SCIENCE • ENGINEERING
HEALTH SCIENCE • MATHEMATICS • PHYSICS

Make it Science. Make it Technology.
Make it Engineering. Make it Mathematics.

Make it Millikin.

Learn about Millikin's integrative STEM programs, outstanding facilities and competitive intercollegiate robotics team, Blue Bots.

millikin.edu/stem