ScienceNews

IRRESISTIBLE

Ultraprocessed foods act like addictive substances, and today's temptation could lead to chronic illness

SCIENCENEWS.ORG

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NOVEMBER 2025

Thermo Fisher Scientific
Junior Innovators Challenge
A program of Society for Science

CONGRATULATIONS to the 2025 Finalists!

Thermo Fisher Scientific and Society for Science salute the amazing young scientists and engineers selected from nearly 2,000 entrants as finalists in the Thermo Fisher Scientific Junior Innovators Challenge.

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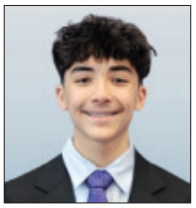

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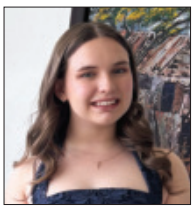

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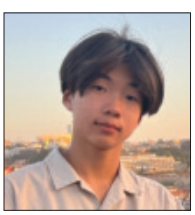

Lucas Shengwen Yen
Santa Clara, California

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The Thermo Fisher Scientific Junior Innovators Challenge, a program of Society for Science, is the nation's premier science and engineering research competition in the United States, created to inspire sixth, seventh and eighth grade students to pursue their personal passion for STEM subjects into high school and beyond.

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AMY OSBORNE/AFP/GETTY IMAGES


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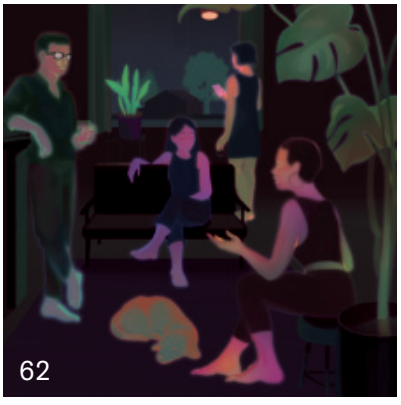

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FROM TOP: OSH EDELSON/AFP/GETTY IMAGES; CORNELIA LI

Big questions on how food affects our health

Food is complicated. We eat to stay alive, we eat for pleasure, we eat to stay healthy or get healthier. And increasingly, we eat because the food is telling us to eat more. Consider the gummy worm. Though eating replicas of underground invertebrates may not sound alluring, evidently it is: Americans spent more than 5 billion dollars on gummy worms in 2024. That led us to choose the chemical-laden confection as the cover "model" for this issue of *Science News*, which delves into the science behind big questions on food and health.

First stop, ultraprocessed foods. Gummy worms and other highly processed salty, fatty or sugary foods have come to dominate the American food supply, accounting for more than half of the calories that people consume at home. They are engineered to ping the brain's reward system, inducing us to crave them, senior neuroscience writer Laura Sanders reports (Page 42). Researchers in the fields of nutrition, obesity and addiction have built the case as to why these foods are so perilous, and efforts to protect people's health are underway in other countries. Emulating them in the United States would require actions from the federal government such as stronger regulations or improved labeling. The Trump administration has flagged the health risks of ultraprocessed foods but so far has not made major changes.

We also examine the current craze for consuming more protein, with big scoops of protein being added to seemingly everything—even Starbucks coffee. But most Americans already eat more protein than they need, social sciences writer Sujata Gupta reports (Page 48). What matters more for our bodies is the quality of the protein, researchers say, especially for older people. Getting that quality can be as simple as eating beans and rice together.

And no compendium of food trends would be complete without checking in on the keto diet. First devised in the 1920s to treat epilepsy, this super-high-fat regimen is fiercely defended by people who say it is healthier than eating more varied fare. And while starting a keto diet can help people lose weight, senior writer Meghan Rosen reports on a new study in mice that suggests a downside (Page 30). Adhering to a keto diet long-term could increase the risk of metabolic problems, liver disease and cardiovascular disease.

Nancy E. Shute

Nancy Shute
Editor in Chief
nshute@sciencenews.org

The Story of the Barber With the Razor-Sharp Wit

★★★★

"It's a bold, substantial piece that has become part of my daily ritual."

—Ross R.
Bloomington, IN

A.

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From sports stars to red carpets, we found the most famous men's necklace

The Figaro necklace has been the go-to style for men—especially sports stars—for decades, prized for its bold links and unmistakable pattern. Its alternating short and elongated links create **a sleek, masculine look** that's as at home courtside as it is at a black-tie event. But the style's name has an intriguing origin: it's inspired by Figaro, the quick-witted, charming barber from 18th-century French plays and Mozart's famous opera *The Marriage of Figaro*. His razor may be sharp, but his mind is sharper. Figaro is celebrated for his wit, resourcefulness, and flair for getting into—and out of—trouble. Sounds a little like you? I certainly can relate.

Figaro was clever, stylish, and always in the center of the action—qualities reflected in the necklace that bears his name. Figaro represents the timeless archetype: the witty rogue whose brilliance is matched only by his undeniable charisma. For men who want to project strength, sophistication, and a touch of swagger, the Figaro remains unmatched. Whether paired with a T-shirt or a tailored suit, it's a statement of confidence that's been winning fans for generations. Now you can have a Figaro for everyday use that is **super strong in 18K gold-clad** stainless steel, or if you just signed your own free agent contract, the solid 14K gold version is at a great price too.

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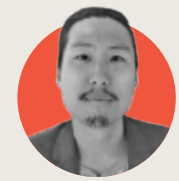
LAURA SANDERS

SENIOR NEUROSCIENCE WRITER

● GUMMY BEARS. Potato chips. Chocolate chip cookies. It can be hard to stop eating these treats once you start. But are they actually addictive? Laura Sanders explores the question in this issue's cover story (Page 42). And she explains how these products — some of which maybe shouldn't be considered "food" at all — worm their way into our brains. The big picture is, of course, more complex than neuroscience alone. "Our behaviors around food are influenced by all sorts of other things: memories, family, context, culture," she says. As an example, her mother's family ran an ice cream factory in Blue Earth, Minn., and Sanders remembers eating lots of vanilla ice cream floats with strawberry soda. That history feeds into her warm feelings toward the cold treat. She says, "Ice cream is the one treat I won't apologize for."

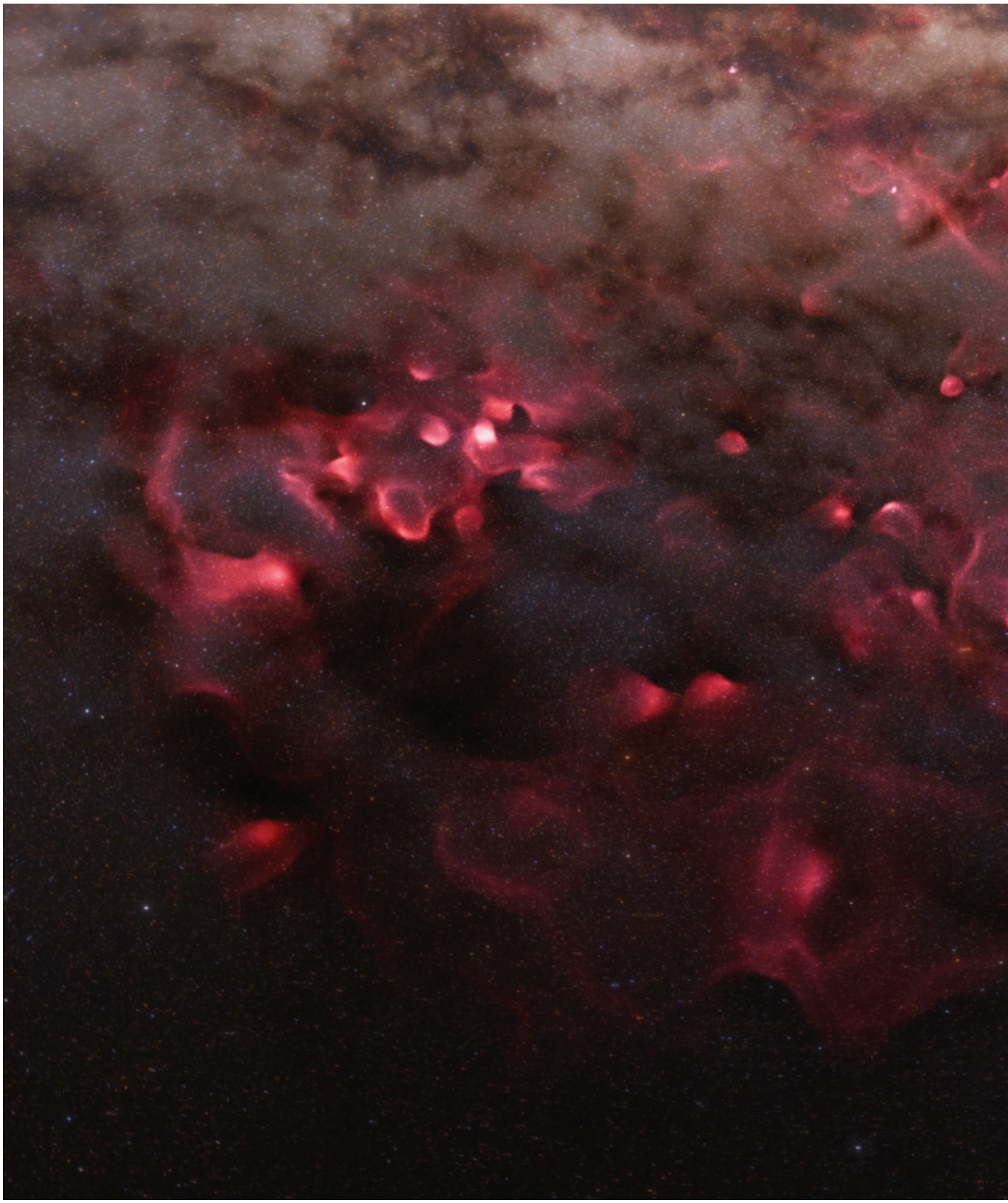


Chang Won Chang
Science News has an ace team of designers who use their artistic and journalistic talents to help readers easily grasp complex scientific concepts. One of those designers is Chang Won Chang, who worked on this issue's feature article about how much protein people need (Page 48). "This story is very numbers driven, so it made sense to include more infographics than actual images," says the art director. "We try to bring content alive with visuals, so that we can inform our readers and encourage them to come back for more," he says.

Aimee Cunningham
Some readers might be amazed to learn that catching a common cold may help prevent a COVID-19 infection (Page 24). But that finding didn't come as a total surprise to biomedical writer Aimee Cunningham. "There is a whole area of research on how one viral infection can boost or reduce a second infection by a different respiratory virus," she says. As she reports, the body's immune system gets revved up by a cold, dampening a coronavirus infection. But with the coronavirus and influenza virus, "there's evidence that a co-infection with those two may mean an amped-up inflammatory response in the lungs," making things worse, she says.

Dwight Eschliman
What do you do when you're a photographer tasked with conveying the allure of a gummy worm? Dwight Eschliman gave the chewy snack the glamour treatment for this issue's cover, then called on his cabinet of food ingredients, including those used to make gummy worms, to reveal what's in the sweet treats (Page 42). It's not a pretty picture. The first time Eschliman photographed the ingredients of an ultraprocessed food item was with a Twinkie. "It came as a shock to me that it included 37 or so ingredients," says Eschliman, who seeks to capture both emotion and information in his food photography. "So I decided to photograph them all."

CLOCKWISE FROM TOP LEFT: SOCIETY FOR SCIENCE (FIRST THREE); D. ESCHLIMAN



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ASTRONOMY

STELLAR NURSERIES SURROUND THE SUN

By McKenzie Prillaman

● **A new simulation provides** the most detailed chart yet of nearby stellar nurseries, predicting where gas in and around star-forming clouds within about 4,000 light-years of the sun should glow (left, seen in red).

Using a map of interstellar dust from the Gaia telescope to infer hydrogen density, astrophysicist Lewis McCallum and colleagues converted the dust map into one showing hydrogen. They then added the ionizing effects of 87 ultrahot stars — a type found only in star-forming regions. The team's simulations show where stripped electrons recombine with hydrogen and emit a specific wavelength of light.

"We live inside this sea of turbulent gas," says McCallum, who did this work while at the University of St. Andrews in Scotland. Identifying how that gas gets energized is key to understanding star birth. The illustration below shows the region's location (circled) in the Milky Way.

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News

TECHNOLOGY

FRILLY BUG FEET INSPIRE WATER-STRIDING ROBOT

● A water strider called a ripple bug (*Rhagovelia*) has frilly, fanned feet that unfurl when they touch water and close when lifted. That motion is automatic, resulting from capillary forces rather than muscles, researchers report in *Science*. Inspired by that bit of insect physics, the team made a water-striding robot with fanned feet. This image shows the robot foot fully spread out (large droplet), partially spread (smaller droplet) and fully collapsed (no droplet). Such robots could one day monitor streams or search flood zones. —*Emily Conover*

AJOU UNIV.

PLANETARY SCIENCE

Arizona rock could aid search for life on Mars

By McKenzie Prillaman

● **Vibrant red sandstone** surrounded Nicholas Heinz as he hiked in Sedona, Ariz., in January 2024. But an odd rock, smaller than the palm of his hand, caught his eye. The gray basalt peppered with rust-colored dots clearly didn't belong.

"The rock itself is not particularly unique," says Heinz, a materials scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. "I picked it up that day because it was very out of place for the region." The rock could've come from a nearby ancient volcano and been dropped by a fellow hiker, he says.

Heinz admired the tiny specks trapped in the weathered basalt, so he stuck the stone in his backpack to take home. Six months later, he learned that this rock could serve as the perfect stand-in for an intriguing one found on Mars — one that possibly hints at ancient life.

In July 2024, NASA's Perseverance rover encountered a reddish rock sprinkled with dark flecks dubbed "poppy seeds" and millimeter-sized, off-white splotches ringed in black called "leopard spots." Instruments on the rover revealed the Martian rock — named Cheyava Falls, after a Grand Canyon waterfall — contains organic compounds, carbon-based compounds that are building blocks of life. Additionally, the leopard spots' black rims, which have iron phosphate, resemble the chemistry and texture of features on earthly rocks associated with microbes, researchers later reported in *Nature*.

Perseverance bagged a sample of the peculiar rock. NASA had planned for some future mission to pick samples up and bring them to Earth, but those plans are jeopardized due to funding cuts.

Meanwhile, Heinz had been testing a new rock characterization technique called optical photothermal infrared spectroscopy, or O-PTIR, and planned to try it on the basalt he had picked up. He realized this terrestrial rock contained bits of trapped material similarly sized and spaced as those on Cheyava Falls.

"When all these things sort of lined up, I said, 'Well, this is a really great example of what the technique can do for this very specific Mars sample upon its return to Earth,'" he says. Heinz and colleagues published their test of O-PTIR with the terrestrial rock in *Review of Scientific Instruments*.

O-PTIR uses two lasers to reveal a rock's composition. One laser's infrared light heats up an area roughly 15 micrometers wide on the sample,

↖ **Materials scientist Nicholas Heinz picked up this piece of basalt on a hike in Arizona. It ended up resembling an intriguing rock found on Mars.**

N. HEINZ

causing the molecules to vibrate. Shining a visible-light laser there can uncover details about the materials based on how the light scatters when bouncing off the molecules.

It's "like a mirage on a hot day, where you see the air just above the road that starts bending light and makes things look kind of wavy," Heinz says. "That change in the visible light gives you all the chemical information that traditional infrared techniques give."

Traditional techniques lack the fine-scale spatial resolution of O-PTIR, which is important because of the low concentration of organic compounds expected in alien rocks, Heinz says.

He and his colleagues tested O-PTIR on three locations within a rust-colored inclusion on the terrestrial rock and one location on the rock's main gray body. It showed the inclusion probably contains olivine minerals with iron and magnesium. In the gray part of the rock, O-PTIR detected a protein-rich organic material with different types of stretched chemical bonds.

If applied to the Cheyava Falls sample, such information about chemical bonds could reveal more about the rock's minerals, organics and their histories, says geobiologist Mike Tice of Texas A&M University in College Station, who was not involved in the new study. That could help uncover whether the leopard spots are truly a sign of life.

Testing more samples or rock types could strengthen the work, says planetary geologist Brian Hynek of the University of Colorado Boulder, who was also not involved. Still, O-PTIR adds to the ways to study rocks that may contain organics of biological origin, he says. "It opens up a whole new world of analyses." ✖

ANIMALS

WARM AUTUMNS COULD DRIVE MONARCH DECLINE

BY JUDE COLEMAN

Toastier fall weather might cause migrating monarch butterflies to wing it and change their flight plans, starting the countdown toward death.

Eastern monarchs captured during their autumn migration and exposed to warm temperatures in the lab came out of their usual reproductive hiatus, evolutionary biologist Ken Fedorka and colleagues report in *Royal Society Open Science*. Breaking that hiatus means the butterflies will probably die sooner than they normally would. "Once you decide to go reproductive, your clock starts ticking," says Fedorka, of the University of Central Florida in Orlando.

In North America, the last generation of monarch butterflies (*Danaus plexippus*) of the year are born in reproductive diapause. They fly up to thousands of kilometers south to overwintering sites. Come spring, the monarchs begin reproducing and briefly fly north before dying, with subsequent generations continuing the journey north.

Since the 1990s, monarch populations have dropped, particularly at overwintering sites. Researchers think higher temperatures caused by climate change CONT. ON PAGE 14

Eastern monarch butterflies fly thousands of kilometers to overwintering sites. ↓

AMY OSBORNE/AFP/GETTY IMAGES

CONT. FROM PAGE 13 could be detrimental. But until now, no studies have specifically looked at temperature's impact on diapause.

Fedorka and colleagues placed nearly 500 wild butterflies in mesh cages within a temperature- and light-controlled incubator. The team exposed the butterflies to the higher and lower ends of typical temperature ranges along their migration path. After 26 days, the surviving butterflies were randomly assigned to warmer or cooler overwintering conditions and monitored again.

Many of the monarchs exposed to higher temperatures began breeding in the migration phase. "These monarchs are ready to drop out of migration on a moment's notice," Fedorka says. Warm monarchs of both sexes had a 28 percent higher risk of death. Further research is needed to see how the results apply in the wild.

Insect ecologist Sonia Altizer of the University of Georgia in Athens notes that the butterflies' propensity for abandoning their migration means they could one day swap their migratory lifestyles for partial ones. That would be a great loss.

"It's an incredibly beautiful ... phenomenon," Altizer says. "If we lose these migratory populations, we can't just bring them back." ✖

28 percent

Higher risk of monarch death associated with migrating in warmer temperatures

NILS JACOBI/GETTY IMAGES

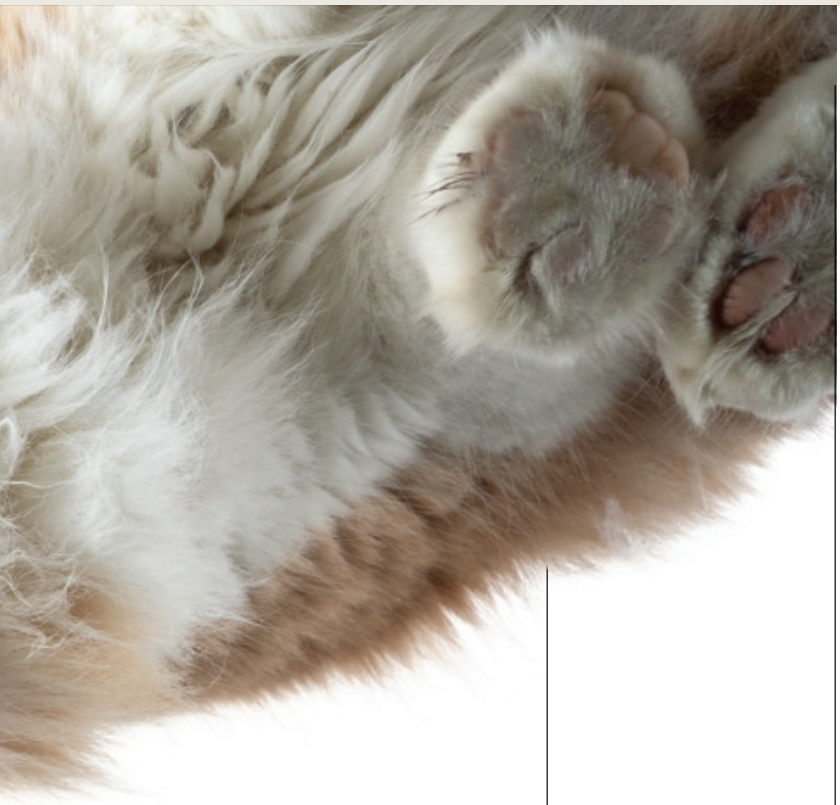
HEALTH & MEDICINE

Elderly cats with dementia offer clues to Alzheimer's

By Claudia López Lloreda

● **As cats age,** they may yowl more than usual at night, have trouble sleeping or sleep too much, and act generally confused or disoriented. A new study shows that, just like in humans with Alzheimer's disease, amyloid-beta plaques build up in the brains of aging felines and may contribute to dementia-like behaviors.

In cats, that buildup could be causing a cascade of problems within the brain, such as hyperactivation of immune and other



brain cells that attack the synapses that connect nerve cells, researchers report in the *European Journal of Neuroscience*. Aged cats with and without dementia had similar features and only a small number of cats were studied. But these findings could start helping researchers better understand how cats age and potentially develop treatments for feline dementia, as well as provide new insights into how the disease progresses in humans.

Earlier studies had found amyloid-beta in the brains of cats, but scientists didn't know to what extent it disrupted brain function.

↖ **Aged cat brains have features of Alzheimer's disease, including hyperactive cells that eat up important connections between brain cells.**

Robert McGeachan, a veterinarian at the University of Edinburgh, knew that the number of synapses decreased early in Alzheimer's disease in humans. So he and his team decided to focus on these connections in their cat study. They looked at the postmortem brains of seven young cats and 18 older ones, including eight with behavioral signs of dementia.

Using fluorescent markers that find and cling to amyloid-beta, the team found that the brains of aged cats, with or without dementia, had more of the protein than the younger brain samples. The amyloid-beta plaques in the older cats also tended to accumulate right around synapses.

In all the aged cats, immune cells called microglia, which regulate inflammation, and astrocytes, which help maintain the brain's natural environment, were hyperactive. These cells also looked like they were lurking near the amyloid-beta clumps, a sign that they were dispatched to the area to tackle the proteins. But instead of attacking only the clumps, the microglia and astrocytes also seemed to be attacking some synapses.

The results mimic what is seen in human brains with Alzheimer's, says Roberta Marongiu, a neuroscientist at Weill Cornell Medicine in New York City who was not involved with the study. Microglia and astrocytes also swarm around amyloid plaques and wreak havoc on neurons and their connections in humans with Alzheimer's.

The similarities mean that cats could make a good mimic of human Alzheimer's, she says. Current ways of studying Alzheimer's include using mice, which have to be genetically modified to develop Alzheimer's. Contrary to these engineered animals, aging cats develop dementia spontaneously. "It's exciting to have a naturally occurring model," Marongiu says.

McGeachan hopes that studying more brains — as the team is currently doing — might reveal patterns between cats with and without dementia. The team also wants to look at other hallmarks associated with Alzheimer's, such as accumulation of the tau protein, to see how they show up in cat brains.

While cats are unlikely to replace mice as model animals for Alzheimer's — cats are more expensive, for one — our feline friends could also benefit from more research, McGeachan says. "We can improve health for humans and for animals." ✖

HEALTH & MEDICINE

MARIJUANA MAY AFFECT WOMEN'S FERTILITY

By Sofia Caetano Avritzer

● Chemicals in cannabis may push eggs to become ready for fertilization. But this may come at a cost: more eggs with the wrong number of chromosomes, women's health researcher Cyntia Duval and colleagues report in *Nature Communications*.

Delta-9-tetrahydrocannabinol, or THC, is the main psychoactive chemical in marijuana. It binds to cannabinoid receptors in the brain.

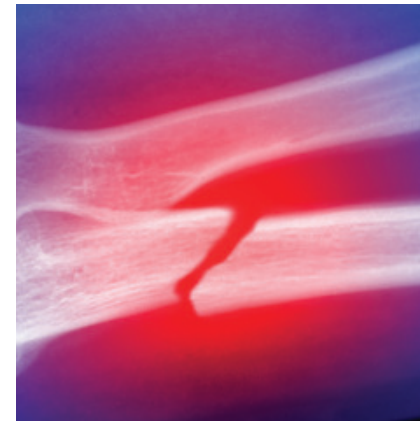
But these receptors are also in our reproductive organs. The receptors usually bind endocannabinoids, molecules naturally produced by the body and essential for functions like producing eggs and sperm. Consuming THC can affect cannabinoid receptors in the reproductive system. Many studies report that using cannabis decreases sperm count and motility.

But the effect on eggs has been hard to determine. One of the few ways to study eggs is during in vitro fertilization, or IVF, in which women receive hormones that make multiple eggs mature at once, which are then collected to create embryos.

Duval, who works at CReATe Fertility Centre, an IVF clinic in Toronto, analyzed eggs and fluid collected from 1,059 women who had IVF in the clinic. She found THC in the fluid from 62 of the women. Women with higher THC levels around their eggs had larger numbers of mature eggs.

Artificially matured eggs exposed to THC were more likely to have the wrong number of chromosomes, which could lead to failure to form embryos, unsuccessful uterine implantation and nonviable pregnancies, Duval found.

Only a much larger study could say if this decreases women's chances of conceiving, Duval says. But the results hint at THC's effect on female fertility. ✖



PETER DAZELEY/THE IMAGE BANK/GETTY IMAGES PLUS

HEALTH & MEDICINE

Hormone therapy may raise fracture risk

By Sofia Caetano Avritzer

● **Women who have stopped** menopausal hormone therapy might be at a higher risk of bone fractures compared with those who never took these medications.

A review of women's health records revealed an association between an initial rise in fracture risk and women who had used the medication for less than 5 years, researchers report in the *Lancet Healthy Longevity*. This suggests it could be important to track some women's bone health in the years after they stop hormone therapy.

Hormone therapies are approved by the U.S. Food and Drug Administration as a preventive treatment for bone weakening during menopause. A 2022 statement from the North American Menopause Society (now known as the Menopause Society) recommends their use to prevent fractures in women up to 60 years old or who are within 10 years of menopause, as long as there are no contraindications like a history of breast cancer.

But the new findings suggest that these treatments might also come with some risk to women's bones once they stop taking the drugs.

Around 1 in 4 U.S. CONT. ON PAGE 18

↑ Stopping menopausal hormone therapy could increase some women's risk of bone fractures.

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CONT. FROM PAGE 16 women 65 and over are diagnosed with osteoporosis, a loss of bone density that makes bones weak and more likely to break. It is especially common after menopause, when estrogen production declines. Estrogen is "in skin, it's in our brain, it's in our bones," says Yana Vinogradova, a medical statistician at the University of Nottingham in England. Its loss causes brittle bones, difficulty sleeping and other symptoms. "The whole body is affected," she says.

Menopausal hormone therapy, or MHT, which delivers estrogen and other hormones through methods like pills or patches, can be used to ease symptoms such as hot flashes and night sweats in the early years of menopause — and it can also reduce fracture risk. But most women who start the therapy don't take the hormones the rest of their lives, says JoAnn Manson, an endocrinologist at Brigham and Women's Hospital in Boston.

That's because in the early 2000s, a clinical trial showed that hormone pills containing estrogen and progestin could raise the risk of breast cancer, blood clots, stroke and heart disease. This led many physicians to discontinue MHT in women over 60 who have also gone through most of the menopause symptoms, Manson says. The prevention of bone density loss goes away when women stop taking these medications, she notes.

How this decreased bone density affects the risk of breaks has been less clear. A follow-up of that clinical trial showed no change in the fracture risk of women who stopped MHT. But some observational studies have found that the risk does go up, says Stephanie Faubion, an internist at Mayo Clinic in Rochester, Minn., and medical director of the Menopause Society.

"The problem," Vinogradova says, "is that it always depends on how many people you have." Large studies show what happens on average, so she and her colleagues analyzed the medical records of more than 3 million U.K. women 40 and over who were registered with a primary care doctor from 1998 to 2023.

The team found that women who had stopped estrogen–progestogen therapies between one and 10 years of starting had an increased fracture risk. If you followed 10,000 women age 40 and older for a year, there would be about 156 fractures in women who had taken the drugs for less than five years — 14 more than nonusers.

It is very important to watch out for this initial increased risk, Faubion says. "Do we need to use another drug ... to help them not lose bone during that time?"

The risk was lower for women who used MHTs for five or more years, with only five additional fractures over the baseline. This longer treatment also provided lasting benefits: More than a decade after stopping, these women had 13 fewer fractures compared with nonusers.

Deciding whether to start or continue hormone therapy is complex, Manson says. A woman at high risk of osteoporosis but low risk of cancer and stroke might be a good candidate for long-term use, but not if she had high cancer or stroke risk.

"It has to be a personalized decision based on the individual woman's benefits and risks," she says. Clinical trials, rather than less-controlled observational studies like this one, are needed to confirm whether stopping MHT truly increases fracture risk, she adds.

Faubion has already sent the new study to her menopause women's health group. "I do think it will in some ways change practice." ✖

"It has to be a personalized decision based on the individual woman's benefits and risks."

— JoAnn Manson

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B.

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NEUROSCIENCE

YOUR RED IS MY RED, AT LEAST TO OUR BRAINS

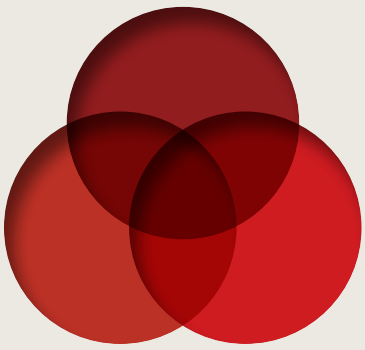
By Laura Sanders

● It's a late-night debate in college dorms worldwide: Is my red the same as your red? Neuroscientists weigh in on this classic puzzler in the *Journal of Neuroscience*. Their answer is a resounding maybe.

There were two possibilities for how brains perceive color, says Andreas Bartels of the University of Tübingen and the Max Planck Institute for Biological Cybernetics in Germany. Perhaps everyone's brain is unique. Or it could be that seeing red kicks off a standard, predictable pattern of brain activity.

The answer is overwhelmingly the second option, the new study suggests. "There are commonalities across brains," Bartels says. His team monitored the activity of nerve cells spread across visual brain areas as 15 people saw shades of reds, greens and yellows. The team then used those benchmarks to predict what color a person was looking at, based solely on the individual's pattern of brain activity.

The results show that neural reactions to colors are somewhat standard and don't vary much from person to person. But these neuroanatomical findings can't answer the question of how it *feels* to see red, Bartels says. How brain activity creates subjective inner experiences is a bigger and thornier question. ✖



LIFE

MUTATIONS MAY HAVE HELPED HORSES BECOME RIDEABLE

BY JAKE BUEHLER

Two key gene variants may have made early domesticated horses more tame and more physically resilient to bearing a rider, researchers report in *Science*. The resulting horses were among the most significant advances in Bronze Age biotechnology.

Ancient horse DNA suggests modern domesticated horses originated in southwestern Russia more than 4,200 years ago, molecular archaeologist Ludovic Orlando and his colleagues reported in 2021. While this revealed the where and when for the domestication of horses, says Orlando, of the Centre for Anthropobiology and Genomics of Toulouse in France, there were still unanswered questions about precisely which horse genes changed in those early populations.

Orlando and a team of scientists from China and Switzerland analyzed the genomes — the full set of genetic instructions — of 71 horses from a range of breeds and time periods. The researchers focused on 266 places in the horse genomes to track the history of these genes from the early domestication process onward. Of these, nine genes showed strong signatures of selection, meaning the traits they produced in the horses may have been targeted by human breeders.

Two of these genes were particularly interesting because they showed heavy selection very early on in horse domestication. One gene, *ZFPM1*, influences anxiety levels in mice and overall well-being in humans. *ZFPM1* underwent strong selection some 5,000 years ago, suggesting that one of the first steps in horse domestication involved making the animals tamer.

Another location in the genome, near a gene called *GSDMC*, experienced strong selection a bit later, between about 4,700 and 4,200 years ago. Mutations at this spot in humans are associated with chronic back conditions and pain. In horses, they are linked with body shape. The team ran experiments on mice genetically modified to have *GSDMC* inactivated and found the mice had straighter spines and stronger forelimbs.

Orlando and his colleagues think changes to *GSDMC* would have altered how horses move and bear weight, possibly

C. CHANG

making them more suitable steeds. Over just a few hundred years, a variant of this gene exploded in frequency and went from barely detectable to present in almost all horses.

"That means people intended to put that variant more frequently in the population," Orlando says. Horses with the mutation had an estimated 20 percent more offspring than those without. "When you see something like that, you know you're onto something that was really a game changer for horse biology."

Rideable horses were also a pivotal shift for human societies, setting the stage for far greater mobility and changing the face of war and transportation.

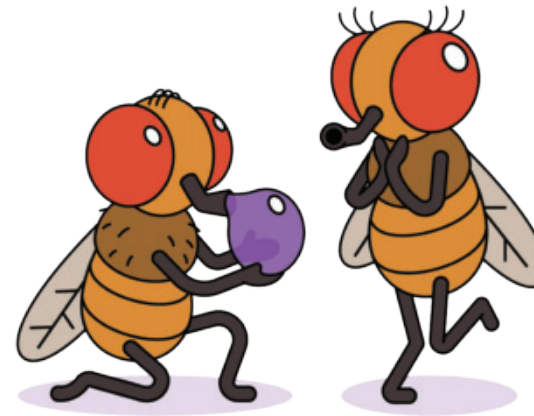
The findings are "a really resounding case of circumstantial evidence," says Samantha Brooks, a geneticist at the University of Florida in Gainesville. "We know from our archeological record that we can begin to see the types of changes that indicate these horses were used during domestication, and then we can simultaneously see these strong shifts in the genome itself at two very specific locations."

While *GSDMC* appears important to the rise of horse riding, Orlando notes there may be other genes that were missed in their analysis or crucial cultural innovations — such as tactics for interacting with horses — that didn't leave their footprints in the genome.

Orlando is interested in how particular genetic traits in horses may have fed into the success and development of horse-fueled steppe empires in Mongolia and China.

"We are sequencing a lot of those [ancient] horses to understand what kind of horses those societies and states developed to make the societies we read about in history." ✖

EMILE HOLMEWOOD



↗ Some male flies use "romantic" barf to attract mates.

ANIMALS

A single protein makes love-sick flies spill their guts

By Sofia Caetano Avritzer

● **Vomiting up a droplet of sugar** might not seem like the most romantic gesture from a potential suitor. But for one fly species, males that spill their guts can be quite a catch.

Drosophila subobscura flies might have evolved their peculiar "romantic" barfing by repurposing brain cells that usually control digestion, researchers report in *Science*.

Most male fruit flies court by following females around and vibrating their wings to serenade them with a species-specific love song, says Adriane Otopalik. But some fly species, like *D. subobscura*, spice things up a little. The males will vomit a bit of their last meal and offer it to females they are interested in, says Otopalik, a neuroscientist at Howard Hughes Medical Institute's Janelia Research Campus in Ashburn, Va.

Nuptial gifts like these are common in some animals. Male spiders use trinkets to win over their potential mates without getting eaten. Scientists think female flies, who can be "very choosy," might use romantic barf to pick suitable suitors, says Otopalik, who was not involved in the study.

The thousands of neurons that control most CONT. ON PAGE 22

CONT. FROM PAGE 21 of male fruit flies' courtship produce a male-specific version of a protein called fruitless. Daisuke Yamamoto, an evolutionary biologist at National Institute of Information and Communications Technology in Kobe, Japan, and his collaborators wondered if these courtship brain cells contained the key to understanding how nuptial gift-giving evolved.

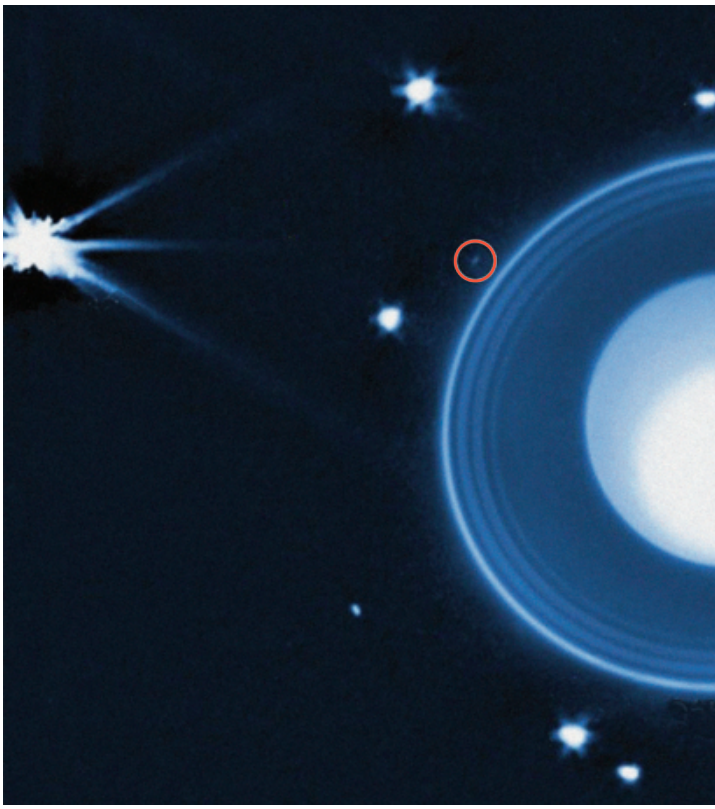
The team found that a group of 16 to 18 digestion-controlling neurons in the *D. subobscura* brain had the male version of the fruitless protein. Activating just that small number of brain cells triggered males to spill their guts, making them more successful at mating.

These same neurons in the related species *Drosophila melanogaster* don't produce the male-specific fruitless protein. *D. melanogaster*'s digestion neurons are not connected to the courtship neurons. But when the researchers made those brain cells in *D. melanogaster* produce the male-specific fruitless protein, male flies vomited as they pursued females. This also made these cells larger, growing toward and possibly connecting to the courtship neurons in this species.

In *D. melanogaster*, the digestion neurons are involved in bubbling, a behavior where overstuffed flies vomit some of their stomach contents, Yamamoto says.

"These [digestion] neurons actually directly control the motor system," projecting into the flies' gut and mouthparts, Yamamoto says. So nuptial gift-giving probably evolved by borrowing preexisting vomit circuitry and repurposing it into the courtship system.

The brain cells probably got connected by accident, he says. But the connection was fruitful, and barfing became quite the seduction tactic. ✖



NASA, ESA, CSA, STScI, M. El Moutamid/SwRI, M. Hedman/Univ. of Idaho

PLANETARY SCIENCE

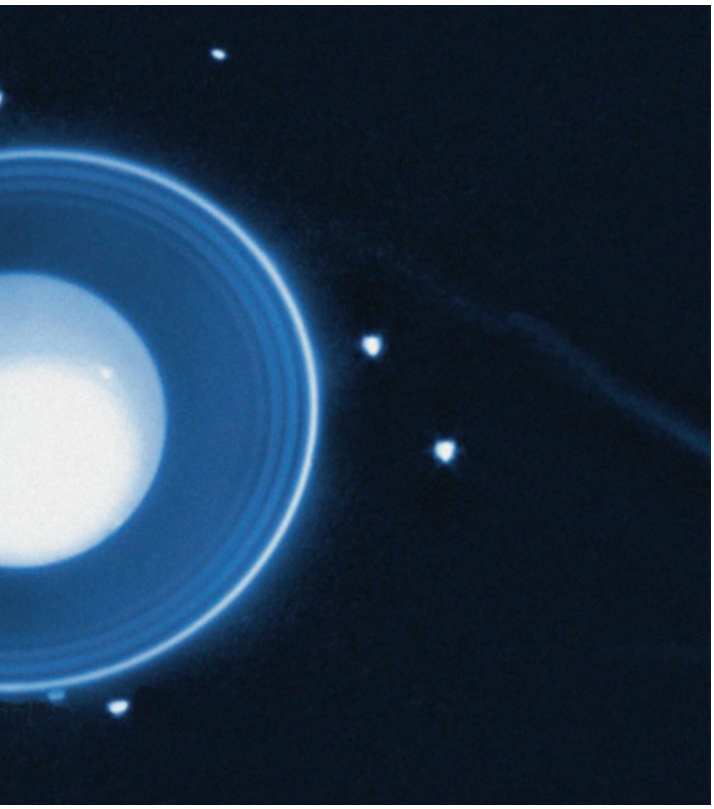
Webb spotted a new moon orbiting Uranus

By McKenzie Prillaman

● **Uranus hosts yet another moon**, which looks like a tiny, faint smudge in images captured by the James Webb Space Telescope, NASA reports. The newfound object marks the 29th observed lunar companion for the sideways-tilted ice giant.

"Uranus is a very strange planet," says planetary scientist Maryame El Moutamid of the Southwest Research Institute in Boulder, Colo. Most of its rings are narrow, just a few kilometers wide, hinting that moons orbiting their edges might constrain the rings' sizes.

El Moutamid leads a project studying the odd planet's rings and moons. In February, she had JWST snap a series of 10 long-exposure images of Uranus over the course of nearly



seven hours. All the images contained an unknown blurry blotch traveling around Uranus, just beyond the planet's set of narrow inner rings.

The repeated appearances, along with the object's speed, suggested the faint spot was a newly discovered moon. El Moutamid and colleagues confirmed the lunar companion's presence by ruling out any other kind of object or an error in the data.

"At first I couldn't believe it," El Moutamid says. "It's the first time I ever discovered a moon — I was really excited."

The newfound moon, currently called S/2025 U1, is about 56,000 kilometers from Uranus' center, orbiting in a circular path. El Moutamid and colleagues estimate that the moon is roughly 10 kilometers wide, although the researchers are seeking additional data for a more accurate measurement. S/2025 U1 is smaller and fainter than the 28 other lunar companions, which is probably why past telescopes and the Voyager 2 flyby — equipped with cameras less sensitive than JWST's — missed the mini moon. ✖

↑ Researchers spotted a small, faint moon (circled) orbiting Uranus in a series of JWST images.

OLGA YASTREMSKA/ISTOCK/GETTY IMAGES PLUS

SPACE

MAGNETS COULD HELP MAKE OXYGEN IN SPACE

By Emily Conover

● For astronauts, producing oxygen in space is a weighty problem.

The process of electrolysis splits water into oxygen and hydrogen using electricity. But under weightless conditions, bubbles of gas don't rise to the water's surface. Instead, they cling to electrodes submerged in the water, impeding the reaction. Placing a neodymium magnet near an electrode helps dislodge the bubbles, researchers report in *Nature Chemistry*.

To test the idea without leaving Earth, aerospace engineer Álvaro Romero-Calvo of Georgia Tech in Atlanta and colleagues used a drop tower in Germany. A capsule was catapulted 120 meters up a tower so experiments could be performed in near-weightlessness as the capsule fell. In the experiments, bubbles streamed off electrodes with magnets, but stuck to those without.

The magnetic field made the water slightly magnetic, causing the water to be repelled from the magnet and the bubbles to move toward it. Adding an acid produced electrically charged particles called ions in the fluid. As the ions moved through the magnetic field, they experienced a sideways force, which sent the fluid and bubbles swirling.

The swirling motion can be used to direct the bubbles to the center of the device, where they could be collected and eventually used to let astronauts breathe easier. ✖

HEALTH & MEDICINE

A COLD TODAY HELPS KEEP THE COVID AWAY

By Aimee Cunningham

● A recent bout of the common cold may be a defense against a COVID-19 infection.

A study that included nasal swabs of more than 1,000 participants assessed whether infections with common respiratory viruses, including the cold-causing rhinovirus, impacted later coronavirus infections. Having had a cold in the past month was linked to about half the risk of developing a SARS-CoV-2 infection compared with those who'd had a cold-free month, researchers report in the *Journal of Infectious Diseases*.

When an infection did occur, having a cold beforehand made COVID-19 milder — there was less coronavirus for the body to contend with. The viral load, a measure of the amount of virus in the body, was almost 10 times higher when a person had not had a cold before COVID-19.

A cold might prevent or temper COVID-19 because the smaller viral load was linked to the production of certain airway defense proteins activated by rhinovirus. It appears that having a cold means those proteins are ready if the coronavirus appears.

The work analyzed data from the Human Epidemiology and Response to SARS-CoV-2 (HEROS) study, which had previously found that kids are more likely than adults to have asymptomatic COVID-19 infections.

In the new study, which explores kids' tendency toward milder coronavirus infections, the team compared coronavirus positive and negative cases from the 30 days before a household's first infection, genetically analyzed nasal swabs from rhinovirus infections and tracked how often people got colds. Some of the airway defense proteins were more highly activated in kids after a cold than in adults, the researchers report. And compared with adults, kids in the study were more likely to get colds. ✖

ASTRONOMY

BRIGHTEST FAST RADIO BURST EVER DETECTED

BY MCKENZIE PRILLAMAN

A powerful blast of energy detected in March marks the brightest fast radio burst — a mysterious type of outburst from space — observed to date.

This ultrabright flash originated 130 million light-years from Earth, closer than most fast radio bursts with pinpointed locations, allowing an in-depth investigation into what produced the puzzling signal. Two papers describe the findings in the *Astrophysical Journal Letters*.

Fast radio bursts, or FRBs, are high-energy, millisecond-long flashes of radio waves. Astronomers have detected about 4,000 unique FRBs, largely thanks to the Canadian Hydrogen Intensity Mapping Experiment, or CHIME, a telescope array in British Columbia.

On March 16, CHIME sensed a burst of electromagnetic energy about twice as bright as past record-holding FRBs, says astrophysicist Amanda Cook of McGill University in Montreal. She and her colleagues nicknamed it RBFLOAT, short for "radio brightest flash of all time," in honor of a research group's inside joke about the divisive taste of root beer.

RBFLOAT's intrinsic energy is "dead average," Cook says. But "it was so bright, we knew it was very close," because the waves disperse energy as they travel to Earth.

The burst's proximity allowed researchers to study RBFLOAT's environment in detail. Data from other telescopes revealed that the FRB came from the edge of a young star-forming region. Additionally, researchers using the James Webb Space Telescope spotted infrared signals coming from the same area as RBFLOAT.

The infrared light may hint at a red giant star losing mass to a companion magnetar — a highly magnetized neutron star known to shoot bursts of energy — which caused it to release an FRB. Another possibility is that a magnetar ejected matter, producing an FRB along with X-rays and other wavelengths of light, but that the latter wavelengths were absorbed by surrounding dust and reemitted in infrared.

Researchers primarily suspect magnetars of pumping out the mysterious radio blasts, and these young astronomical objects track with RBFLOAT's observed environment, Cook says. ✖

ANIMALS

Thumbnails may have helped rodents take over the world

By Erin Garcia de Jesús

● **Rodents may have a rule of thumbnails.** Many rodents have curved claws that help the animals climb or dig. But most also have flat nails on their thumbs, researchers report in *Science*. This feature may help the critters deftly break open nuts and seeds, a skill that set rodents up to take over the world.

Rodents make up nearly half of mammals on Earth, with myriad squirrels, mice, rats and more scurrying around the world. Studies have shown that having big teeth and strong chewing muscles to break open hard foods such as nuts — a food source that few ancient mammals could access, meaning less competition for early rodents — was key to the group's evolutionary success.

Yet the new findings suggest that bite and brawn aren't the only things that have helped rodents flourish around the world, says Rafaela Missagia, an evolutionary biologist at the University of São Paulo. "It's also the ability to hold and manipulate food efficiently."

CLOCKWISE FROM TOP LEFT: ©MHALSTED/INATURALIST (CC BY-NC); ©АНТОН МИР-МАР/INATURALIST (CC BY-NC); RON GREER; NERION/500PX/GETTY IMAGES

Missagia and colleagues scrutinized the thumbs of museum specimens from more than 425 genera in the rodent family tree, with at least one species from each genus. The team also scoured sources such as textbooks and videos to find information on rodent feeding habits and where they live.

Rodent thumbs can have a nail, a claw or nothing at all, the team found.

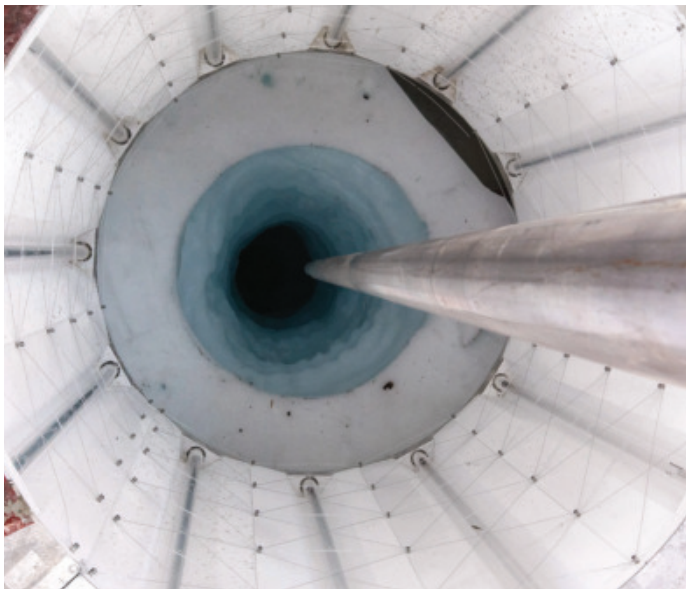
Nearly 90 percent of genera have species with thumbnails, and analyses of the rodent family tree suggest that the trait goes back millions of years. Species that spend time underground, such as gophers, tend to have claws on every digit; critters that don't eat with their hands, like guinea pigs, typically don't have thumbs, or nails, at all.

Having claw and nail combos suggests that rodent hands can serve two functions, says study coauthor Anderson Feijó, an evolutionary biologist at the Field Museum of Natural History in Chicago. Rodents might "use the thumb to have a very good grasp and not have the claws get in the way. But sometimes the claw is useful to dig, to grasp, to find food."

Feijó plans to film rodents using their hands with high-speed cameras to test whether short thumbnails do give the animals more dexterity. Missagia also wants to look for differences in the bones that support the nails and claws.

"If they indeed differ," she says, "we can infer the type of [nails or claws] for species that are extinct." ✖

← **Thumbnails may give rodents the dexterity needed to crack open seeds and nuts.**



MICROBES

‘Swiss Army knife’ microbes live beneath Antarctic glacier

By Douglas Fox

● **Scientists have gotten** their closest-ever view of the denizens that inhabit a frigid underworld.

An analysis of the genetic blueprints of nearly 1,400 microbes sampled from one buried Antarctic lake reveals that these single-celled creatures have surprisingly flexible metabolisms and are evolutionarily distant from any other known microbes, researchers report in *Nature Communications*.

Dotted with subglacial rivers and lakes, West Antarctica is three times the size of Texas, smothered under a kilometer or more of glacial ice. This cold, dark landscape “is a massive area of our planet [where] we have no idea what is going on,” says Alexander Michaud, a polar microbiologist at the Ohio State University in Columbus, who was not part of the study. This new work, he says, provides “an unprecedented, detailed look into who’s living there and how they’re doing it.”

Scientists have sampled liquid water and mud from only two of the more than 600 subglacial lakes known in Antarctica. The first time, in 2013, a team from the United States drilled through 800 meters of glacial ice and CONT. ON PAGE 28

↖ Researchers melted a narrow hole (shown) through 1,087 meters of glacial ice to reach Lake Mercer.

BILLY C. COLLINS/SALSA

EARTH

USEFUL METALS GET UNEARTHED, THEN TOSSED

By Nikk Ogasa

● Many useful metals unearthed from U.S. mines are discarded.

When mining operations dig for valuable metals, they exhume ore containing other metals too. Recovering even small fractions of these by-products could offset the need to import them, researchers report in *Science*.

“We’re used to skimming cream off the top,” says Elizabeth Holley, a mining geologist from the Colorado School of Mines in Golden. “We need to be better at recovering more from what we’re using.”

Some mining operations do recover certain by-product metals with their target metals: Platinum-palladium mines in Montana, for example, recover nickel and cobalt. But by-products are often discarded into waste sites, where they become more challenging to extract. Meanwhile, the United States spends hundreds of billions of dollars annually to import them.

Holley and her colleagues studied production data from permitted mining operations on U.S. federal land as well as data from more than 26,000 ore samples, each analyzed for 70 elements.

For many elements, companies would have to recover 1 percent or less of what’s currently mined and discarded to replace imports, Holley says. These include rare earth elements for lights, magnets and batteries; gallium for semiconductors; and tellurium for solar energy and metal alloy production.

Recovering less than 10 percent of the lithium, cobalt, iron and aluminum in the discarded ores could also replace those imports.

Developing recovery methods would be quick compared with opening new mines, Holley says. “By-product recovery … is a low hanging fruit,” she says. “We already have what we need.” ✖

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ARCHAEOLOGY

VENICE'S WINGED LION STATUE ORIGINATED IN ANCIENT CHINA

By Bruce Bower

● A famous bronze statue of a winged lion took an intercontinental trip to Italy.

This symbol of medieval Venetian statehood started out as a tomb guardian sculpture in China's Tang Dynasty, say archaeologist Massimo Vidale of the University of Padua in Italy and colleagues. Tang rulers held power from A.D. 618 to 907.

During the 1260s or shortly thereafter, the fearsome-looking Chinese sculpture reached Venice, where local artisans modified its features to create a winged lion, Vidale's team reports in *Antiquity*.

The statue closely resembles Tang tomb guardians, which sported lion muzzles, flaming manes, horns, wings and pointed ears. On closer inspection, the bronze lion displays signs of having its horns removed, ears shortened and original wings replaced.

Distinct forms of lead identified in metal samples from the lion statue's original parts closely match the lead composition of copper ore deposits in China's Lower Yangzi River basin, the researchers report.

How the statue reached medieval Venice is a mystery. One possibility: Marco Polo's father and uncle, who visited the Mongol court in what's now Beijing from 1264 to 1268, may have sent the original statue along the Silk Road. But for now, any such scenario remains speculative. ✖

CONT. FROM PAGE 26 retrieved samples from Lake Whillans in West Antarctica. Each milliliter of the lake's water contained 130,000 living cells. Using a "DNA barcoding" technique, the U.S. team analyzed a single gene across the samples and found that microbes in the lake generally belonged to groups that were well-known from other parts of the world. At the time, it was a major advance.

But when U.S. researchers drilled into another subglacial body of water called Lake Mercer in 2018, they had collaborators ready to study the lake's microbes using a more advanced technique called single-cell whole genome amplification.

For the new study, scientists with the Korea Polar Research Institute in Incheon isolated 1,374 microbial cells and pieced together each organism's genome. Analyses of the genomes revealed a major surprise: Microbes that had seemed familiar based on single-gene barcoding suddenly looked a lot more unique when their entire genome was unveiled.

That ended a long-held speculation that maybe these microbes had gotten into the lakes when seawater intruded under the ice sheet roughly 6,000 years ago. Instead, the data show the microbes had to have been living there a lot longer.

"They are specialists" for living under glaciers, says Kyuin Hwang, a bioinformaticist at the Korea Polar Research Institute who analyzed the genomes. "They may have adapted to this condition for a very long time."

They probably evolved from microbes inhabiting Antarctica's land, possibly living under ice ever since glaciers began to expand on the continent, roughly 30 million years ago.

The newly read genomes produced another surprise: These microbes were the bacterial equivalent of Swiss Army knives. Many could grow with or without oxygen, or alternate between eating organic carbon such as dead cells and absorbing carbon dioxide to manufacture their own food the way plants do. But rather than using sunlight to power their CO_2 absorption, they derived energy from chemical sources, such as oxidizing iron or sulfur from crushed minerals.

"This versatility is what allows them to survive" under the ice, says Hanbyul Lee, a microbial ecologist also at the Korea Polar Research Institute.

It's a harsh environment with very little for the critters to gnaw on other than crushed rocks, says Brent Christner, a polar microbiologist at the University of Florida in Gainesville, who was involved in sampling both lakes. "These microbes, on a good year, maybe divide twice a year," he says.

Christner believes that the microbes living in Lake Mercer were probably washed there from parts of the continent that are farther inland — places that are far more isolated from the outside world, with even less to eat. By Antarctic standards, Lakes Mercer and Whillans might be pretty cushy places, he says. "They're probably the rain forests of Antarctica." ✖

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THE HEALTH CHECKUP

KETO PROBABLY ISN'T YOUR FOREVER DIET

BY MEGHAN ROSEN

Maybe you've seen an influencer make french fries out of almond flour. Or a sandwich recipe that swaps bread for fried cheese. They're called keto meals, and they're largely shared online for one reason: to help people lose weight. In the ketogenic diet, fat is king and carbohydrates are public enemy number one. Going keto means restricting carbs to the bare minimum and replacing those lost calories with fat.

It's the antithesis of the low-fat diet craze of the 1990s. The idea may sound paradoxical. But without our bodies' go-to energy source (sugar), they instead burn molecules called ketone bodies, a type of fuel made by the liver from fat.

That can lead to weight loss, even for those loading up on full-fat cottage cheese. Such results may explain why so many Americans have tried the keto diet. The diet has spawned keto-friendly supplements, snacks and other food products that consumers globally shell out billions for each year.

"I think a lot of people look at a ketogenic diet and think, 'I'll lose weight, I'll be healthier,'" says Molly Gallop, a physiologist at Earlham College in Richmond, Ind.

But staying on the diet long-term could carry some risks, a new study in mice suggests. Mice fed a ketogenic diet for up to a year — decades in human time — experienced health problems including glucose intolerance and signs of liver and cardiovascular disease, Gallop and her colleagues report in *Science Advances*.

This uncovers potential hidden costs to going keto, says physiologist Amandine Chaix of the University of Utah in Salt Lake City. "It's a cautionary tale," she says. People sticking to a high-fat plan need to be careful, she says, "because this is not a magical dietary approach."

The classic keto diet specifies that roughly 90 percent of a person's calories should come from fat. That's close to double the fat proportion of a typical American diet. A raft of studies in humans have shown that keto diets can prompt weight loss in adults who are overweight. And Johns Hopkins neurologist Tanya McDonald, who prescribes the diet for patients with epilepsy, points out that the treatment was first used for the neurological condition a century ago. But scientists don't know much about the diet's long-term effects in the general population. It can be hard for people to adhere to such a restrictive diet, McDonald says, and that makes it difficult to study.

The diet is easier studied in mice, Chaix says. In the new study, mice on a keto diet weighed less than those on a Western-inspired one, supporting the idea that it helps keep body weight down. But other results raised red flags. Mice on the keto diet had excess fat in their blood, a hallmark of cardiovascular disease. And tests found that male mice's livers weren't working properly. But what stood out most was the animals' difficulty disposing of sugar in the blood, Gallop says.

Normally, the pancreas secretes the hormone insulin, which tells tissues to draw sugar from the blood and store it in cells for use as energy. But the insulin-making cells of keto mice struggled to release the hormone. The researchers traced this trouble to the cellular machinery that pumps out insulin. Why it's not working remains a mystery, Chaix says.

It's also unclear whether those findings apply to humans, but the results track McDonald's thoughts on keto diet use. "We don't recommend that the general public use ketogenic diets without medical supervision," she says.

Chaix and Gallop's work suggests a surprise silver lining: Quitting keto solved the mice's glucose issue, the team found. So that problem, at least, appears to be temporary. ✖

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Features

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SCIENCE & SOCIETY

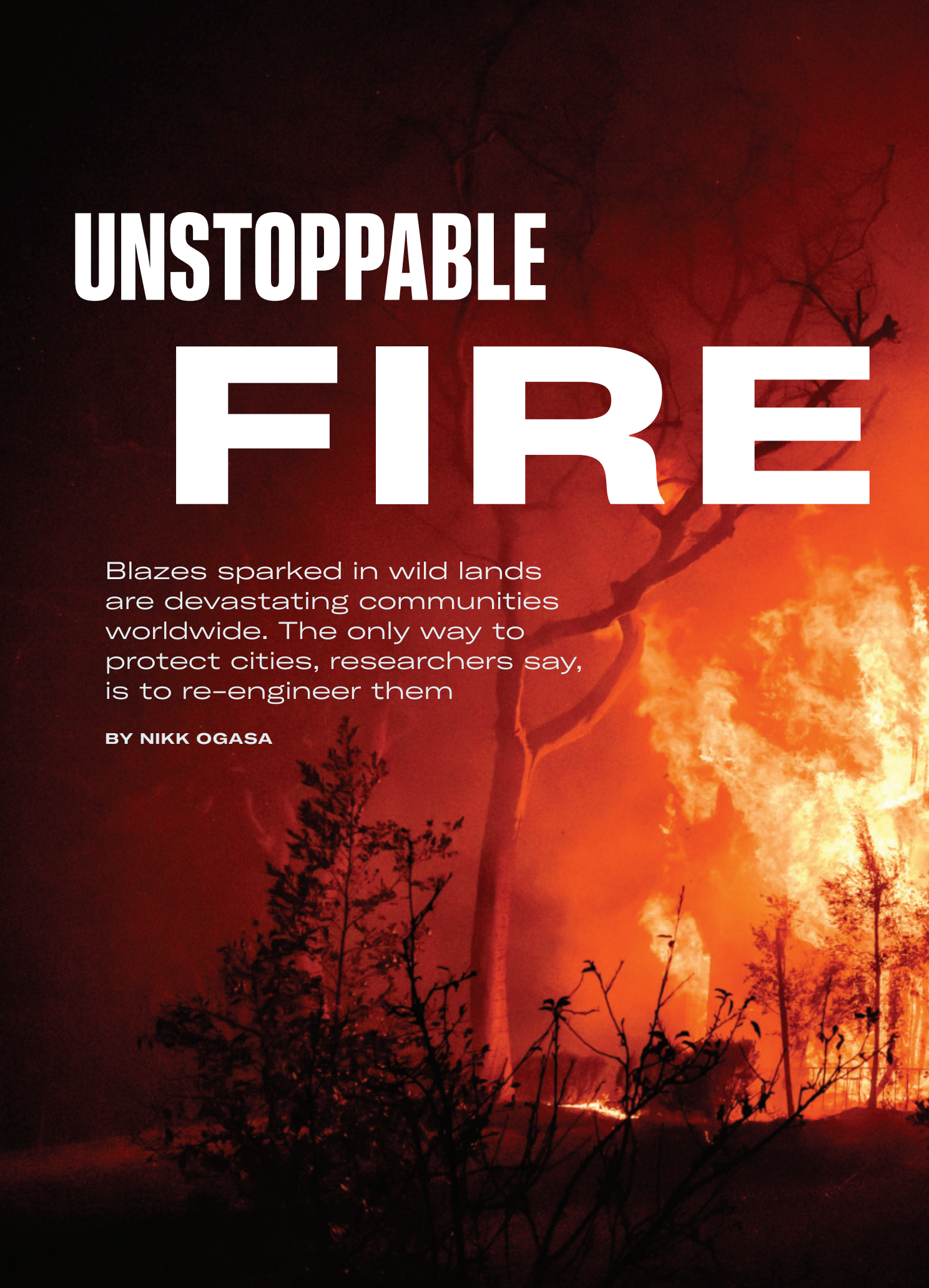
THE EVER-EVOLVING "HEALTHY FOOD" TREND

● What's considered "healthy food" changes constantly. In the 1890s, deeply religious American physician John H. Kellogg introduced cornflakes as a breakfast food (1920s advertisement shown). He believed eating bland food would improve health by curbing the urge to masturbate, which he considered sinful. And then there's margarine, promoted in the mid-1900s as a healthier alternative to butter, until research proved otherwise. The latest craze: vast amounts of extra protein in foods. But is it as beneficial as it seems? (See Page 48) —*Karen Kwon*

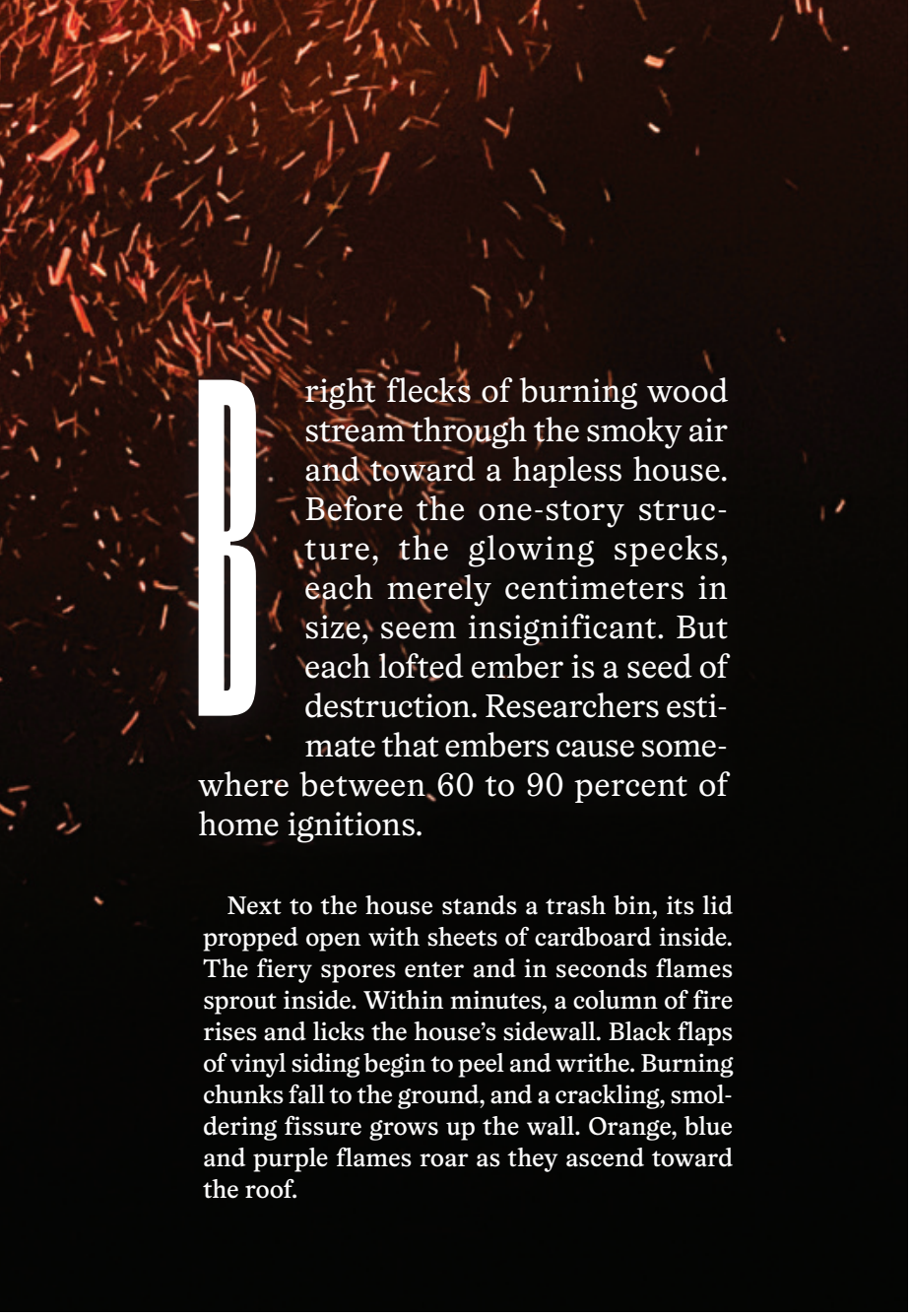
UNSTOPPABLE FIRE

Blazes sparked in wild lands are devastating communities worldwide. The only way to protect cities, researchers say, is to re-engineer them

BY NIKK OGASA



↖ The Eaton fire killed 19 people and destroyed more than 9,000 buildings in January. It was one of the 14 wildfires that ravaged Southern California that month.



Bright flecks of burning wood stream through the smoky air and toward a hapless house. Before the one-story structure, the glowing specks, each merely centimeters in size, seem insignificant. But each lofted ember is a seed of destruction. Researchers estimate that embers cause somewhere between 60 to 90 percent of home ignitions.

Next to the house stands a trash bin, its lid propped open with sheets of cardboard inside. The fiery spores enter and in seconds flames sprout inside. Within minutes, a column of fire rises and licks the house's sidewall. Black flaps of vinyl siding begin to peel and writhe. Burning chunks fall to the ground, and a crackling, smoldering fissure grows up the wall. Orange, blue and purple flames roar as they ascend toward the roof.

Then, a hiss pierces the air as firefighters step forward to spray the flames. Their intervention is not serendipitous. The burning home is not a real home. It is just the side of one, as if a giant butcher had trimmed a neat piece of a house's exterior. The conflagration had been staged in a vast room at the National Fire Research Laboratory in Gaithersburg, Md.

Standing before the ruined structure, Alexander Maranghides, a fire protection engineer at the National Institute of Standards and Technology in Gaithersburg, Md., assesses the damage. "All from embers," he says.

Experiments like this one reveal key details about how wildfires devastate individual structures and entire communities, as they did around Los Angeles earlier this year and in Maui in 2023. The information is crucial for protecting the communities that are most vulnerable to encroaching wildfires — those within the wildland-urban interface, or WUI. That's land manager jargon for anywhere that human development meets or mingles with undeveloped natural areas, such as forests or grasslands. Roughly 40 percent of people on Earth — some 3.5 billion — live along these fringes of nature, where most of the largest, deadliest and most destructive fires in recent history have occurred.

As these fire-prone zones globally expand, climate change is making fire seasons longer, hotter and drier. When those conditions converge with powerful winds that can fan flames and carry embers for kilometers, communities can be overwhelmed.

"Wildfire control doesn't work during the extreme conditions," says Jack Cohen, a retired U.S. Forest Service fire scientist who spent decades studying fire in the wildland-urban interface. The focus needs to shift away from fighting blazes and toward modifying communities to resist catching fire, he says. "It's not a wildfire problem. It's a structure ignition problem."

For decades, Maranghides and other researchers have dedicated themselves to figuring out how to make communities more resilient, resulting in guidelines like NIST's Hazard Mitigation Methodology, first released in 2022. It identifies dozens of vulnerabilities and how to lessen them. It also raises a key point: In neighborhoods where homes are closely spaced, fire resilience works only if the whole community is involved.

That's because a home on fire can spread flames to other structures that are within about 50 feet. In such neighborhoods, hardening only some of the structures leaves them all vulnerable, Maranghides says. Once a home ignites in flames, it transforms into an existential threat to its neighbors. Even a

PREVIOUS SPREAD: JOSH EDELSON/AFP/GETTY IMAGES; THIS PAGE: IGNATIEV/GETTY IMAGES

single unprotected building can jeopardize the whole neighborhood. Hardening all the buildings in a community is the only way to protect each of them.

That's the crux of the problem: getting each resident involved in hardening the community. Guided by the principles from NIST and similar methodologies, community-scale hardening has started in some places in the West, reflecting a recognition that society must adjust to coexist with fire, so long as people live within its reach. "Wildfire is inevitable," Cohen says, "but community destruction doesn't have to be."

LESSONS FROM DEVASTATION

On November 17, 2018, a team of NIST researchers traveled to the foothills of California's Sierra Nevada to investigate the most destructive fire the state had ever seen. About a week and a half earlier, katabatic winds ripping down from the mountains had snapped a power line, igniting flames in a steep-sloped waterway called Feather River Canyon around dawn.

By sunset, the fire had ripped through the towns of Concow, Paradise and Magalia, destroying more than 18,000 structures, damaging 7,000 and killing 85 people. Much of the Camp Fire's spread occurred via the sky. The wind lofted embers for kilometers, seeding new blazes far ahead of the main fire front. "It's a kind of a hopscotch," explains Steve Hawks, a wildfire researcher and veteran firefighter who spent 30 years working for the California Department of Forestry and Fire Protection, or CAL FIRE. "Eventually [the] main fire front will catch up to it, but it's trailing behind."

The NIST team had arrived while the flames were still burning. They spent four days in the field, documenting damage and speaking with meteorologists and first responders on site. Nearly a dozen deployments followed over the next six months. Data was gathered from a multitude of sources, from fire engine logs to evacuation information. NIST has since spent over six years analyzing that data. Its first report on the Camp Fire was released in 2023, and another is slated for 2026.

Because these reports are so comprehensive, NIST's WUI Fire Group has completed just four fire case studies. "Think of it as CSI at the community level," Maranghides says. Field observations help guide NIST's fire research in the lab. For instance, researchers noticed that fences were acting as conduits for spreading flames, prompting research into how fence design and materials affect fire spread. And observations of burning sheds spreading flames to residences led to experiments that helped determine that

A melted splotch is all that remains of a trash bin after a wildfire in Los Angeles in January (top). At the National Fire Research Laboratory in Gaithersburg, Md. (bottom), scientists tested how trash bins fuel the spread of fires. ↓

FROM TOP: IBHS; NIST

wooden or steel storage sheds should stand at least 4.5 meters away from homes. When a shed catches fire, its walls seal in heat and flammable gases, which can cause jets of fire to shoot out of any openings. “The shed simulates wind,” Maranghides says.

NIST researchers also design experiments to study how flames and embers ignite and spread on or between structures made of different materials, in various circumstances. These tests reveal the conditions under which a vulnerability becomes dangerous, Maranghides says. That information then goes into updates to NIST’s blueprint for fire-adapted communities — the Hazard Mitigation Methodology, or HMM.

NIST’s methodology combines approaches to prevent a community from burning down when faced with a fire. The first involves hardening structures against flames using resilient designs and materials. For instance, metal siding could be used to shore up the base of a wall. The second approach entails removing, relocating or reducing a home’s exposure to materials that could ignite from embers and spread flames, such as patio furniture, plants or vehicles.

While the HMM may sound like a typical fire code, it’s more of a “code plus,” Maranghides says. Unlike conventional fire codes, the methodology emphasizes community-scale efforts rather than addressing just one home or property, Maranghides says. Fire doesn’t care about property lines.

“Your parcel could be pristine, so that you could have done everything right, but those neighboring parcels all around you have to also be prepared,” agrees Michele Steinberg, wildfire division director of the National Fire Protection Association, a nonprofit based in Quincy, Mass., that helps develop fire safety codes.

And for each home in the community, every vulnerability must be addressed. In places where homes are within 15 meters of one another, embers could ignite one home and trigger a destructive domino effect — flames spreading from structure to structure. “When you get bombarded by a million embers, those embers are going to find those vulnerabilities,” Maranghides says. “You cannot just do half the ember hardening. It doesn’t work that way.”

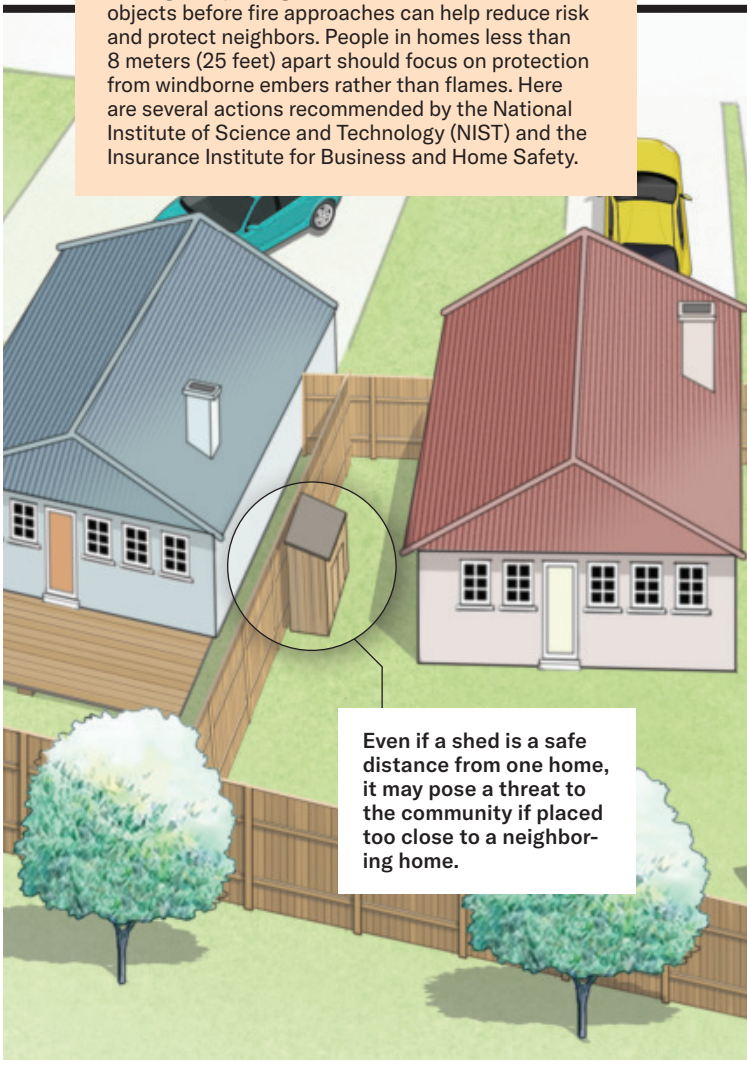
Other fire protection guidelines miss vulnerabilities identified by NIST, Maranghides says. Roughly 75 percent of the ember vulnerabilities and 50 percent of the flame vulnerabilities in the HMM are lacking from fire building codes from California, the National Fire Protection Association and International Code Council, a Washington, D.C.-based nonprofit that publishes safety standards, he says. “The code is not enough.”

One guidance that’s comparable to NIST’s is the Wildfire Prepared Neighborhood Standard. It was developed by the Insurance Institute for Business & Home Safety, a research and communications nonprofit organization that’s funded by property insurance companies and based in Richburg, S.C.

The institute conducts fire ex-

FENDING OFF FIRE

Moving or replacing combustible structures and objects before fire approaches can help reduce risk and protect neighbors. People in homes less than 8 meters (25 feet) apart should focus on protection from windborne embers rather than flames. Here are several actions recommended by the National Institute of Science and Technology (NIST) and the Insurance Institute for Business and Home Safety.



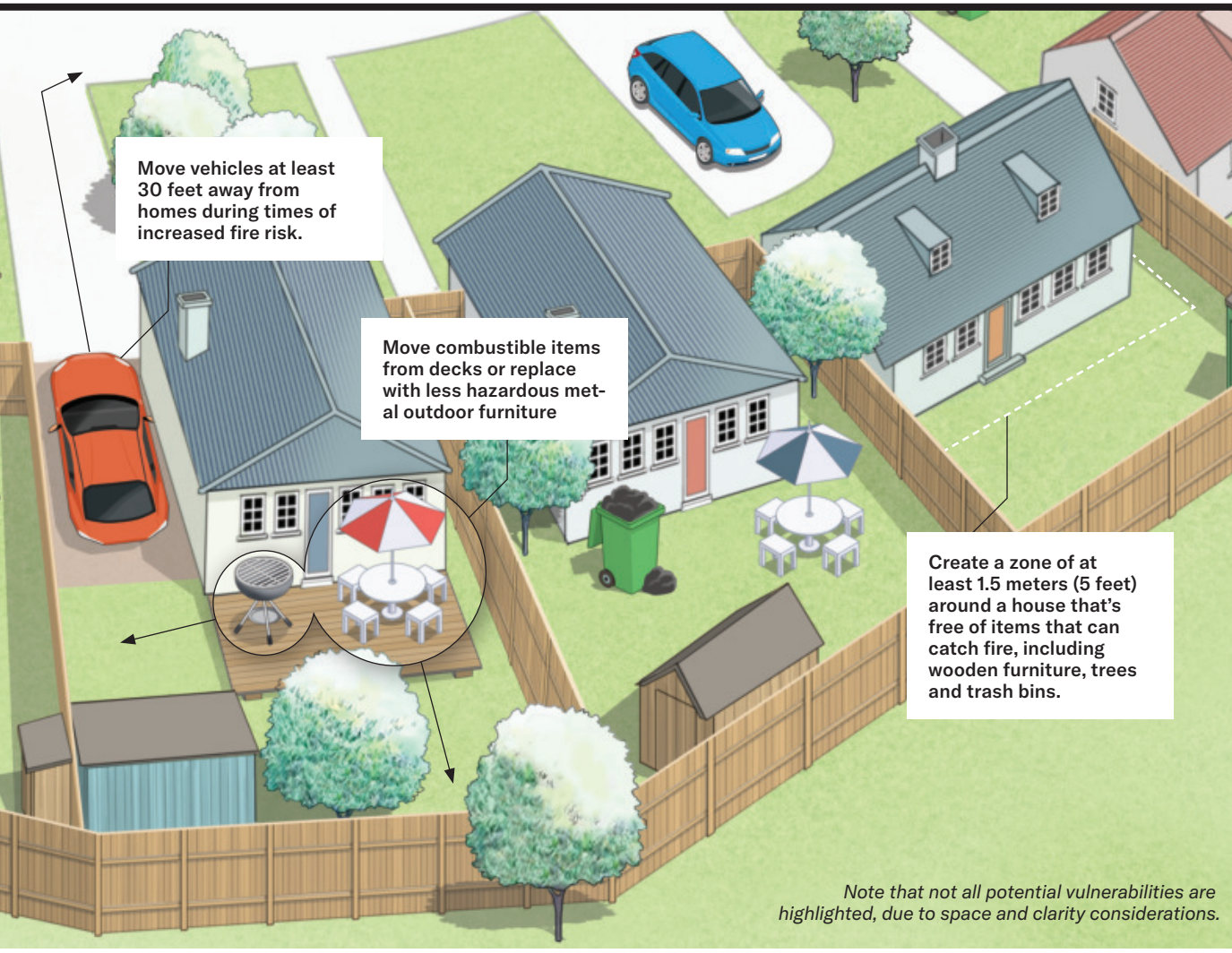
Even if a shed is a safe distance from one home, it may pose a threat to the community if placed too close to a neighboring home.

periments and field studies of wildland-urban interface fires, producing findings that often align with NIST's. For instance, while surveying the aftermath of the Palisades Fire, Hawks and colleagues observed plastic trash bins with holes melted through them, suggesting embers could penetrate even closed bins. What's more, they found the remains of trash bins — melted plastic and metal axles — near burned sections of buildings. "We noted a lot of damage ... came from those bins where the ember would land on top," says Hawks, who is the institute's senior director for wildfire. The institute recommends that residents move bins at least 30 feet away from homes during long absences and Red Flag warnings, an alert indicating increased fire risk due to warm, dry and windy weather.

Though many of the measures in Wildfire Prepared Neighborhood align with or have been drawn from NIST's work, the institute goes one step further by certifying homes and communities that meet the standard, Hawks says. The certification may help people secure home insurance at a time when insurance companies in California and other states are dropping thousands of homeowners' policies due to increasingly severe and costly climate disasters.

Earlier this year, developers unveiled a new community of 64 homes in Escondido, Calif., called Dixon Trail. It is the first community to receive the Wildfire Prepared Neighborhood designation from the insurance institute. Each

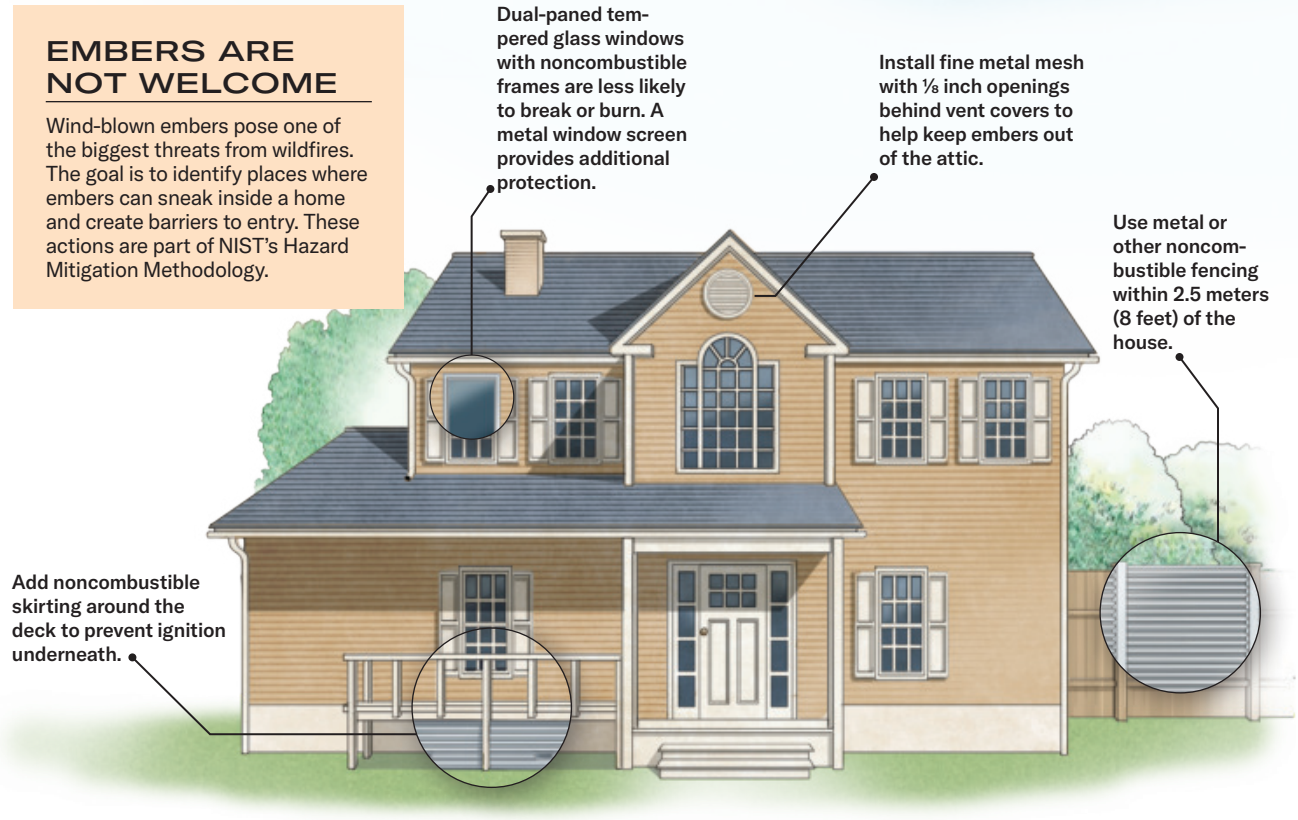
PETER BULL



Note that not all potential vulnerabilities are highlighted, due to space and clarity considerations.

EMBERS ARE NOT WELCOME

Wind-blown embers pose one of the biggest threats from wildfires. The goal is to identify places where embers can sneak inside a home and create barriers to entry. These actions are part of NIST's Hazard Mitigation Methodology.



of the homes is insured, Hawks says, despite California's tough insurance market.

Someone visiting Dixon Trail might not immediately spot anything unusual about the homes. They may overlook the enclosed eaves that help keep out embers, the dual-paned, tempered glass windows that are resistant to breaking in high heat and the metal fences that won't catch fire. But what might stand out is the five-foot zone surrounding each house that's largely free of combustible material — be it mulch, furniture or plants — surrounding each house.

As strong as the science is, "it's only as good as the implementation," Steinberg says. The real question, she says, is "how do we get there?"

BRINGING SCIENCE TO THE NEIGHBORHOOD

The Dixon Trail community may be impressive, but the largest opportunity for protecting communities from wildfire lies in refitting homes that already exist.

Around 130 kilometers north of San Francisco lies Clear Lake, the largest natural body of freshwater located wholly within California and the namesake of Lake County. Two cities, numerous towns and countless oak trees surround the lake's bass-filled waters. Fire is a recurring part of life here. Just 3 months ago, the Lake Fire burned 401 acres near Clear Lake's eastern shore.

"Pretty much everyone who lives here or lives in the surrounding area has been traumatized by fire one way or another, whether it's being evacuated or losing their home," says Deanna Fernweh, a resident who was born and raised in Lake County. "It feels like a crisis that we can never really run away from."

On Clear Lake's southern shore lies Kelseyville Riviera, a relatively new community of about 1,500 homes and 3,400 people. Here, a state-led initiative called the California Wildfire Mitigation Program is partnering with the Federal Emergency Management Agency and local organizations to help people retrofit against fire. Their standards are informed by the HMM, the California building code and CAL FIRE materials tests.

Communities were selected based on their vulnerability to fire and future impacts from climate change, as well as how many residents are older, disabled, living in poverty, without a car and with language barriers.

Lake County is one of six counties selected for the program so far, and Kelseyville Riviera was

PETER BULL

identified as particularly at risk. "We have dense vegetation that surrounds that community ... really only one way in, one way out, and the road is narrow," says Fernweh, who is program manager for North Coast Opportunities, a nonprofit leading the project. "A lot of the lots are small, so some of these homes are only 25 feet away from each other and, as you know, fire hops from rooftop to rooftop," she adds. "It just kind of checked all those boxes as being one of the most vulnerable areas in Lake County."

There are big advantages to partnering with local organizations to retrofit homes. "First, it's a lot easier to have a neighbor to come and talk to you about this stuff, than have me come from Sacramento," says J. Lopez, executive director of the California Wildfire Mitigation Program in Sacramento, a state program that provides financial assistance to fire-prone areas. "Second of all ... now the knowledge system is in the community."

The initiative is still in its infancy. So far, at least 30 homes in Kelseyville Riviera have been retrofitted, part of 70 completed across the state so far. Another 200 homes across the state have been assessed or are currently being retrofitted, and hundreds more people have applied. The cheapest retrofit so far, on a Lake County home, cost about $36,000, Lopez says, while the most expensive, at about $110,000, was in San Diego County.

Lopez hopes the effort will scale up once it advances past the pilot phase. In 2028, the California Wildfire Mitigation Program Authority is due to submit a report to the California legislature that details the costs, challenges and objectives of the initiative, with the goal, Lopez says, of making the program permanent.

U.S. Census Bureau data show that new homes built from 2020 through 2022 make up only 2 percent of owner-occupied homes, underscoring the vast need for retrofits. But it's hard to get people on board, especially if they must foot the bill, Steinberg notes. "It will take everybody working together, and it will take change in policy and practice from the national down to the local level."

That alignment may take years to achieve. "No single entity — federal, state, local, public or private — actually has full authority over this issue," says Frank Frievalt, director of the Wildland-Urban Interface Fire Institute at Cal Poly in San Luis Obispo, Calif.

In the meantime, Frievalt refers people to the guidelines provided by NIST and the Insurance Institute. "Don't wait on your local government, don't wait on your insurance, don't wait on a fire inspection," Frievalt says. "Look at the things that you can do to protect your home. The goal is not insurability. The goal is survivability."

The good news is that the threat of fires on the wildfire-urban interface are a solvable problem. But "this is not going to turn on a dime," Maranghides says.

Still, he foresees a scenario a generation from now, when a wild land fire runs up against a community, it will simply peter out.

Compared with earthquakes, twisters and so many other natural hazards, fire may be the natural phenomenon that is most within our control to mitigate. "In a tornado ... the energy is in the atmosphere," Maranghides says. "Here, the energy is in the community." ✖

ARIANA DREHSLER/THE NEW YORK TIMES/REDUX

Homes in the Dixon Trails subdivision in Escondido, Calif., have fire-resistant features such as metal fences and tempered glass windows. ↓

Gummy worm ingredients (shown) may hold less appeal than the final processed treat.

When food becomes an ADDICTION

Ultraprocessed foods may share properties with addictive substances, leading to worrisome consequences for our health

BY LAURA SANDERS

PHOTO BY ESCHLIMAN STUDIO

STYLING BY KAYLAN LOVE | RETOUCHING BY BLINKLAB

When I sat down to write this story, I remembered the gummy worms in the snack drawer of my kitchen. So I got up and grabbed a handful. I should add that I had just finished lunch, and I don't really like gummy worms.

And yet, I ate them.

That's not an unusual moment in my life, and maybe in yours too: eating a treat that serves almost no nutritional purpose. My treat, for instance, had sugar but little else of substance on the ingredient list: gelatin, natural and artificial flavors, carnauba leaf wax and colors, including Red 40, Yellow 5, Yellow 6 and Blue 1. As I read the list in growing disgust, I helped myself to another worm.

But after reporting this story, I'm going to cut myself some slack. There's growing recognition that these sorts of highly processed foods are engineered to make us want more. Like gummies stuck in the teeth, foods high in sugary, crunchy, salty, creamy or savory qualities can stick in our brains and urge us to eat another handful.

These foods, scientists are increasingly convinced, have addictive properties, similar to the pulls created by alcohol, nicotine and opioids. And certain kinds of engineered foods, usually combinations of salts, fats and sugars, create such a strong desire to eat them that they could be classified as addictive substances.

55
percent
Average calories consumed in the United States from ultraprocessed foods from 2021 to 2023

62
percent
Average calories consumed by 1- to 18-year-olds from ultraprocessed foods

53
percent
Average calories consumed by adults 19 years and older from ultraprocessed foods

Highly engineered foods can worm their way into the brain's reward system, triggering powerful "eat more" signals. Studies suggest ultraprocessed foods can lead to cravings, loss of control, withdrawal and tolerance — all hallmarks of a substance use disorder.

There are still lots of questions about exactly what these foods do to us, who is most at risk of overeating them, and what strategies might empower us to wrestle back control. Yet questions about how these increasingly abundant food products affect our brains and the rest of our bodies are more important than ever. A big chunk of the U.S. diet — over half of the calories Americans eat, on average — is now categorized as "ultraprocessed."

Ultimately, the goal of research on food and addiction is to give people a better understanding of how what we eat affects us so we can make informed decisions, says neuroscientist Alex DiFeliceantonio of the Fralin Biomedical Research Institute at Virginia Tech Carilion in Roanoke. But there's a competing goal at play here, she says: "The goal of a food company is to have you eat more food."

Writing in *Nature Medicine* this summer, addiction and nutrition experts including Nora Volkow, the director of the National Institute on Drug Abuse, make the scientific case that these food products "share more commonalities with addictive substances than they do with naturally occurring foods." It's time, they write, for policy makers and scientists to recognize the danger — and do something about it.

WHAT IS FOOD?

Like anyone who eats — which is to say, everyone — I thought I had a pretty good handle on what food is. But it turns out that my handful of cheese puffs doesn't really count, according to Ashley Gearhardt, a psychologist at the University of Michigan in Ann Arbor.

"This stuff isn't food. It's a hedonically optimized substance created through processing to make corporations a lot of money," she says. "We shouldn't give [ultraprocessed foods] a pass just because they have calories."

Neuroscientist Nicole Avena of Icahn School of Medicine at Mount Sinai in New York City has her own questions about the vocabulary at work here. "I don't even know if we should be calling them food anymore," she says. "So I've been referring to them as foodlike products."

But if these "foodlike products" aren't food, what are they?

The term "ultraprocessed food" is, in many ways, as squishy as a pale yellow Peep. For decades, food scientists have been tinkering with ingredients, preservatives, colorings, bulking agents and more to keep food unspoiled, visually appealing and delicious.

Scientists often use the NOVA classification system to sort foods into four categories: unprocessed or minimally processed (an apple, for instance, or chicken); processed cooking ingredients (sugar or butter); processed foods (cheeses or canned vegetables); and ultraprocessed foods (hot dogs or potato chips).

Ultraprocessed caloric conglomerates "basically contain limited to no whole food pieces or products and contain additives," says Tera Fazzino, a psychologist at the University of Kansas in Lawrence.

These products are built piecemeal from sugars and fats that have been taken from their naturally occurring form and then concentrated and packaged into something new, often with additives to improve the flavor and mouthfeel. Then they're packaged into an appealing wrapper with a

recognizable logo.

"Just as a cigarette has little in common with a tobacco leaf, an Oreo shares few characteristics with the corn and soybeans from which it was made," Volkow, Gearhardt and others write in their *Nature Medicine* piece.

These foods have been around for decades, and they're everywhere. In 2003, ultraprocessed foods accounted for about 51 percent of people's calories at home. By 2018, the percentage had risen to just over 54.

In 2019, Fazzino and her colleagues wrote a paper describing a related but not completely overlapping definition: hyperpalatable. It means what it sounds like: extra delicious, irresistible, yum. Fazzino points out that regular old foods that everyone can agree are foods — apples, carrots, salmon — are also palatable, and they also carry signals of reward. But hyperpalatable foods are next level.

Take children's breakfast cereal. A recent study found that from 2010 to 2023, fiber and protein went down in U.S. cereals, while fat, salt and sugar increased. Those results, published May 21 in *JAMA Network Open*, are but one example of the larger shift toward increased fats and sugars and away from nutrients. And removing ingredients like fiber that make us feel full while increasing the ones that scream "delish" is a recipe for eating too much.

"In the U.S. food system, there's a pretty strong degree of overlap" between hyperpalatable and ultraprocessed food, Fazzino says. In some other countries, there was less overlap, Fazzino and colleagues reported June 6 in *PLOS One*. Perhaps that's because food processing in some places outside the United States can be less intense.

"They do something to it and they stick in a package," Fazzino says. That's not the same thing as making the food taste deliriously delicious.

ADDICTIVE BITES, THEN AND NOW

Decades ago, food and addiction were seldom mentioned together. But around 2007, food policy expert Kelly Brownell, then at Yale University, and addiction researcher Mark Gold, then at the University of Florida, began talking about the intriguing links. Their conversations led to a two-day meeting at Yale University in the summer of 2007 that forced the fields of addiction and nutrition together — the first meeting of its kind.

Half the people invited were from the nutrition and obesity field, and half were from the addiction field, Brownell says. There was some skepticism at first that the idea was legit, that addiction could be a helpful framework when it came to food.

"The people from the addiction field were much quicker to embrace the concept that food could be triggering addictive processes than the people in the nutrition field," Brownell says. "And the reason I think is that it was newer to the people in the nutrition field. They weren't used to thinking about the concept of addiction." But over the years, the idea that foods, particularly ultraprocessed foods, could spur addictive responses in people became more widely accepted.

As a grad student in the 2000s, Avena found that sugar use shared characteristics consistent with addiction, based on criteria set forth at that time in the Diagnostic and Statistical Manual of Mental Disorders, or DSM, a handbook for psychiatrists that described substance use disorders.

"It was a little bit, I would say,

↓ Virginia Tech neuroscientist Alex DiFeliceantonio plates a meal for study participants. Her studies compare the effects of ultraprocessed and minimally processed foods.

CLAYTON METZ

tumultuous in the beginning, because nobody was really keen on this idea," she says. But the research moved forward, much of it pointing to parallels with other addictive substances. A key piece of the argument lies in the reward regions of the brain, including the striatum, a well-connected, deep part of the brain that influences motivation and good feelings. The striatum can signal when things are beneficial to the body. A stash of honey, with its burst of calorie-dense sweetness, would kick off a big reward signal in the brain of a hungry person.

Neuroscientists have been amassing evidence from animal studies and people that shows how ultraprocessed foods change the brain in ways that are reminiscent of other addictive substances. Studies have uncovered detailed neurochemical effects, structural changes and alterations in key brain regions' activity.

"When we look in the brain, there are neurochemical changes that happen in response to food that are very much like what you would see in response to drugs or alcohol," Avena says. Scientists have found changes in the brain's reward systems, including the chemical messengers dopamine, serotonin and brain-made opioids. Many of these changes, researchers suspect, all conspire to make a person be more alert to food.

DiFeliceantonio and her colleagues found, for instance, that people who were given a high-fat, high-sugar yogurt dessert daily for two months had stronger neural reactions to food cues in brain areas that handle reward. The dessert essentially rewired the reward circuitry in these volunteers, boosting their motivation for eating treats. In further experiments, these people also performed better in laboratory tasks of learning, to DiFeliceantonio's utter surprise.

JUST CAN'T STOP

Yet substance use disorders are much more complex than what can be measured in experiments by brain scientists. They involve combinations of behaviors, emotions, triggers and history. These include intense cravings, repeated attempts to stop and continued use despite being well aware of the damage.

Gearhardt is an addiction clinician, and she sees patients who will tell her that they are struggling with these foods. "They're saying, 'I'm addicted to this stuff, I am telling you I'm addicted ... I know it's killing me. I've got diabetes, I'm going blind, and I cannot stop.' And people would just tell them, 'No, you're wrong, you just have to try harder, count your calories, do your macros.' "

Listening to those experiences solidified her perspective that there is something pernicious about these foods. Running through the checklist of substance use disorders in its current form in the DSM, some people meet the benchmarks for problematic behaviors and symptoms around ultraprocessed foods, researchers argue. That's based on nearly 300 studies from 36 countries.

Using the Yale Food Addiction Scale, about 14 percent of adults and 12 percent of children meet the criteria for food addiction, a figure that's very close to the estimate for alcohol use disorder prevalence. The survey includes questions about eating habits, such as whether a person overate to the point where they felt ill, and whether a person had strong urges to eat.

In a set of preliminary findings, DiFeliceantonio and colleagues found that 18- to 21-year-olds on an ultraprocessed diet ate more than the same cohort on a minimally processed diet. And they ate more in the absence of hunger. The same wasn't true for slightly older adults who were ages 22 to 25. Figuring out who might be more affected by different types of food is still a big question.

FOOD CLASSIFICATION

The NOVA classification system sorts foods into categories not by nutrients, but by processing levels. The scale ranges from one, for unprocessed or minimally processed foods, to four, for ultraprocessed foods.

Unprocessed/minimally processed	Processed ingredients	Processed	Ultraprocessed
Meat	Salt	Canned foods	Packaged snacks
Eggs	Sugar	Salted nuts	Ice cream
Fresh, frozen or dried fruits and vegetables	Butter	Cured meats	Instant food
	Starches	Fruit in syrup	Energy bars
Grains and legumes	Oils	Cheeses and fresh bread	

LIVING WITH PROCESSED FOOD

With growing recognition of how ultraprocessed foods have been designed and perfected to keep us snacking, attempts to cut back can feel futile. That's especially true when many people live in places without access to healthy, fresh food. Even if unprocessed foods were readily available, they can be costly and take up more time and space to prepare.

But there has been some progress. Federal agencies are scrutinizing these foods, with childhood nutrition as a focus. States are exploring bans on ultraprocessed foods in schools. And a lawsuit was brought in Pennsylvania against food companies that are accused of knowingly hooking people on their products despite being aware of the harms. The suit has since been dismissed, but similar efforts might follow.

After tobacco products got more tightly regulated, many of those companies pivoted to food products, Fazzino says. Researchers studied foods for sale from 1988 to 2001. Over time, tobacco-owned food companies were more likely to sell hyperpalatable foods than food companies with other types of owners, researchers reported in 2023 in *Addiction*. "U.S. tobacco companies were systematically involved with the development and the dissemination of these foods into our food supply," Fazzino says.

Now there are movements to improve school lunches, movements to promote better labeling and movements to educate people about how to spot unhealthy foods that have been "healthwashed" by companies.

Efforts to regulate ultraprocessed food products are pushing ahead whether experts consider these foods addictive or not. When I asked DiFeliceantonio why the addiction lens matters, she replied: "It comes back to this idea of us making decisions in a difficult environment." If a substance is designed to be irresistible, then "decisions actually are no longer your own because they're being governed by your drug, by your substance," she says. "And so if these foods are addictive, we can't make good decisions about them.

"I don't even know if we should be calling them food anymore. So I've been referring to them as foodlike products."

—NICOLE AVENA, NEUROSCIENTIST

"We have enough data at this point to understand that ultraprocessed foods, on the population level, are killing us, are leaving us to live shorter lives with a higher disease burden, and we're telling people, 'Well, stop eating them,' " she says. But through an addiction lens, that strategy falls short.

What's more, so much of normal or abnormal behavior is a social construct, Avena says. "So if it's socially acceptable to drink alcohol, then that's fine, right? But it's not socially acceptable for 6-year-olds to drink alcohol, right?" It's the same with processed foods, she says. "I think they become so socially acceptable to have these foods all the time, to bring them to parties, to give them to our kids, that it's basically become normalized."

Change may come from a growing recognition of the potential harms from eating ultraprocessed foods, Avena says. "If you know there's a risk associated with it, then that makes you think twice."

Some food companies are already working to unprocess their products in response to public pushback, Avena says. "I think if enough people start to say, you know what? I don't want all these donuts for my kids for their lunchbox, or I don't want Lunchables.... I want a healthier version of it. I want something that is going to be less processed. I think that the companies will have to step up to the plate, and you see that happening," Avena says. At food shows, she's already seen examples of smaller companies trying to design and market nutritious food. Foods designed for people on GLP-1 drugs that are high in protein and not too sweet or processed are already being created and sold.

But the most effective avenues for change may be stronger regulations that mandate healthier food, tax unhealthy food and require better labeling. In Chile, aggressive rules for packaged foods high in sugar, saturated fat, salt or calories — in other words, many ultraprocessed foods — are already yielding progress, Brownell says. That country has restricted marketing, added taxes on certain products and mandated glaringly obvious warning labels. These efforts seem to be shifting people's purchases. A recent study found that less sugar, salt, saturated fat and total calories from products marked with warnings found their way into people's cabinets.

"The more that the conversation is shifted to the individual and away from the actual source of the problem, which I think is the addictive foods, then we don't have a real solution," Fazzino says. "As a public, we deserve to be protected from the things that can cause us harm." ✖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Not all proteins are created equal

Most Americans are eating enough protein. But research shows it can be tricky to eat the right mix

BY SUJATA GUPTA

Protein is having a moment. Crucial to helping the body build muscle, bones, cartilage, skin and blood, protein has begun cropping up as an additive in everything from cookies and chips to beverages. Social media influencers with muscles seemingly carved from stone tout high-protein diets as key to, well, looking like them.

The official memo is that people in the United States are getting more than enough protein. Recent figures from the U.S. Department of Agriculture suggest that adults in the United States are eating 35 to 55 percent more protein than the recommended daily allowance established by the government of 0.8 grams of protein per kilogram of body weight. "Based on that ... we don't have a protein issue in the [United States]," says nutritionist Joseph Matthews of the University of Arkansas for Medical Sciences (UAMS) in Little Rock.

Except there's a catch: Dietary guidelines worldwide tend to hinge on the assumption that all whole-food protein sources are created equal. In the United States, for instance, the guidelines stipulate that the protein in an ounce of meat equals the amount of protein in, for example, a cooked egg, a quarter cup of cooked beans, a tablespoon of peanut butter or half an ounce of mixed nuts.

Mounting evidence says that's not true. "Those equivalencies aren't equivalent," says metabolism expert Rob Wolfe, also at UAMS. "We should pay attention to the quality of the protein." Quality is determined by the molecular makeup of a given protein and how it gets digested in the body. Work by Wolfe and others shows that animal foods such as meat, dairy and eggs typically contain higher quality proteins than plant foods, including legumes, nuts and seeds.

So right now, even if most people are eating enough protein, they may not be eating the right mix. Older populations are especially vulnerable, with some estimates suggesting that up to half of U.S. adults over age 70 struggle to eat enough high-quality proteins. That deficiency can lead

CHRISTIAN GRALINGEN

to lost muscle mass over time and weakness. That can make it hard for people to perform daily tasks and increase their risk of falls.

It's not that people should be eating more meat, says Glenda Courtney-Martin, a nutritional scientist and dietitian at the University of Toronto Hospital for Sick Children. People in wealthy countries are generally advised to eat less meat to reduce greenhouse gas emissions and improve overall health, because eating meat is linked to ailments from cardiovascular disease to cancer.

Instead, she and other nutritionists say people can get high-quality protein if they adjust how much plant-based protein they eat, which foods they eat together and even how they prepare their protein sources.

PROTEIN QUANTITY VS. QUALITY

Proteins are made up of long amino acid chains. How those amino acids are sequenced determines the type of protein created. To work properly, the human body needs 20 amino acids. Our cells can make 11 of those amino acids, while the remaining nine, called essential amino acids, must come from food.

Foods vary widely in their essential amino acid composition. Beef, chicken, fish, milk and eggs contain enough of all the essential amino acids; nuts and most beans do not. Additionally, proteins in food come bound up in fibers and other substances that the body must break down to access the essential amino acids. This affects what nutritionists call their bioavailability. In general, the body is better at breaking down animal proteins than plant proteins.

Moreover, the body will make only as many proteins as possible with the amino acids present and bioavailable in a given time frame, though researchers aren't yet sure if this means hours or days. Any extra amino acids cannot combine to make a complete protein, so they get tossed out.

"If only half the protein you eat is actually being digested and absorbed into the body, [and the rest] just passes through you and is excreted, it's not providing any benefit," Wolfe says.

Current dietary guidelines, which consider protein quantity but not quality, can mislead consumers, Wolfe and his team argued in May 2021 in the *Journal of Nutrition*. The researchers randomly assigned 56 adults ages 18 to 40 to one of seven food options: beef sirloin, pork loin, eggs, kidney beans, peanut butter, tofu or mixed nuts. Each person ate what counts as the same amount of protein under the U.S. dietary guidelines. Using an intravenous tracer, the team could measure how efficiently each person turned amino acids from the protein source into muscle proteins, a process known as muscle protein synthesis. The researchers found that participants in the animal product groups synthesized more proteins than participants in the plant groups.

In an accompanying commentary, Courtney-Martin says that this sort of research is key to sustainably transforming the global food system. The study shows that U.S. dietary guidelines "promote a false equivalence that all proteins are equal, which indeed, they are not," she writes.

One solution is to build dietary guidelines around essential amino acids rather than proteins, says nutritional biochemist Donald Layman of the University of Illinois Urbana–Champaign. "We don't have a protein requirement at all. What we have is a requirement for nine essential amino acids."

To that end, Layman and his team have developed a tool, the EAA-9, to calculate amino acid requirements. Consider an egg. A single egg provides around 25 percent of the recommended daily allowance for several amino acids, but only 15.77 percent of the allowance for the essential amino acid histidine. Because the body will toss out all the amino acids in excess of the histidine, an egg gets an EAA-9 score of 15.77. Peanut butter, meanwhile, is so deficient in the essential amino acid lysine that a single tablespoon clocks in with a score of just 4.04.

Current U.S. guidelines stipulate that the amount of protein in a tablespoon of peanut butter is equivalent to the amount of protein in a single egg, but based on the EAA-9, that's woefully off base, Layman and colleagues reported in July in the *Journal of the Academy of Nutrition and Dietetics*. Per those scores, a person would need to eat roughly four times as much peanut butter to get the same protein benefits found in a single egg. When it comes to legumes, a person

35 – 55 percent

The amount of protein U.S. adults are eating in excess of the daily recommended allowance

would need to eat more than twice the recommended daily intake — for instance, over half a cup of kidney beans instead of the recommended quarter cup — to match an egg's protein benefits.

Part of the reason protein guidelines tend to fall short is they assume people are eating a meat-heavy diet, experts say. The Netherlands illustrates how to reorient nutrition guidelines around a plant-based diet without compromising people's consumption of high-quality proteins, Matthews says. For several years, the country has sought to reduce greenhouse gas emissions by encouraging people to eat less meat. The Health Council of the Netherlands recommends that people reduce red meat consumption while eating weekly servings of legumes and fish. The council also advises that people eat daily servings of fruits and vegetables, dairy and nuts.

In their early guidelines, the Health Council of the Netherlands advised individuals who don't eat meat, including vegetarians and vegans, to consume 30 percent more protein than meat eaters. More recently, though, Dutch officials said vegetarians can meet their protein needs through animal foods, including dairy and eggs. Vegans should still try to eat more protein.

Increasing the amount of protein people get from plant-based sources without eating more calories can be tricky, researchers say. In the United States, most of the suggested protein swaps have roughly the same amount of calories. Calibrating serving sizes according to amino acid availability instead of caloric intake shows that a person would need to eat 370 calories of peanut butter or 120 calories of kidney beans to get the same protein benefits found in a single, 70-calorie egg.

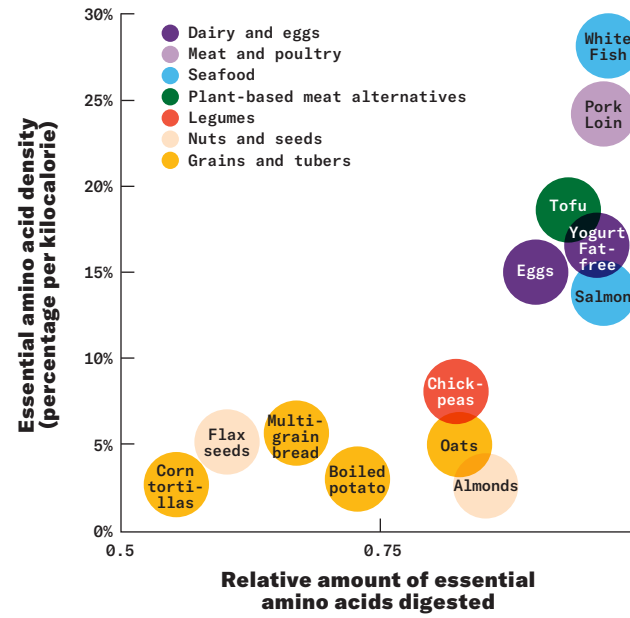
"If your diet has mostly lower-quality proteins, then you need more quantity," Matthews says.

VULNERABLE POPULATIONS

Certain populations may struggle to safely reduce meat consumption, Dutch officials noted. Pregnant and breastfeeding individuals, for instance, require more protein than average.

Meanwhile, mounting evidence suggests that lowering meat consumption may be particularly challenging for older adults, who often struggle to eat large meals. Older adults also seem to require more of certain amino acids than younger adults. For instance, Courtney-Martin's work shows that adults over 60 require more than double the amount of the amino acid leucine

PROTEIN QUANTITY VS. QUALITY



↑ Different foods provide higher quality proteins based on their essential amino acid density and how well they're digested in the intestines.

than current recommendations.

Inadequate amino acid intake can hamper people's ability to turn proteins consumed into muscle. And that can in turn increase older adults' likelihood of developing sarcopenia, an age-related musculoskeletal disease that leads to reductions in muscle mass, strength and performance. Thought to afflict over a quarter of people over age 60 worldwide, sarcopenia can increase the likelihood of injuries, such as broken bones from falls, and the time it takes to recover from such injuries.

Part of the challenge for older adults is less efficient muscle protein synthesis, research shows. For instance, Dutch researchers found that muscle protein synthesis in healthy, twentysomething males was similar for groups that consumed plant proteins, such as those in potatoes or wheat, and milk proteins. But the team reached the opposite conclusion in a similar study of healthy older adults.

In that study, the team recruited 16 adults ages 65 to 85 and compared how their bodies responded to a vegan meal of chickpeas, quinoa, soybeans, broad beans and soy sauce versus a meal of lean ground beef, string beans, potatoes, applesauce and herb butter. Both meals contained complete amino acid profiles and similar quantities of protein. Participants who

ate the nonvegan meal had higher levels of essential amino acids in their blood six hours after eating than those who ate the vegan meal, the team reported in the *Journal of Nutrition* in July 2024. Crucially, those eating the nonvegan meal showed 47 percent higher muscle protein synthesis rates than those eating a vegan meal.

Some scientists now argue that the daily protein requirements should be raised for adults age 65 and older — from 0.8 grams to up to 1.5 grams of protein per kilogram of body weight.

↑ Grocery store shelves are lined with processed foods with added protein. But experts recommend getting most protein from whole foods.

HOW TO BALANCE YOUR PROTEINS

Athletes and pregnant or lactating individuals may also benefit from eating more protein than current recommendations. But most younger adults in developed nations can safely replace some animal proteins with plant proteins, Courtney-Martin says. A diet higher in plants may even help people feel better.

Many people with Western diets consume too much saturated and trans fats, leading to cardiovascular disease — "a plague in developed nations," Courtney-Martin notes. Considerable research shows that diets high in plant foods also contribute to improved blood sugar control, better bowel health and lower cholesterol.

The benefits are more than physiological. Food production, particularly meat production, takes a heavy environmental toll in terms of greenhouse gas emissions, biodiversity loss and land-use changes, researchers wrote in February 2019 in the *Lancet*. They recommended that people worldwide consume primarily plant foods, some seafood and poultry and almost no red meat.

Whatever the reason, one key to reducing meat consumption is helping people learn how to eat, and ideally enjoy, plant-based foods while still meeting their protein needs.

Matthews, Wolfe and their team listed several recommendations for how to improve the protein quality of foods in July in the *Journal of Nutrition*. Legumes, for instance, don't have very much of the amino acid methionine, but they have ample amounts of lysine. Rice has the opposite amino acid profile. So eating beans and rice together, as is common throughout the world, can provide a high-quality protein. This is not a new concept; more than 50 years ago, Frances Moore Lappé, author of the 1971 book *Diet for a Small Planet*, noted that combining different plant-based foods gives people access to amino acid profiles similar to those in animal-derived protein.

Another tactic is substituting rice with other cereals, such as sorghum or millet. And simple processing methods for lentils and beans such as soaking, sprouting and fermentation can reduce antinutrients, compounds that hinder the body's ability to digest proteins, such as phytates, tannins and calcium oxalates.

People can also get more protein out of meats and other animal products so they can eat less of them, the team noted. For instance, older adults may have difficulty chewing their food, which limits protein availability. Such people can opt for the same amounts of foods but choose ground beef over steak or soft foods such as yogurt.

But consumers still need clear guidance on how to get the most from what's on their plates, Courtney-Martin says. She envisions simple dietary guidelines built around plant-based diets and personalized to the needs of given demographic groups. For instance, a model plate for a young adult might show chickpeas, rice and vegetables as a complete meal, while a similar plate for an older individual might depict that same trio of foods alongside a small cut of meat, an egg or a cup of yogurt.

Most people in Western nations have some wiggle room to reduce their consumption of animal proteins and still meet their nutritional needs, Courtney-Martin says. For her part, she has started cooking a pot of beans or lentils and storing them in the fridge for a week. Instead of having two pieces of chicken for dinner one night, she can have one piece with a quarter cup of legumes.

"I am consistently eating less animal than I would normally eat," she says. ✖

LEFT: KEITH HOMAN/ALAMY; OTHER TWO: STEVE CUKROV/ALAMY

JUST RELEASED!

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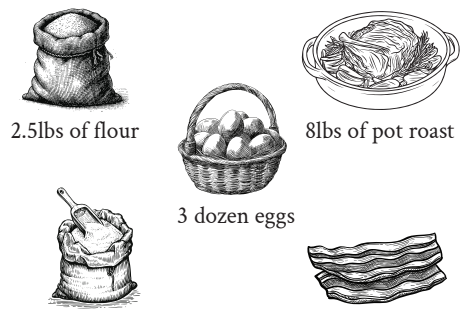

Prized Last-Year Coins
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Curiosities

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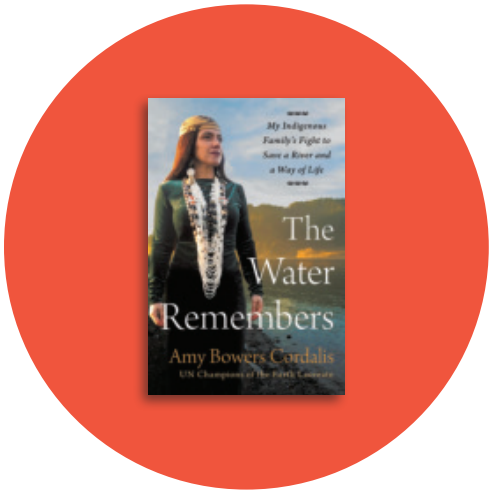
LIFE

THE DIM GLOW WE ALL POSSESS

● Plenty of organisms on Earth emit bioluminescence as a result of chemical reactions in their bodies. Firefly squid (*Watasenia scintillans*; one shown above), for example, generate blue light from special organs called photophores found all along their 8-centimeter-long figure. But bioluminescence isn't the only way for earthlings to shine. Every being produces what are called biophotons, measly emissions that cannot be seen with bare eyes (see Page 62). Scientists are researching what function biophotons play in all organisms. —*Karen Kwon*



AN INDIGENOUS FIGHT TO RESTORE A RIVER

By Aina Abell

THE WATER REMEMBERS | *Amy Bowers Cordalis*
Little, Brown & Co. | $30

In September 2002, an estimated 34,000 to 78,000 adult Chinook salmon died in the Klamath River within the Yurok Reservation in Northern California. The U.S. government had diverted river water to farms during a drought. The resulting low levels and warm temperature of the water, coupled with the flow of toxic blue-green algae that bloomed in the reservoirs behind the river's four dams, created the perfect conditions for "ich," a parasitic gill rot disease, to spread and suffocate the fish. It was one of the largest fish kills recorded in U.S. history.

The ecological disaster catalyzed an Indigenous-led movement to remove the dams, the oldest of which had choked the river, blocking fish migrations and tainting water quality, for over 100 years. In *The Water Remembers*, Yurok tribal member, activist and attorney Amy Bowers Cordalis shares an intimate look into her family's and nation's decades-long fight to restore the health of the Klamath and preserve their way of life — a multigenerational effort that culminated in the largest dam removal and river restoration project in history.

The Yurok people believe it is their duty to live in balance with nature. They steward the Klamath and its surrounding ecosystems. In return, the river gives them sustenance, physically and spiritually. This sacred reciprocity is reflected in Yurok stories, Cordalis writes, which "teach that if the Klamath salmon and the Klamath River die, so will the Yurok people."

Cordalis' reverence for the river, the salmon and the craft of fishing drips from every page of this memoir. She describes the thrill that overcomes her and other members of the Yurok Nation when salmon return to the Klamath River from the Pacific Ocean to spawn. Bobbing in a boat, gill net in hand, surrounded by trees, water and wildlife, is a spiritual practice.

Every page is also stained with stories of historical injustice. For nearly two centuries, colonization, genocide and their lingering scars have threatened the Yurok's way of life, from the United States' theft of Yurok land since the 19th century to California's mid-20th century ban on Yurok fishing to boost non-Indigenous logging and fishing businesses.

Through it all, Cordalis' family has resisted. Cordalis' great-grandmother, Geneva Mattz, and her sons fished and sold bootlegged salmon throughout the ban. In the late 1960s, her great-uncle Ray Mattz sued California for violating his Indigenous rights by repeatedly arresting him for fishing on his ancestral land — a case that he won in the CONT. ON PAGE 59

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CONT. FROM PAGE 56 U.S. Supreme Court in 1973. The 2002 fish kill reinvigorated this tradition of resistance. Cordalis, then a 22-year-old intern at the Yurok Tribal Fisheries Department, witnessed the devastation firsthand. Her gruesome descriptions of the limp and rotting carcasses of thousands of salmon crowded on the riverbank convey the visceral and emotional response of the Yurok to what Cordalis deems an "ecocide."

The moment set Cordalis' path to law school, eventually becoming the Yurok Nation's general counsel and one of the key leaders of the historic "Undam the Klamath" movement. After two decades of demonstrations, as well as painstaking negotiations between tribal, corporate and U.S. government entities, the U.S. Federal Energy Regulatory Commission voted to undam and restore the Klamath River in 2022.

Today, the river flows freely, with the last dam removed completely in October 2024. That same year, salmon were able to migrate and spawn farther upriver, past the former dam sites, for the first time in over a century. Projects to restore the Klamath Basin's ecosystems are planned through 2028.

The Water Remembers is a moving and deeply personal account of a rare environmental success story — one in which Indigenous people, corporations and the state and federal government collaborated (though not always for the same reasons) to restore a river in crisis. While the book is rife with the Yurok people's struggle for justice, it is also an emblem of hope that environmentally responsible solutions to climate crises are possible. "All humans have ancestral knowledge in our blood about what it was like to live on a healthy planet," Cordalis writes. "The medicine is still here, in you and me. In all of us. We can restore the balance. We can renew the world." ✖

OTHER BOOKS ON THE SHELF

SCIENCE UNDER SIEGE | *Michael E. Mann and Peter J. Hotez*

PublicAffairs | $32

Dangerous antiscience movements are spreading globally. Two renowned scientists unveil the forces stoking the fire and provide a road map to put trust back into scientific truth.

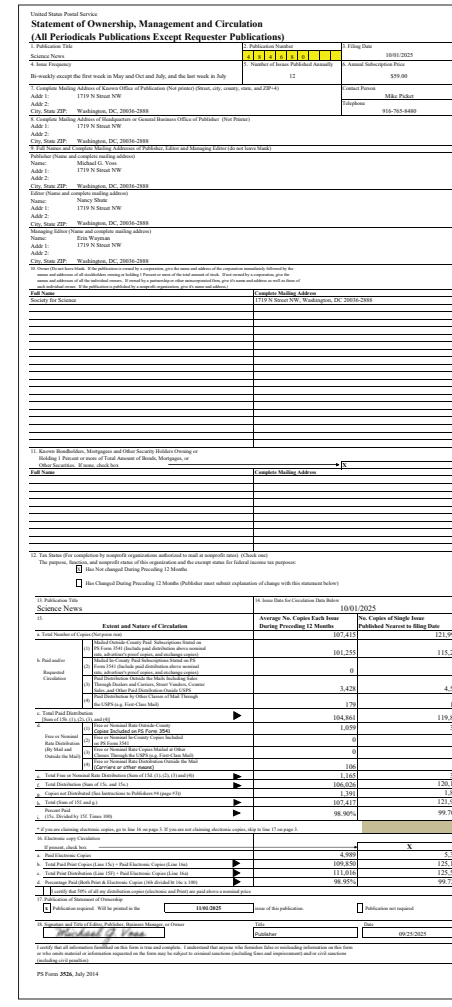
LAB DOG | *Melanie D.G. Kaplan*

Seal Press | $32

A journalist adopts a beagle that spent years in a research lab. Their love story sparks an investigation into the use of the hounds in biomedical research and product testing, as well as the promising future of nonanimal testing. ✖

"All humans have ancestral knowledge in our blood about what it was like to live on a healthy planet."

— Amy Bowers Cordalis



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Conversations with Maya

Maya Ajmera, President & CEO of the Society for Science and Executive Publisher of Science News, spoke with David R. Liu, Thomas Dudley Cabot Professor of the Natural Sciences at Harvard University, Howard Hughes Medical Institute Investigator and vice-chair of the faculty at the Broad Institute of MIT and Harvard. Liu is an alumnus of the 1990 Science Talent Search (STS), a program of Society for Science.

HOW DID PARTICIPATING IN STS IMPACT YOUR LIFE? Competing in STS was a transformative event in my life. I grew up in Riverside, Calif., and while I felt that my public high school helped foster my interest in science and writing, I didn't know how my knowledge compared with other students. When I arrived at STS, I immediately felt impostor syndrome and felt that someone must have made a mistake. Over time, however, I realized that the judges placed a higher value on how quickly and eagerly I could learn, as opposed to how much I knew as a high school senior. That's a lesson that has strongly influenced my career.

I think the short answer to your question is this: the end result of having a good experience during STS and being named a finalist was gaining confidence in myself.

WHAT INITIALLY DREW YOU TO SCIENCE? Frankly, it was studying bugs and plants in my backyard. I've always been introverted, and for me, an ideal way to spend an afternoon in the warm California weather was in my backyard, looking at insects and plants and trying to understand how they functioned, how they behaved and how they could communicate with each other. I began to do what I now realize were experiments, but back then I was just following my curiosity.

YOU ARE A PIONEER IN DEVELOPING TECHNIQUES TO TREAT GENETIC DISORDERS, NOTABLY BASE AND PRIME EDITING, OTHERWISE KNOWN AS CRISPR. HOW DO THESE TECHNOLOGIES DIFFER? CRISPR, as it evolved in nature, is really DNA-cutting scissors. CRISPR is a bacterial immune system that cuts DNA to defend bacteria from viral infection. CRISPR proteins such as Cas9 find a target DNA sequence that matches a sequence in its guide RNA, and then it cuts the DNA double helix into two pieces, literally cutting a chromosome into two pieces. That's a very effective way to disrupt genes, which is after all exactly what CRISPR-Cas9 evolved to do in nature. Around 2013, I became particularly interested in treating genetic diseases. But most genetic diseases cannot be treated by disrupting a gene, and instead require correcting the mutations that cause the disease.

So together with Alexis Komor, then a new postdoc, we decided to try to develop a new form of gene editing that uses the DNA targeting mechanism of CRISPR. Instead of disrupting genes, we would precisely fix genes on an individual DNA base in the genome at a specific site.

Base editors, which we first reported in 2016, were the first direct way to convert one genetic base pair into another base pair in living systems, including in animals and in human patients. In 2019, we reported on prime editing, which I'll explain like this: If you think of CRISPR-Cas9 DNA as cutting scissors and base editors as DNA letter rewriting pencils, then prime editors are sort of like DNA word processors. They perform true search and replace editing where you can take a specific segment of DNA and replace it with any other segment of DNA that you specify.

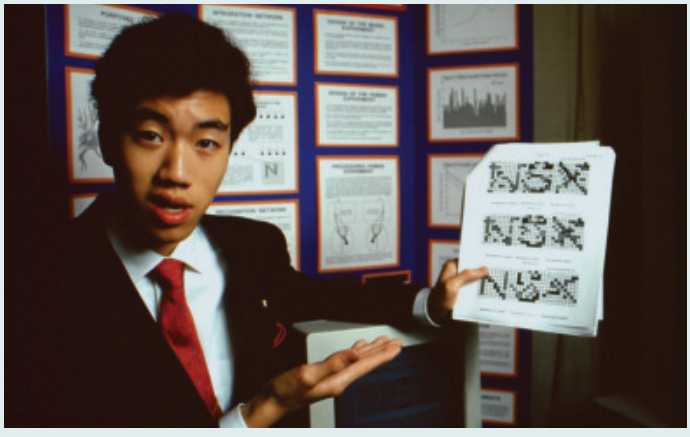
WHAT IS THE THERAPEUTIC POTENTIAL OF THESE TECHNOLOGIES? Collectively, base editing and prime editing can correct the vast majority – more

than 90 percent – of all known pathogenic human mutations. There are more than 200,000 mutations known now that collectively cause 10,000-plus genetic diseases. Of course, correcting the mutation doesn't necessarily mean that you can cure the disease, but it's an important step toward treating the root cause. Base editing and prime editing have been involved in at least 23 clinical trials around the world.

In 2022, Alyssa Tapley, a 13-year-old T cell leukemia patient, became the first person to receive a base-edited therapeutic. Her T cell leukemia was cleared by CAR T cells, which are T cells that are engineered to kill cancer cells. The CAR T cells Alyssa received were modified with three critical base edits, which enabled those CAR T cells to kill her cancer, but not her healthy tissues, and not each other. She is now a healthy teenager.

YOU HAVE COFOUNDED MULTIPLE BIOTECH COMPANIES. HOW DO YOU SEE THE ROLE OF ACADEMIA EVOLVING IN TRANSLATING CUTTING-EDGE RESEARCH TO REAL-WORLD THERAPIES? Academia plays an essential role, especially in the risk-averse environments like we're facing right now. Generally, companies are not founded to develop completely new ways of doing things. Instead, therapeutics companies take well-validated research and try to industrialize and commercialize it. If academics hadn't developed the kinds of gene-editing technologies that we've talked about in this conversation, it is unlikely that an existing pharmaceutical or biotech company would've taken the concept from interesting observation all the way to a drug.

WHAT DO YOU SEE AS THE BIGGEST MISCONCEPTION THE PUBLIC HAS ABOUT GENE EDITING? AND HOW CAN THIS TECHNOLOGY BE DEPLOYED ETHICALLY AND RESPONSIBLY? The public's initial reaction to the knowledge that we could edit genes was a fear of some kind of dystopic science fiction-like *GATTACA* future, in which super soldiers and designer babies ruled the world. That's a misconception for several reasons, most importantly because there's no simple way to create edits that ensure a human suddenly has traits as complex as athletic ability, intelligence or the ability to be a good soldier.



David R. Liu presents his STS project in 1990. ↙

LOOKING BACK, DID YOU RECEIVE ANY ADVICE THAT YOU STILL CARRY WITH YOU TODAY? WHAT IS YOUR APPROACH TO MENTORSHIP? All my mentors encouraged me to pursue what I was most curious about, not what anybody thought my field should be. During my 26-year academic career as a chemist, I've seen chemistry go through periods where people were uncertain as to what chemistry should be. I always ended up pursuing what I was most curious about because that's how I could do my best work. Whether you're successful or not, as one of them said, you want to succeed or fail doing David Liu science, not doing the science that somebody else told you to do.

WITH THE CURRENT CLIMATE IN HIGHER EDUCATION, HOW WOULD YOU QUALIFY THE IMPORTANCE OF INVESTMENT INTO BASIC RESEARCH? There are few investments that the U.S. can make that pay a bigger return to the country, to the economy and to our quality of life than investing in science and science education. For all the gene-editing technologies we discussed, the key innovations were largely the result of U.S. federal investment in science research. We seem to be at a critical moment in which science is in jeopardy, even as other countries are doubling down on their investment in science. There are more clinical trials using base editing or prime editing in China right now than there are in the U.S., even though those two technologies were developed in my lab, funded by U.S. taxpayers.

WHAT GIVES YOU HOPE FOR THE FUTURE? That's an easy question. The best part about being an educator is I get to have a lab of 30 or so graduate students and postdocs, and I get to teach classrooms full of students. They fill me with optimism about the potential of our future. These young people are bright and motivated and are poised to become the next generation of world-changing scientists. We must ensure that we continue to support them and continue to support the science that they feel so passionate about.

IT'S NOT MOVIE MAGIC, BUT WE ALL HAVE A (VERY TINY) GLOW

BY BETHANY BROOKSHIRE

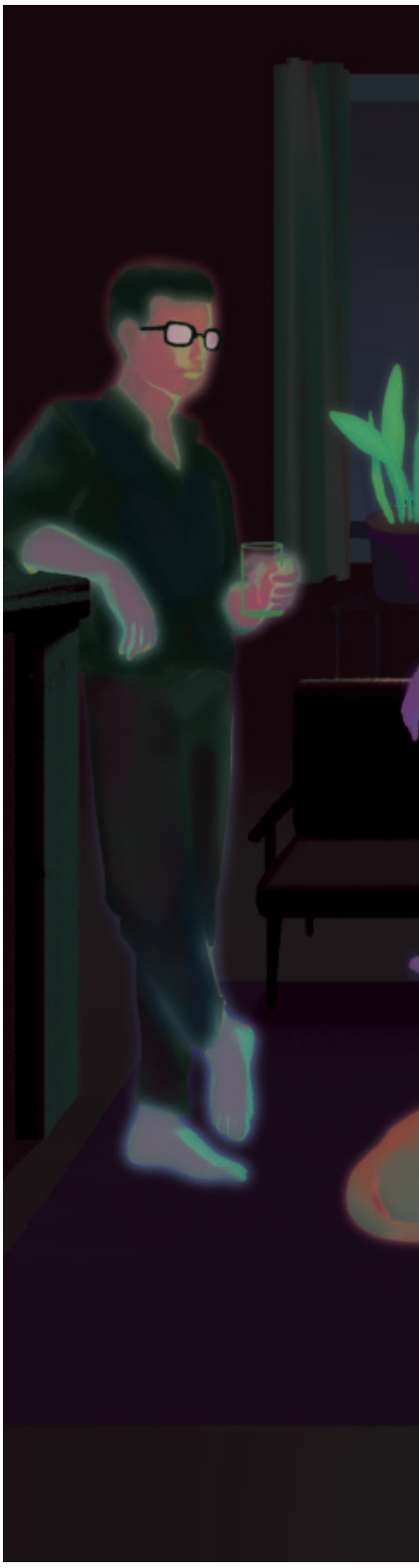
Many science fiction and fantasy stories are enveloped in a warm glow, and it's not just because of nostalgia. Some characters literally glow — from ET's fingertip to the demon markings in this year's hit movie *K-Pop Demon Hunters*. This glow-up is easy to draw or add in post-production for movie magic. But while we can't see it unaided, we — and every organism around us — really do produce tiny amounts of light. Scientists still aren't sure whether these biophotons serve a purpose, or if they're just glowing motes of cellular junk.

It's not bioluminescence, a well-known set of chemical reactions, says Catalina Curceanu, who is a nuclear and quantum physicist at Italy's National Institute of Nuclear Physics–National Laboratories of Frascati. Nor is it thermal radiation — the result of our heat production.

Instead, biophotons are individual photons that appear to be a by-product of normal cellular processes, though it's unclear how they form, says quantum physicist Christoph Simon, of the University of Calgary in Canada. For example, cells often produce reactive oxygen species, small molecules with highly unstable oxygen atoms that can serve as signals in the cell or can damage other molecules.

When these reactive molecules attack lipids — long links of fatty acids that form things like cell membranes — they produce "a kind of a chain reaction," Simon says. "When two of those radicals meet and make another radical," energy is released. That energy might be a photon with a wavelength between 200 and 1,000 nanometers — from ultraviolet through the visible spectrum to near infrared.

Many biophotons will never see the surface of the cell, let alone our skin. Instead, they're absorbed by the vast forest of proteins, lipids and other cell structures. But some do escape, "about 1,000 photons per square centimeter per second" from our skin, Simon says. It's about a millionth the intensity of a firefly and can't be seen with the naked eye, adds Simon, who with



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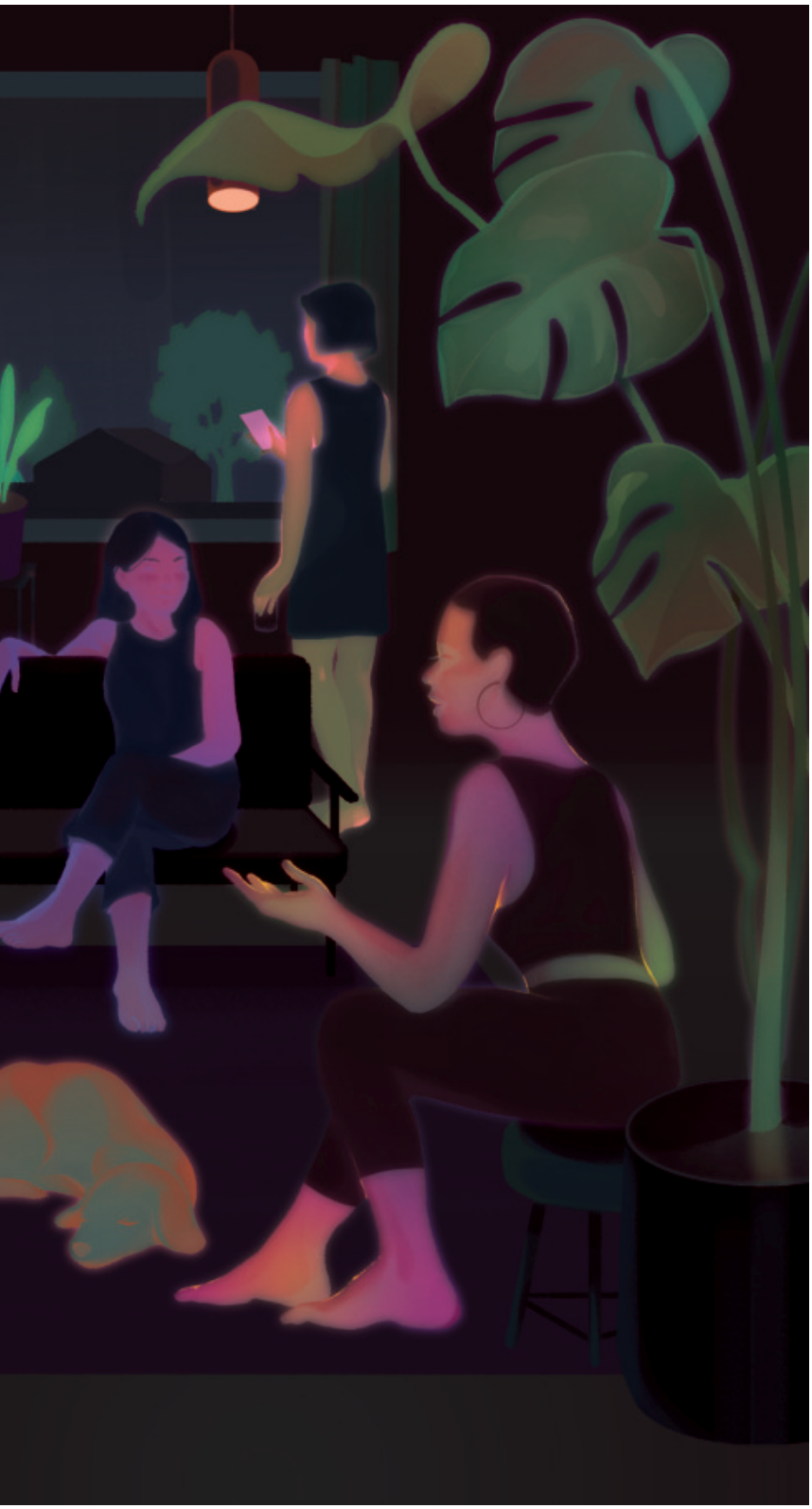


colleagues has detected these photons from the skin of live mice.

Germinating lentils and beans also give off biophotons, Curceanu and colleagues found. “It shows some pattern, some complexity … like this signal might be used for something,” she says.

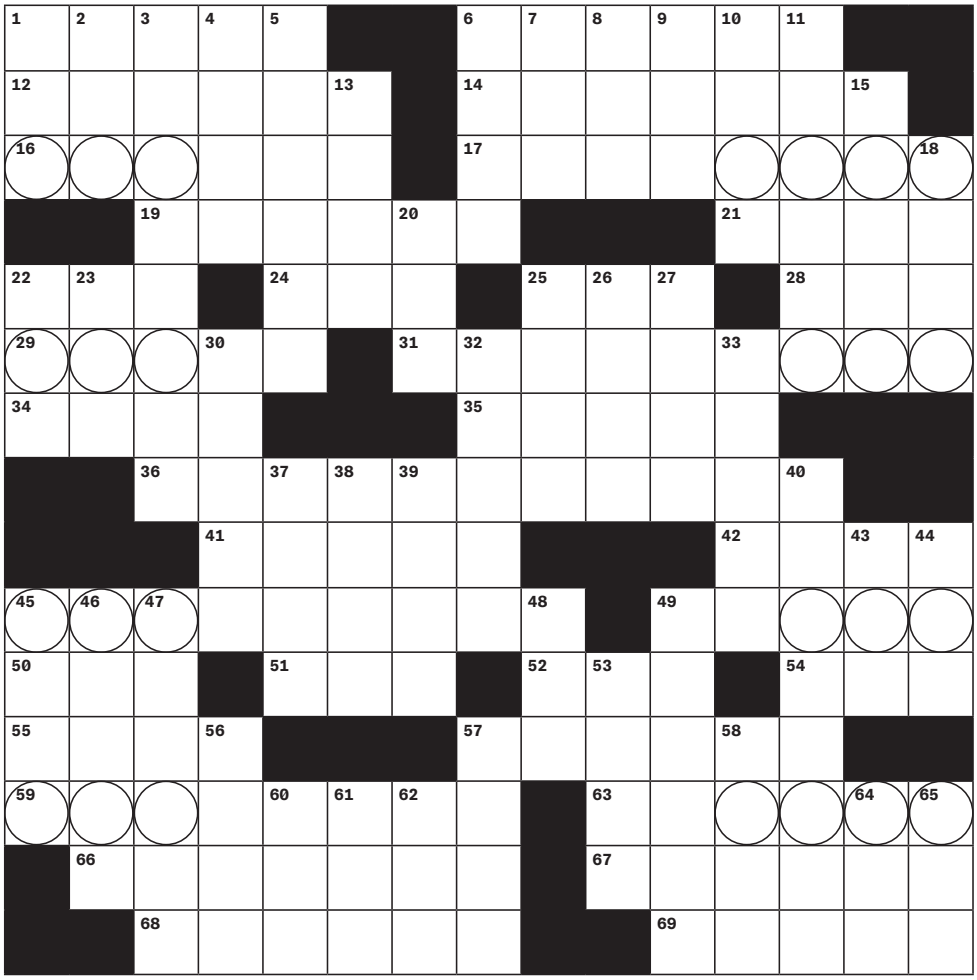
What that something is, though, is a mystery. Many organisms have molecules called rhodopsins that detect light. We have them in our eyes. But the true work of this light might be happening in the shadows.

Some smaller molecules in the body can absorb and reemit light, says Philip Kurian, a theoretical physicist at Howard University in Washington, D.C. The amino acid tryptophan, a building block of proteins, is especially fluorescent.

Kurian and his colleagues have shown that some cell structures like microtubules — which form the structural skeleton in cells — have protein arrangements that could allow tryptophan to act as a quantum information network. The amino acids could share a photon, giving it a chance of being in two different places in the network at the same time, a quantum superposition.

The effect boosts the fluorescence of the tryptophans “and that allows for greater information processing,” he says. So these biophotons could be used to speed information processing in cells — or beyond. This might explain why our brains are capable of so much processing with so relatively little power, Kurian says.

The glow of science fiction is not the light of biophotons, Curceanu notes. “It’s easy to get it wrong on biophotons and to imagine that we are all glowing in some totally not realistic way.” But life does emit a tiny bit of light, and scientists are working to find out why it shines. ✖



WORLDS APART

BY AUGUST MILLER AND SHANNON RAPP

ACROSS

1 ___-Saxon
6 Like a watch with hands
12 Coloring in a salon
14 Excision
16 Brazilian palm tree whose seeds can be used to make jewelry
17 Big soda bottle size
19 Tines
21 "Whip It" band whose name is an anagram of DOVE
22 Opposite of post-
24 Practical purpose
25 Participate in a Q&A, perhaps
28 Roadside assistance org.
29 Mythical man–goat hybrid
31 Spring filing
34 "I'm ___ it!" ("I'm a fan!")
35 Distance traveled by light in a vacuum in 1/299,792,458 seconds
36 One of four major bodies orbiting beyond the asteroid belt … or a feature of four rows in this puzzle?
41 Video game stage
42 Mood
45 Body that feeds the Caspian Sea
49 Letter grade modifier
50 Parent celebrated in June
51 Sports org. with the New England Revolution
52 Texter's "To me …"
54 Org. that published a zombie pandemic guide
55 "Sounds good to me"
57 Kind of grasshopper that swarms
59 One riding the coattails of a successful parent, in modern slang
63 Acclimate
66 Water ___ (insect capable of running across a pond's surface)
67 Insect's middle section
68 Arizona city home to pink sandstone formations
69 Won all the games in a series

DOWN

1 Word such as "descriptive" (Abbr.)
2 Sch. whose main campus is in lower Manhattan
3 Pinocchio's maker
4 Untruth teller
5 Traveling from gig to gig
6 ___ and sciences
7 Just released
8 "Ti ___" (Italian for "I love you")
9 Chuckle in a chat box
10 Roman poet who wrote "Metamorphoses"
11 ___ Basque (French cake with layers)
13 Juniper-flavored spirits
15 "Reading Rainbow" host Burton
18 "Good Luck, Babe!" singer Chappell
20 Procure
22 Tire pressure unit (Abbr.)
23 Conducted, as an experiment
25 Leap named for figure skater Paulsen
26 Mlle. : French :: ___ : Spanish
27 Eager
30 "___ regret that!"
32 Plenty
33 Famed fountain in Rome
37 Another word for "word"
38 This is not good!
39 Amps (up)
40 Pharmaceutical solution
43 Flower-to-be
44 Key above the tilde
45 Yaki ___ (stir-fry dish)
46 Tools for gathering garden debris
47 Changes with the times
48 First South American city to host the Olympics, familiarly
49 They open at the dentist
53 Hurdle for aspiring DOs
56 Days of ___ (olden days)
57 Constellation named for a string instrument
58 Put away, as baggage in an overhead bin
60 Make an effort to buy
61 Shakespeare's "Much ___ About Nothing"
62 "Severance" producer and director Stiller
64 Quick snooze
65 Abbr. after a business phone no.

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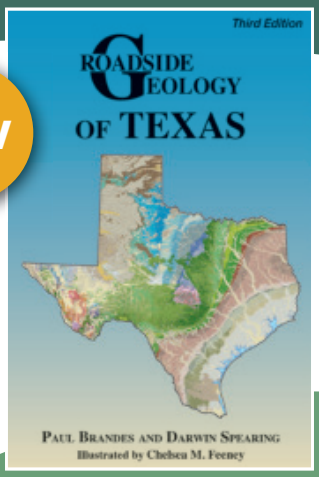

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