Superconductor Controversy | Early Galaxies Too Big to Explain

Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ MARCH 25, 2023

IN OUR AIR

Microplastics are all around us, but the risk to human health is largely unknown

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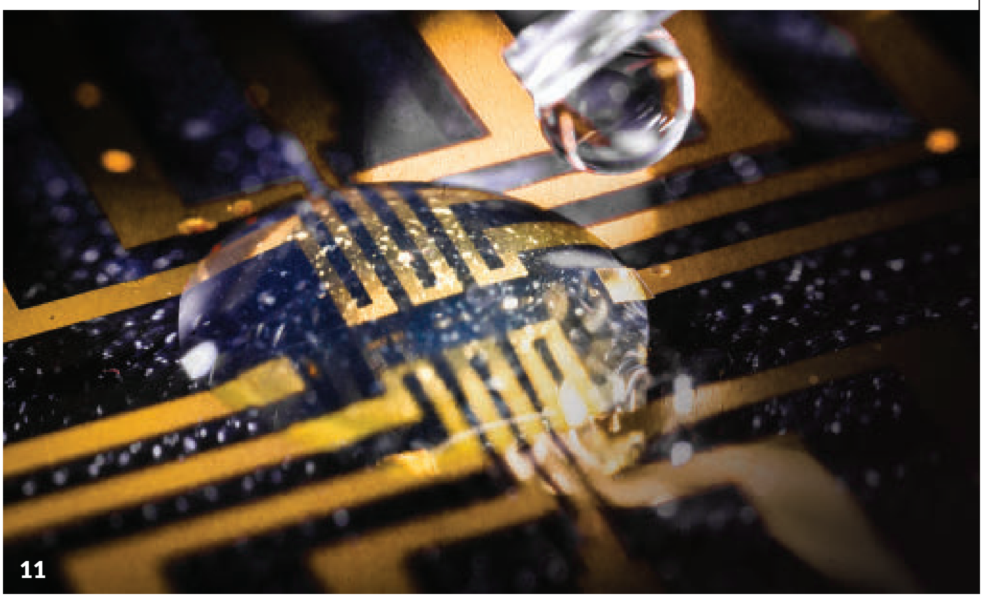
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COVER Concerns are growing about the presence of microplastics in the soil, water supply, air — and our bodies.
Lisa Sheehan

FROM TOP: EMILE HOLMWOOD; G. BRENNEIS *ET AL*/*PNAS* 2023; THOR BALKHED

Where does plastic go when we're done with it?

Human-made plastic materials have become so essential that it can be hard to grasp that they barely existed a century ago. At my desk, I'm typing on a plastic keyboard, scrolling a plastic mouse, picking up a plastic pen, tapping on a plastic calculator. Day after day, more plastic enters my life, whether it's a shampoo bottle, a plastic clamshell of grapes or new running shoes.

The invention of synthetic plastics in the early 1900s was a triumph of innovation, with chemists realizing they could orchestrate molecular structures to create materials that are lighter, stronger, brighter, cheaper, more flexible and more durable.

During World War II, nylon and other plastics became essential to the war effort. When the war ended, the nascent plastics industry focused on making products for everyday life. That's a history we explored last year as part of our Century of Science project (*SN: 1/29/22, p. 16*). You can read more on the rise of plastics and other innovations at www.sciencenews.org/century.

But the ubiquity of plastic has become a curse, with discarded objects clogging waterways and landfills. And when plastic does finally fall apart, minute particles disperse in the environment. We've known for years that microplastics have permeated the oceans (*SN: 2/20/16, p. 20*). In this issue, we report on research confirming that microplastics are also accumulating in our bodies. Plastic particles have been found in human blood, in body tissues and in breast milk (Page 22).

Talk about environmental contamination hitting close to home. As independent journalist Anne Pinto-Rodrigues reports, microplastics probably enter the human body through the food we eat, the water we drink and even the air we breathe. Though consuming microplastics along with lunch is creepy enough, the notion that we might be inhaling invisible bits with each breath feels much more disturbing.

Researchers have only recently begun quantifying the abundance of microplastics in the air, so it's not yet clear where people face the most exposure, whether at home, at work, on the road or somewhere else. Also unclear is what impact, if any, microplastics have on human health. Studies are just getting started to find the answers to these fundamental questions, and getting actionable data will take time.

I'm sure many of the pioneering chemists of a century ago didn't think about the ultimate fate of the miracle materials they invented, nor of potential long-term impacts on health and the environment. Science abounds with examples of unintended consequences. The discovery of radioactive elements led to life-saving medical treatments and nuclear power, but also to nuclear weapons and disasters like the Chernobyl power plant meltdown.

Microplastics are an unintended consequence that we can't put back into the Tupperware. Merely switching from plastic to paper bags won't fix this problem. Science now needs to determine the extent of the threat microplastics might pose and invent new ways to protect against any harms.

—Nancy Shute, Editor in Chief

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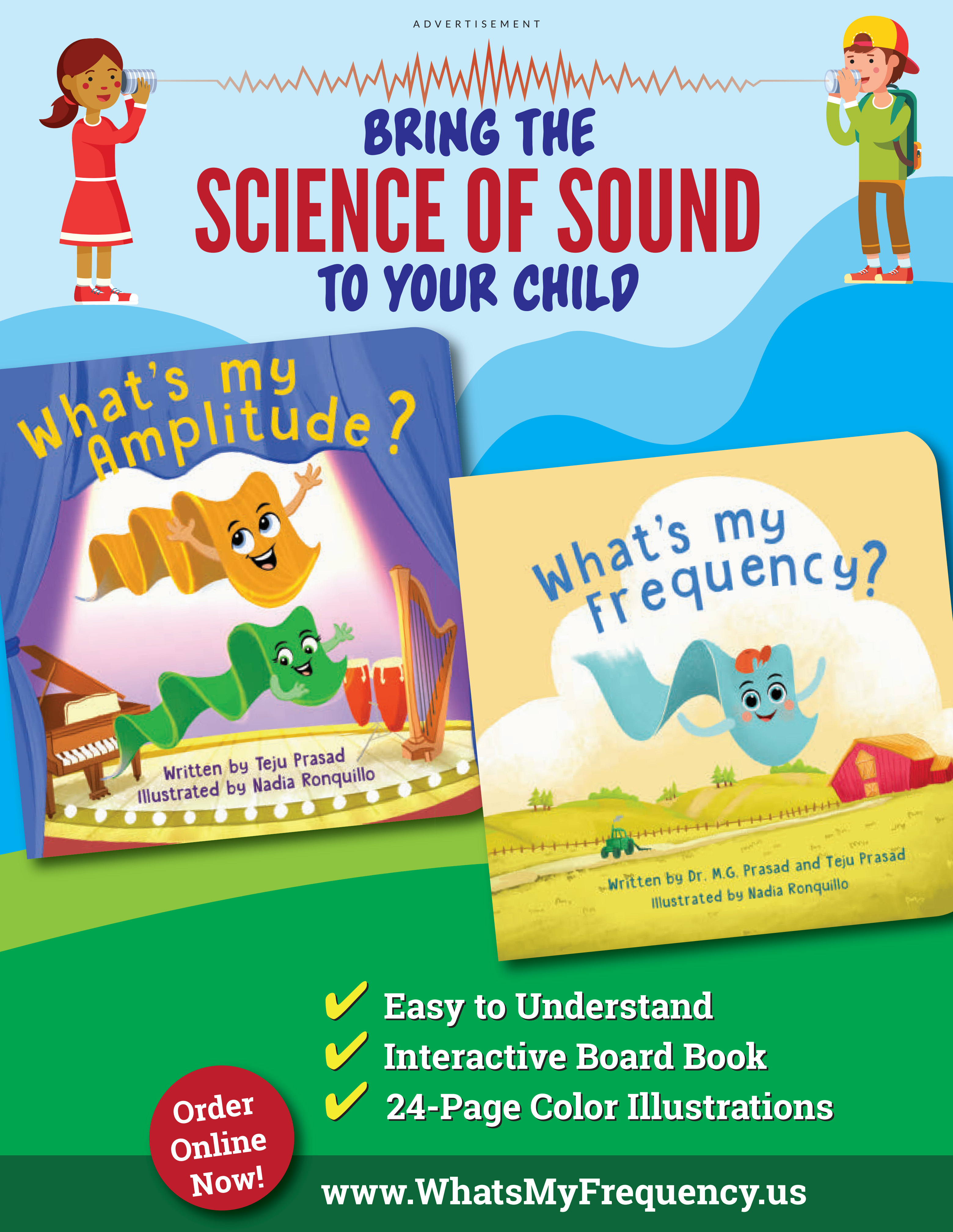
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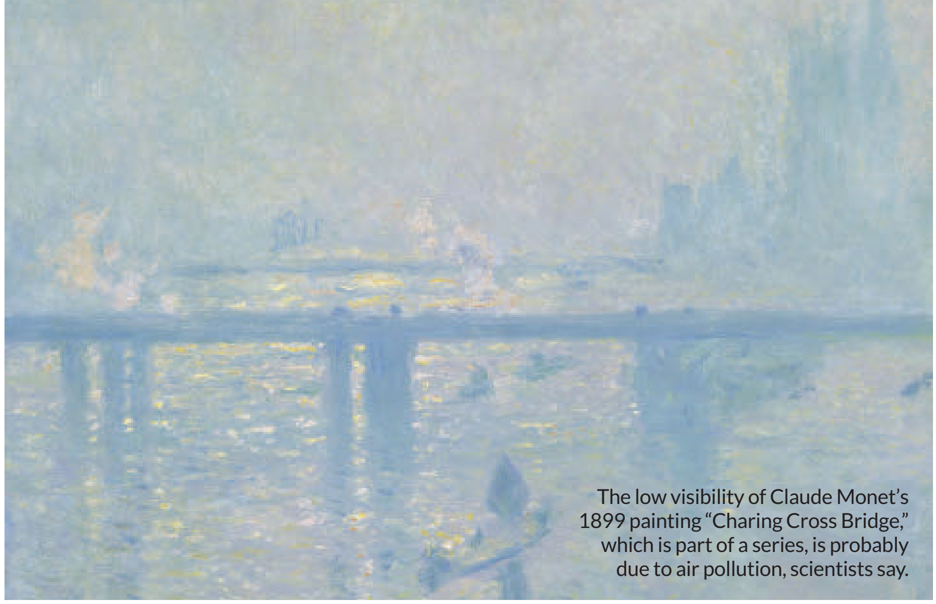
Excerpt from the March 31, 1973 issue of *Science News*

50 YEARS AGO

What pollution does to you

Scientists [attempted] to correlate pollution levels with various complaints of patients.... As expected, when smog increased, so did incidence of eye irritation, pulmonary disorders and nosebleeds.... Finally, for reasons not yet understood, more patients complained of animal bites on days when the air contained more suspended particulate matter.

UPDATE: The harms of air pollution go beyond irritated eyes, lungs and noses. Scientists have linked exposure to dirty air with an increased risk for heart disease, diabetes and dementia (*SN: 9/30/17, p. 18*), and have found associations with violent behavior. Air pollution appears to lead to aggressive behavior in other animals too. For example, the risk of dogs biting people goes up on smoggy days, an analysis of nearly 70,000 U.S. cases found. More bites occurred with increasing ground-level ozone, which occurs when pollutants react in sunlight, scientists reported in December on the preprint server Research Square. The dogs' aggression may be due to a stress response or brain impacts from the ozone exposure.



The low visibility of Claude Monet's 1899 painting "Charing Cross Bridge," which is part of a series, is probably due to air pollution, scientists say.

THE SCIENCE LIFE

Smog influenced impressionism's dreamy style

The 19th century landscape paintings hanging in London's Tate Britain museum looked awfully familiar to climate physicist Anna Lea Albright. Artist Joseph Mallord William Turner's signature way of shrouding his vistas in fog and smoke reminded Albright of her own research tracking air pollution.

"I started wondering if there was a connection," says Albright, who had been at the museum on a day off from the Laboratory of Dynamic Meteorology in Paris. After all, Turner—a forerunner of the impressionist movement—was painting as Britain's Industrial Revolution gathered steam.

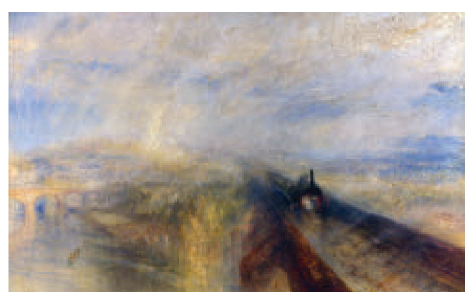
Turner's early works, such as his 1814 painting "Apullia in Search of Appullus," were rendered in sharp details. Later works, like his celebrated 1844 painting "Rain, Steam and Speed—The Great Western Railway," embraced a dreamier, fuzzier aesthetic. Perhaps this emerging style wasn't a purely artistic phenomenon, Albright thought. Perhaps Turner and his successors painted exactly what they saw: their environs becoming more and more obscured by smokestack haze.

To find out how much realism there is in impressionism, Albright teamed up with Harvard University climatologist Peter Huybers, who's an expert in reconstructing pollution before instruments existed to closely track air quality. The pair's analysis of 116 paintings by Turner, Paris-based impressionist Claude Monet and several others tells a tale of two modernizing cities.

Low contrast and whiter hues are hallmarks of the impressionist style. They are also hallmarks of air pollution, which can affect how a distant scene looks to the naked eye. Airborne particles called aerosols absorb or scatter light, making the bright parts of objects appear dim and shifting the entire scene's color toward neutral white.

The artworks that Albright and Huybers analyzed, which span from the late 1700s to the early 1900s, decrease in contrast as the 19th century progresses. That trend

Scientists tied rising air pollution to 19th century painter Joseph M.W. Turner's changing style, illustrated by "Apullia in Search of Appullus" (1814, left) and "Rain, Steam and Speed" (1844, right).



tracks with a rise in air pollution, the pair reports in the Feb. 7 *Proceedings of the National Academy of Sciences*.

Albright and Huybers distinguished art from aerosol by using a mathematical model to analyze the contrast and color of 60 paintings that Turner made between 1796 and 1850, as well as 38 Monet works from 1864 to 1901. The pair compared the findings with sulfur dioxide emissions over the century, estimated from the amount of coal sold in London and Paris. When SO_2 reacts with molecules in the atmosphere, aerosols form.

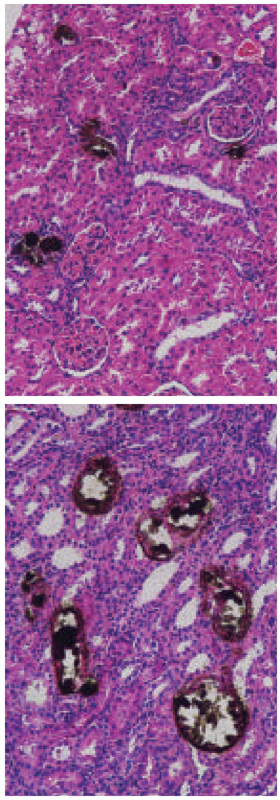
As SO_2 increased, the amount of contrast in Turner's and Monet's paintings decreased. However, paintings of Paris that Monet made from 1864 to 1872 have higher contrast than Turner's last paintings of London made in the 1840s.

Albright and Huybers attribute the difference to the Industrial Revolution's slow start in France. Paris' air-pollution level around 1870 was about what London's was in the early 1800s. This time lag supports the idea that the similar progression in Monet and Turner's styles was guided by air pollution.

The scientists also analyzed the paintings' visibility, or the distance at which an object can be clearly seen. Visibility in Turner's paintings made before 1830 averages about 25 kilometers. Those made after 1830 have an average visibility of about 10 kilometers. Paintings made by Monet in London around 1900, such as his series "Charing Cross Bridge," have a visibility of less than five kilometers.

To strengthen their argument, the scientists analyzed 18 paintings from four other London- and Paris-based artists. As air pollution increased, paintings' contrast and visibility decreased. And again, the decrease seen in French paintings lagged behind the decrease seen in British ones.

Air pollution can explain 61 percent of contrast differences between the paintings, Albright says. "Different painters will paint in a similar way when the environment is similar. But I don't want to overstep and say, 'Oh, we can explain all of impressionism.'" *—Bas den Hond*



Rats fed tiny sacs found in lemon juice developed smaller kidney stones (dark red blobs, top) than rats that weren't (bottom). The sacs keep a key mineral from crystallizing.

MYSTERY SOLVED

How lemons fight kidney stones

A surprise ingredient may explain how lemon juice puts the squeeze on kidney stones. Lemons contain tiny sacs that, when fed to rats, slow stone formation by stopping a key mineral from crystallizing, scientists report in the Feb. 22 *Nano Letters*. If the sacs do the same for humans, the particles might offer a way to prevent kidney stones in people, says pharmaceutical scientist Hongzhi Qiao of Nanjing University of Chinese Medicine.

The rocky lumps form when minerals crystallize inside the kidney. They can knock around in the urinary tract, painfully slicing and dicing tissues as they pass out of the body. Though some medications can help treat kidney stones, many people need them surgically removed. That's why prevention is key.

Lemon juice is a well-known home remedy for kidney stones. Scientists knew that citric acid, which gives lemons their sour power, may do the trick by binding to the minerals that make up stones. But drinking mouth-puckering lemon juice is uncomfortable, Qiao says. It can even eat away at people's teeth. So his team looked for more palatable, potentially preventive ingredients.

The scientists found sacs in lemon juice that were stuffed with fat, protein and DNA. When fed to rats that had been induced to grow kidney stones, the sacs blocked crystallization of a common culprit: calcium oxalate. The sacs also softened stones and made them less sticky, the team showed. *—Meghan Rosen*

THE –EST

Fossilized bug bites hint leaf folding goes way back

As early as 252 million years ago, some plants may have curled up their leaves at night for a cozy "sleep." Fossilized leaves of two now-extinct *Gigantonoclea* species bear signs of nyctinasty, or circadian rhythmic folding at night, scientists report in the Feb. 27 *Current Biology*. That would make these specimens the first known fossilized examples of this curious plant behavior, say paleontologist Zhuo Feng of Yunnan University in Kunming, China, and colleagues.

Symmetrical holes preserved in this fossil leaf suggest insects munched on the leaf while it was folded.

Each leaf fossil, discovered in a rock layer in southwestern China that dates to between 259 million and 252 million years ago, bears oddly symmetrical holes. Insects made those holes while feeding on the leaves while they were folded, the team says.

Modern plants that fold their leaves use musclelike cells that bloat and deflate as water shifts from one part of the leaf to another (SN: 2/25/23, *p.* 13). These cells reside at leaf bases, which weren't preserved in the fossils, so it's unclear whether these ancient plants had them. It's also hard to prove the folding happened at night, but the leaves had to be shut long enough for insects to munch, the team says. *—Carolyn Gramling*

FROM TOP: L. ZHANG *ET AL*/*NANO LETTERS* 2023; Z. FENG *ET AL*/*CURRENT BIOLOGY* 2023

News

PHYSICS

Superconductor claim stirs debate

Material allegedly works under practical conditions

BY EMILY CONOVER & JAMES R. RIORDON

It's a bold claim: The quest to create a superconductor that works under practical conditions is finally fulfilled, a team of researchers says. But controversy has dogged an earlier claim of record-breaking superconductivity from the same team, and the new result is facing scrutiny.

The ultimate test will be whether it can be confirmed by other researchers, says physicist Mikhail Eremets of the Max Planck Institute for Chemistry in Mainz, Germany. "I repeat it like [a] mantra: 'Reproduce.'"

Many materials become superconductors, able to transmit electricity with no resistance, provided they're cooled to very low temperatures. A few superconductors work under warmer conditions, but those must be squeezed to crushing pressures, so they're impractical to use.

Now physicist Ranga Dias of the University of Rochester in New York and colleagues say they have created a superconductor that works at both room temperature and relatively low pressure. A superconductor that operates under such commonplace conditions could herald a new age of high-efficiency machines, supersensitive instrumentation and revolutionary electronics.

"This is the start of the new type of material that's useful for practical applications," Dias said March 7 at the American Physical Society meeting in Las Vegas.

The superconductor is made of hydrogen mixed with nitrogen and the rare earth element lutetium. Dias and colleagues combined the elements and squeezed them in a device known as a diamond anvil cell. The researchers then varied the pressure and temperature and measured the resistance to electrical flow in the compound.

At temperatures as high as about 21° Celsius (70° Fahrenheit), the material seemed to lose any electrical resistance. It still required pressures of 10 kilobars, which is about 10,000 times the pressure of Earth's atmosphere. But that's far lower than the millions of atmospheres of pressure typically required for superconductors that operate near room temperature.

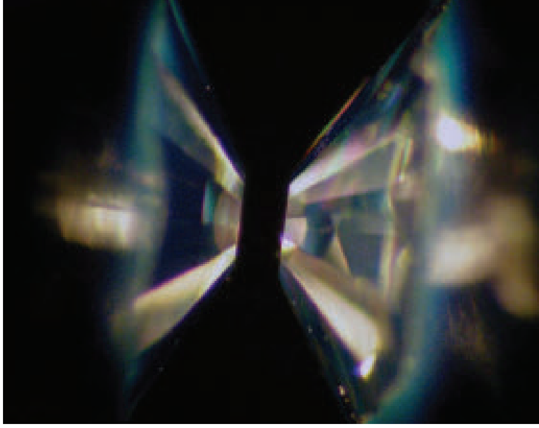
The material displayed several hallmarks of a superconductor, the team reports in a paper published in the March 9 *Nature*. Not only did the electrical resistance suddenly drop as it became superconducting, but the material also expelled magnetic fields and exhibited an abrupt change in its heat capacity, Dias says.

This superconductor might be able to escape the confines of a diamond anvil cell, he says, opening it up to practical applications. A technique called strain engineering, for example, could mimic the required pressure. In such a process, researchers grow a material on a surface that constrains growth, replicating the effects of externally applied squeezing.

Still, the research faces skepticism, in part because of the firestorm over the team's earlier publication that claimed superconductivity in a compound of carbon, sulfur and hydrogen at 15° C (SN: 11/7/20, p. 6). Editors at *Nature* retracted that paper, over the objection of Dias and his coauthors, citing irregularities in data handling that undermined the editors' confidence in the claims (SN: 11/5/22, p. 8).

Several experts have expressed a lack of confidence in the new results, based on that history. Not only was the previous result retracted, but other teams were unable to reproduce it, says Eremets, including his own group. "The main test of validity — reproducibility — was failed, and from my point of view, that's the most important thing."

The stakes are high. "If it's true, it's a great discovery," says physicist Eugene Gregoryanz of the University of Edinburgh. But he views the research with suspicion. "Whether it's true or not, I guess time will show," he says.



Researchers claim to have squeezed room-temperature superconductivity out of a hydrogen compound at moderate pressure using diamond anvils like these.

Others are more positive. "It's an excellent study," says materials chemist Russell Hemley of the University of Illinois Chicago. "The data as presented, in terms of evidence for superconductivity, is very strong." Hemley was not involved with the study, but he collaborated with Dias on a follow-up report to the retracted superconductor paper. Submitted February 16 at arXiv.org, the new paper, which has not yet passed peer review, reports that the previously claimed superconductor does function near room temperature.

The new superconductor is a hydrogen-rich type known as a hydride. Pure hydrogen is predicted to be a room-temperature superconductor but only at extremely high pressures that make it difficult to produce. To lower the pressure, scientists have added other elements.

In 2015, Eremets and colleagues produced a compound of sulfur and hydrogen that was superconducting at up to −70° C (SN: 12/26/15, p. 25). A few years later, a compound of lanthanum and hydrogen was found to superconduct under still chilly conditions, but even closer to room temperature (SN: 10/13/18, p. 6). Both materials require pressures too high for practical use.

It's hard to understand how the new superconductor fits with other hydrides. Theoretical calculations of how similar hydrides behave suggest that such a material wouldn't be superconducting at the reported temperatures and pressures, says theoretical physicist Lilia Boeri of the Sapienza University of Rome. "It looks very strange," Boeri says. "It's something completely unexpected…. If it's true, it's very different from the other hydrides." ■

DAN SHIM/ASU

ANTHROPOLOGY

Ice Age Europeans met different fates

DNA reveals the history of two hunter-gatherer groups

BY BRUCE BOWER

Ice sheets expanded across much of northern Europe from around 25,000 to 19,000 years ago, making a huge expanse of land unlivable. That harsh event set in motion a previously unrecognized tale of two human populations that played out at opposite ends of the continent.

Western European hunter-gatherers outlasted the icy blast in the past. Easterners got replaced by migrations of newcomers.

That's the implication of the largest study to date of ancient Europeans' DNA, covering a period before, during and after what's known as the Last Glacial Maximum, paleogeneticist Cosimo Posth and colleagues report in the March 2 *Nature*.

As researchers have long thought, southwestern Europe provided refuge from the last ice age's big chill for hunter-gatherers based in and near that region, the scientists say. But it turns out that southeastern Europe, where Italy is now located, did not offer lasting respite from the cold for nearby groups, as previously assumed.

Instead, the groups were replaced by genetically distinct hunter-gatherers who presumably had lived just to the east along the Balkan Peninsula. Those people, who carried ancestry from parts of southwestern Asia, began trekking into what's now northern Italy by about 17,000 years ago, as the Ice Age began to wane.

"If local [Ice Age] populations in Italy did not survive and were replaced by groups from the Balkans, this completely changes our interpretation of the archaeological record," says Posth, of the University of Tübingen in Germany.

Posth and colleagues' conclusions rest on analyses of DNA from 356 ancient hunter-gatherers, including molecular evidence for 116 people from 14 countries in Europe and Asia. Excavated human remains that yielded DNA date to between about 45,000 and 5,000 years ago.

Comparisons of sets of gene variants inherited by these hunter-gatherers from common ancestors enabled the team to reconstruct population movements and replacements that shaped ancient Europeans' genetic makeup. For the first time, ancient DNA evidence included individuals from the Gravettian culture, which dates from about 33,000 to 26,000 years ago in central and southern Europe, and from southwestern Europe's Solutrean culture, which dates to between about 24,000 and 19,000 years ago.

Contrary to expectations, makers of Gravettian tools came from two genetically distinct groups that populated western and eastern Europe for roughly 10,000 years before the Ice Age reached its peak, Posth says. Researchers have traditionally regarded Gravettian implements as products of a biologically uniform population that occupied much of Europe.

"What we previously thought was one genetic ancestry in Europe turned out to be two," says paleogeneticist Mateja Hajdinjak of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, who did not participate in the new study. And "it seems that western and southwestern Europe served as a [refuge from glaciation] more than southeastern Europe and Italy."

TOM BJOERKLUND

This artistic portrayal of a southeastern European hunter-gatherer from the ancient Gravettian culture, which dates to between about 33,000 and 26,000 years ago, was inspired by newly analyzed genetic evidence and previous archaeological finds.

Descendants of the western Gravettian population, who are associated with Solutrean artifacts and remnants of another ancient culture in western Europe that ran from about 19,000 to 14,000 years ago, outlasted the Ice Age before spreading northeastward across Europe, the researchers say.

Further support for southwestern Europe as an Ice Age refuge comes from DNA extracted from a pair of fossil teeth that belonged to an individual linked to the Solutrean culture in southern Spain. That roughly 23,000-year-old adult was genetically similar to western European hunter-gatherers who lived before and after the Last Glacial Maximum, paleogeneticist Vanessa Villalba-Mouco, also of the Max Planck Institute for Evolutionary Anthropology, Posth and colleagues report March 1 in *Nature Ecology & Evolution*.

Meanwhile, the genetic evidence suggests that hunter-gatherers in what's now Italy were replaced by people from farther east, probably based in the Balkan region. Those newcomers must have brought with them a distinctive brand of stone artifacts, previously excavated at Italian sites and elsewhere in eastern Europe, known as Epigravettian tools, Posth says. Many archaeologists have suspected that Epigravettian items were products of hunter-gatherers who clustered in Italy during the Ice Age's peak freeze.

But, Hajdinjak says, analyses of DNA from fossils of Ice Age Balkan people are needed to clarify which groups moved through Italy, and when those migrations occurred.

Ultimately, descendants of Ice Age migrants into Italy reached southern Italy and then western Europe by around 14,000 years ago, Posth and colleagues say. Ancient DNA evidence indicates that, during those travels, they left a major genetic mark on hunter-gatherers across Europe. ■

ENVIRONMENT

Shores still reeling from 2010 oil spill

Marshes continue to erode after the Deepwater Horizon disaster

BY JOSHUA RAPP LEARN

Long after the Deepwater Horizon oil spill, the marshy shores of the Gulf of Mexico are still feeling the effects of the disaster. Marsh grass has retained plant-killing oil, and the soil continues to crumble away at a faster rate than before the spill, causing the shoreline to retreat more rapidly than it would otherwise, researchers report.

Following an explosion in April 2010, the Deepwater Horizon rig pumped nearly 800 million liters of oil into the sea (SN: 3/14/20, *p.* 5). The disaster killed nearly a dozen people and untold sea life. And the oil and its by-products were catastrophic for the Gulf ecosystem, both underwater and along the shore (SN: 4/18/15, *p.* 22).

But the oil also caused structural damage to the shoreline by killing the marsh plants crucial to holding soil in place, researchers report in the April 1 *Environmental Pollution.* That's making the coast more vulnerable to tropical storms, which are intensifying due to climate change.

"If the plants are compromised in any way, shape or form, you're going to lose a lot of land," says ecologist Giovanna McClenachan of Nicholls State University in Thibodaux, La.

McClenachan was working on her Ph.D. at Louisiana State University in Baton Rouge when the disaster happened. She and her supervisor, coastal ecologist Eugene Turner, quickly set up research plots along southern Louisiana's marshy coast. Three times a year for the next eight years, the pair conducted tests on the soil strength with a shear vane, a common tool farmers use to test soil strength, and analyzed the amount of oil present.

The scientists also examined satellite images from 1998 to 2021 to analyze what marsh vegetation looked like before, during and after the spill over a much longer 23-year period.

The concentration of some volatile components of oil, called aromatics, in marsh soil jumped from 23.9 nanograms per gram of sediment on average before the spill to an average of 17,152 ng/g of sediment in 2011, the field tests revealed. By 2018, aromatic levels had dropped to 247 ng/g of sediment — still more than 10 times as high as they were before the spill.

Soil strength declined by half after the disaster. Before the spill, the top 30 centimeters of soil averaged 26.9 kilopascals, a measure of pressure the soil can withstand. By 2011, soil strength had dropped to a low point of 11.5 kilopascals, after which it began recovering at a rate of up to 5 percent its pre-spill value per year. The soil still wasn't fully recovered by 2018, the last year of the field study, when its strength had climbed back to 16.4 kilopascals.

Strong storms that have come through in the years since the spill have not helped the situation. The initial oil spill killed a lot of plants on what was then the marsh shore, McClenachan says. Once those plants died, the soil underneath loosened and washed away. But the oil remained in the water and got pushed farther into the marsh, where it killed more plants.

Roots beneath Louisiana's marsh grass help to retain soil. But when oil kills the grass, the roots die, as seen here, and the soil loosens.

G. MCCLENACHAN

"The soil strength hasn't recovered because there is still oil in the marsh, and that's causing these really strong erosion events during storms that weren't occurring prior to the oil spill," McClenachan says.

Analysis of the satellite images showed that the average erosion rate doubled after the spill. The shoreline along the study area had already been receding at an average of nearly 0.9 meters per year before the spill, due to a combination of natural shifting of the marsh levels and human-caused factors like sea level rise. That loss increased to nearly 1.7 meters per year on average after the spill. Notably, the marsh receded roughly 2.5 meters in the 12 months after Hurricane Isaac struck Louisiana in 2012.

Other studies have suggested storms are the cause of shoreline erosion over the last decade. But Hurricane Katrina, which slammed into the Louisiana coast in 2005, years before the oil spill, did not cause nearly the same level of shore loss as much weaker storms after the oil spill, the new analysis shows. The finding suggests it's not an either/or question. Rather, the oil spill continued to make the shoreline more vulnerable to storm damage.

The new study is unique in that it shows the spill's effect on the stability of the soil itself, says environmental scientist Scott Zengel of Research Planning Inc., a private research consultancy in Tallahassee, Fla., that has analyzed the impacts of the Deepwater Horizon disaster.

"It substantiates the idea that there really was an erosion effect," Zengel says, adding that the length of the study complements previous research showing oil has played a role in changes to the marshes.

These changes can be mitigated to some extent. Techniques like replanting marsh vegetation have been shown to help slow shoreline erosion, Zengel says. For boosting soil retention, "it really points at the plants as being one of the key factors," he says. ■

Praise for the Dancing Iris Collection

★★★★★

"I bought this set of earrings and matching necklace … they are simply beautiful." — W.D. Pfalzgraff, Tillamook, OR

Art Nouveau Is New Again

Swirls of sparkle are an ode to art and nature!

Starting in the 1890s, whiplashes were the graceful, swirling lines that became the hallmark of art nouveau. From paintings to stair railings to brooches, these ornamental S-curves were used to evoke movement in stylized depictions of nature's creations — flowers, trees, insects, even a woman's flowing hair. The motif's ubiquity was short-lived; with the start of World War I, sleek industrial lines began to edge out the flowers and their whiplashes. But during its brief reign, art nouveau marked a triumphant departure from stuffy convention in the art world, and its influence continues to echo in jewelry design to this day.

We're paying tribute to an art movement defined by motion with the Dancing Iris Collection, a necklace, ring and earring set inspired by nature. Showcasing nearly 7 total carats of the Ultimate Diamond Alternative®, Diamond*Aura*®, in yellow gold-finished settings, each piece features glistening purple teardrops intertwined with swirls of white stones and graceful golden whiplashes. Subtle in its abstract design, yet teeming with sparkle and movement, the Dancing Iris is a contemporary take on a century-old celebration of natural, feminine beauty. Gift it to the muse in your life, and you're sure to whip up an art craze of your own.

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NEUROSCIENCE

Implant improves mobility post-stroke

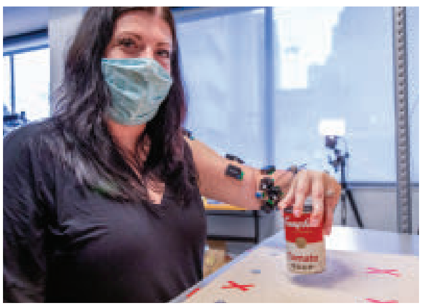
Electrically zapping the spine let patients open a lock and more

BY DARREN INCORVAIA

Sitting in an exam room, surrounded by doctors and scientists, Heather Rendulic opened her left hand for the first time since suffering a series of strokes nine years earlier when she was in her early 20s.

"It was an amazing feeling for me to be able to do that again," Rendulic says. "It's not something I ever thought was possible."

Heather Rendulic picks up and holds a soup can with her partially paralyzed left arm (sporting monitoring equipment) thanks to a small electrical device implanted near her spinal cord.



As soon as researchers surgically implanted and turned on the device, sending electrical pulses into her spinal cord, Rendulic opened her hand and showed other gains in arm mobility, the team reports February 20 in *Nature Medicine*. "We all started crying," Marco Capogrosso, a neuroscientist at the University of Pittsburgh, said in a February 15 news conference. "We didn't really expect this could work as fast as that."

The approach is similar to that recently used for patients paralyzed by spinal cord injuries (SN: 7/16/22 & 7/30/22, *p.* 18). It represents a promising new technique for restoring voluntary movement to those left with upper-body paralysis following strokes, Capogrosso and colleagues say.

A stroke occurs when blood supply to parts of the brain is cut off, often causing short-term or long-term issues with movement, speech and vision. Stroke is a leading, and often underappreciated, cause of paralysis; in the United States alone, 5 million people are living with some form of motor deficit due to stroke. While physical therapy can provide some improvements, no treatment exists to help these patients regain full control of their limbs — and their lives.

Strokes cause paralysis because the connection between the brain and the spinal cord is damaged; the brain tries to tell the spinal cord to move certain muscles, but the message is muddled.

Taking advantage of techniques for injecting anesthetics into the spine, the team invented an electrical device that can be placed along the spinal cord to stimulate nerves there. The stimulation "does not hurt whatsoever," Rendulic says. "It feels like a vibration."

By aligning the electrodes on the device with sensory nerves, "we can enhance the activation of muscles that are weakened by the stroke," Douglas Weber, an engineer and neuroscientist at Carnegie Mellon University in Pittsburgh, said at the news conference. Pulses from these electrodes amplify signals from the brain, stimulating sensory nerves that go on to activate muscles, restoring voluntary body control.

Rendulic and the other patient in the

HEALTH & MEDICINE

Drops may delay myopia in kids

Atropine eye drops postponed the onset of nearsightedness

BY MCKENZIE PRILLAMAN

An eye drop a day could keep myopia at bay — at least temporarily.

Using nightly eye drops with 0.05 percent atropine, a medication that relaxes the eye muscle responsible for focusing vision, may delay myopia onset in children, scientists report in the Feb. 14 *JAMA*.

Myopia, also called nearsightedness, is an irreversible condition in which the eyeball grows too long front to back, causing blurred distance vision. It typically begins in childhood, and the earlier it starts, the worse eye health can become later in life. Elongated eyes increase the risk for ocular complications including cataracts, glaucoma and macular degeneration.

The prevalence of myopia has risen rapidly over the last few decades. About a quarter of the global population has the condition. Myopia is expected to affect half of people worldwide by 2050.

Genetics plays a large role in the condition, says ophthalmologist Jason Yam of the Chinese University of Hong Kong. A 2020 study found that myopia risk is more than 10 times as high in children of two highly myopic parents as in children of nonmyopic parents. But Yam and other scientists suspect that environmental factors such as less time outdoors and more intensive education are causing the recent boom (SN: 2/9/13, *p.* 22).

"It's happening too quickly to be a purely genetic or inherited issue," says optometrist Kathryn Saunders of Ulster University in Coleraine, Northern Ireland, who was not involved in the new work.

Low-dose atropine eye drops are already used to slow myopia progression in several countries in Asia. To see if the medication could also delay myopia onset, Yam and colleagues recruited nonmyopic children ages 4 through 9 who lived in Hong Kong. Each participant received nightly eye drops but was randomly assigned to receive drops with 0.05 percent atropine, 0.01 percent atropine or a placebo. Families and clinicians didn't know which treatment group the children were in.

A total of 353 children used their assigned eye drops for two years. Only about 25 percent of children who took 0.05 percent atropine eye drops, roughly 30 kids, developed myopia in at least one eye, compared with about 50 percent of children who used 0.01 percent atropine or placebo eye drops, around 60 kids in each group. The percentages in each group were similar for eye elongation not severe enough to be considered myopia.

TIM BETLER/UPMC, UNIV. OF PITTSBURGH SCHOOLS OF THE HEALTH SCIENCES study both showed improvements in mobility tasks while the device was on, such as drawing a spiral, opening a lock and gripping, and lifting a soup can. Treatment sessions of continuous electrical stimulation occurred for four hours per day, five days a week, over 29 days. Improvements persisted for as long as four weeks after electrical stimulation stopped.

The researchers are optimistic that they can get even stronger results by pairing the treatment with intensive physical training, neuroscientist Elvira Pirondini of the University of Pittsburgh said at the news conference. The team is testing the device with more patients and exploring whether pairing it with physical training improves outcomes.

The treatment might not work well for patients with severe mobility impairment, says UCLA neurologist Bruce Dobkin, who was not involved in the work. But it could serve as a "new tool to try to maximize the recovery" of stroke patients with more moderate paralysis, in combination with other therapies.

"I really hope and pray that this becomes widely available," Rendulic says. "It's going to change so many lives." ■

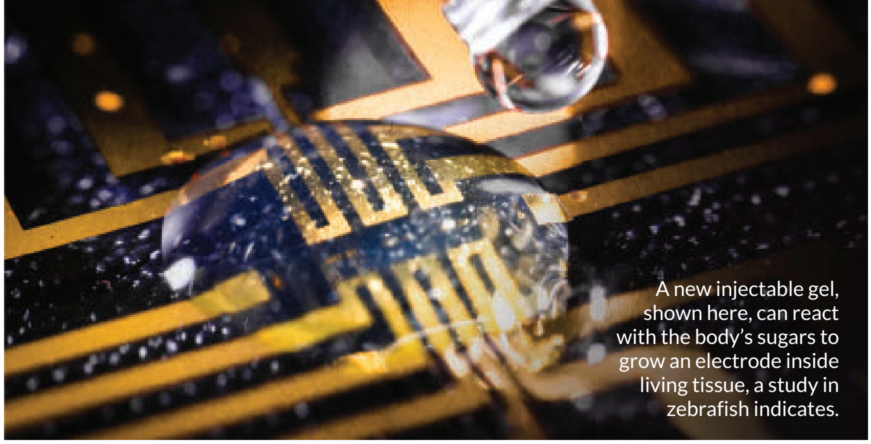
"It's a great first step to encourage us to explore more," Saunders says.

Scientists will need to conduct studies in more diverse populations and environments to reach generalizable conclusions since the trial took place in only Hong Kong. Eye color may also influence dosing, as lighter-pigmented eyes might be more susceptible to side effects, including sensitivity to light.

How atropine slows myopia onset and progression remains a mystery. The medication might improve blood circulation in the eye, Yam says, but that's just one hypothesis.

The study was too short to suggest that atropine eye drops can prevent myopia. But an ongoing follow-up period in which participants continue taking the medication into their teenage years — when eye length stabilizes — will help clarify whether atropine eye drops can ward off the condition altogether. ■

THOR BALKHED



A new injectable gel, shown here, can react with the body's sugars to grow an electrode inside living tissue, a study in zebrafish indicates.

CHEMISTRY

Scientists grow electrodes in living fish

New method harnesses the body's chemistry to create soft tech

BY SIMON MAKIN

For the first time, researchers have harnessed an animal's own chemistry to grow electrodes inside the tissues of living fish, blurring the boundary between biology and machines.

The technique uses the body's sugars to turn an injected gel into a flexible electrode without damaging tissues, experiments show. Zebrafish with these electrodes grown in their brains, hearts and tail fins showed no signs of ill effects, and electrodes tested in leeches successfully stimulated a nerve, researchers report in the Feb. 24 *Science*.

Someday, these electrodes could be useful for studying how biological systems work or improving human-machine interfaces. They also could be used in brain stimulation therapies for depression, Parkinson's disease and other conditions (SN: 2/16/19, *p*. 22).

Soft electronics aim to bridge the gap between soft, curvy biology and electronic hardware. But these electronics typically still must carry certain parts that can be prone to cracks and other issues that impact performance. And inserting these devices inevitably damages tissues, says Magnus Berggren, a materials scientist at Linköping University in Sweden.

Growing soft electronics inside tissues can have drawbacks too. External electrical or chemical signals that transform chemical soup into electrodes can cause damage. It's possible to genetically modify cells to make enzymes that do the job. But Berggren and colleagues' method gets results without genetic alterations.

The team's electrodes exploit energy sources already present in the body: glucose and its by-product lactate. Molecules in a gel cocktail react with glucose and lactate to produce hydrogen peroxide. That activates an enzyme called horseradish peroxidase, which catalyzes the transformation of the gel into a conducting electrode.

The team injected the gel into the brains, hearts and tail fins of transparent zebrafish. The gel turns blue when it becomes conductive, giving a visual readout of its success. "The first time I saw it, I thought 'Wow, it's really working!'" says materials scientist Xenofon Strakosas of Linköping University.

The fish appeared to suffer no ill effects, and the team saw no evidence of tissue damage. In leeches, delivering a current to a nerve via a soft electrode induced muscle contractions.

"The approach leverages elegant chemistry to overcome many of the technical challenges," says biomedical engineer Christopher Bettinger of Carnegie Mellon University in Pittsburgh. But long-term performance is unclear. Substances in the body could degrade electrodes.

The team also needs to refine how precisely the electrodes stimulate nerves, says chemical engineer Zhenan Bao of Stanford University.

The relative abundance of sugars in tissues dictates where electrodes form for now, Berggren says. Swapping a component in the material for elements that attach to specific bits of biology could make targeting more precise, he says. ■

HEALTH & MEDICINE

Antibody may alleviate endometriosis

The treatment reduced signs of the painful disease in monkeys

BY MEGHAN ROSEN

An experimental treatment for endometriosis, a painful gynecological disease that affects some 190 million people worldwide, may one day offer new hope for easing symptoms.

Monthly antibody injections reversed telltale signs of endometriosis in monkeys, researchers report in the Feb. 22 *Science Translational Medicine*. The antibody targets interleukin-8, or IL-8, a molecule that whips up inflammation inside the scattered, sometimes bleeding lesions that mark the disease. After IL-8 is neutralized, those hallmark lesions shrink, the team found.

The new treatment is "pretty potent," says Philippa Saunders, a reproductive scientist at the University of Edinburgh who was not involved in the work. The study's authors haven't reported a cure, but their antibody does seem to have an impact. "It's really very promising," she says.

Many scientists think endometriosis occurs when bits of uterine lining — the endometrium — slough off during menstruation. Instead of exiting via the vagina, they voyage in the other direction: up through the fallopian tubes. Those bits of tissue then trespass through the body, sprouting lesions where they land. They'll glom on to the ovaries, fallopian tubes, bladder and other spots outside of the uterus and take on a life of their own, Saunders says.

The lesions can grow nerve cells, form tough nubs of tissue and even bleed during menstrual cycles. They can also kick off chronic bouts of pelvic pain. If you have endometriosis, you can experience "pain when you urinate, pain when you defecate, pain when you have sex, pain when you move around," Saunders says. People with the disease can also struggle with infertility and depression, she adds. "It's really nasty."

The disease affects at least 10 percent of girls, women and transgender men in their reproductive years, Saunders says. And people suffer for about eight years on average before a diagnosis. "Doctors consider menstrual pelvic pain a very common thing," says Ayako Nishimoto-Kakiuchi, a pharmacologist at Chugai Pharmaceutical Co., Ltd. in Tokyo. Endometriosis "is underestimated in the clinic," she says. "I strongly believe that this disease has been understudied."

Once diagnosed, patients face a dearth of treatment options — there's no cure, only therapies to alleviate symptoms. Surgery to remove lesions can help, but they often come back. Hormonal drugs that stop ovulation and menstruation can also offer relief, says Serdar Bulun, a reproductive endocrinologist at Northwestern University Feinberg School of Medicine in Chicago who was not involved with the new study. But those drugs come with side effects and aren't ideal for people trying to become pregnant. "I see these patients day in and day out," he says. "I see how much they suffer, and I feel like we are not doing enough."

Painful symptoms

Endometriosis is a common gynecological disease, but it can take years before people receive a diagnosis. Here are some signs of the disease:

- **Painful periods**
- **Pain during and/or after sex**
- **Pain while using the toilet**
- **Heavy menstrual bleeding**
- **Bleeding between periods**
- **Infertility**
- **Fatigue**
- **Diarrhea and/or constipation**
- **Bloating and/or nausea**

SOURCE: MAYO CLINIC

The disease endometriosis is marked by telltale lesions (red) that can occur on the uterus (pink), ovaries (white), bladder (yellow) and other places in the body (transparent).

Nishimoto-Kakiuchi and colleagues engineered an antibody that grabs onto the inflammatory factor IL-8, a protein that scientists have previously identified as one potential culprit in the disease. The antibody acts like a garbage collector, Nishimoto-Kakiuchi says. It nabs IL-8, delivers it to the cell's waste disposal machinery and then heads out to snare more IL-8.

The team tested the antibody in cynomolgus monkeys that were surgically modified to have endometriosis. (The disease rarely shows up spontaneously in these monkeys, the scientists discovered after screening more than 600 females.) The team treated 11 monkeys with the antibody injection once a month for six months. Lesions shriveled, and the adhesive tissue that glues them to the body thinned out. Until now, Nishimoto-Kakiuchi says, the team didn't think these hallmarks of the disease were reversible.

Her company has now started a Phase I clinical trial to test the safety of the therapy in humans. The antibody is one of several potential endometriosis therapies scientists are testing. Other trials are testing new hormonal drugs, robot-assisted surgery and behavioral interventions.

Doctors need new options to help people with the disease, Saunders says. "There's a huge unmet clinical need." ■

TUMEGGY/SCIENCE PHOTO LIBRARY/GETTY IMAGES

COSMOLOGY

Shock waves shake up the cosmic web

The observation could offer a look at large-scale magnetic fields

BY ELISE CUTTS

For the first time, astronomers have caught a glimpse of shock waves rippling along strands of the cosmic web — the enormous tangle of galaxies, gas and dark matter that fills the universe.

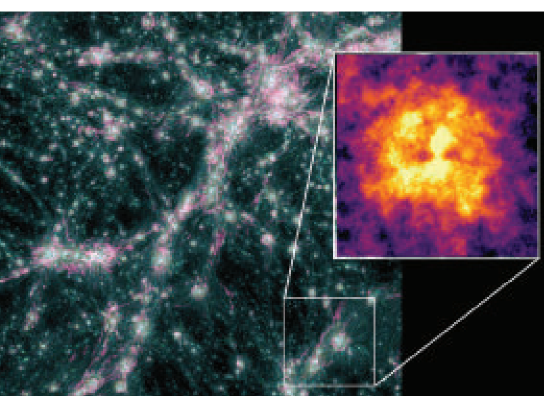
Combining hundreds of thousands of radio telescope images revealed the faint glow cast as shock waves sent charged particles flying through the magnetic fields running along the cosmic web. Studying the shock waves could give astronomers a better understanding of these mysterious fields, researchers report in the Feb. 17 *Science Advances*.

Finally, astronomers "can confirm what so far has only been predicted by simulations — that these shock waves exist," says astrophysicist Marcus Brüggen of the University of Hamburg in Germany.

At its grandest scale, the universe looks something like Swiss cheese. Galaxies aren't distributed evenly through space but rather clump together in enormous clusters connected by ropy filaments of dilute gas, galaxies and dark matter, and separated by not-quite-empty voids.

Tugged by gravity, galaxy clusters merge, filaments collide and gas from the voids falls onto filaments and clusters. Simulations suggest all that action sets off enormous shock waves along filaments.

Shock waves along filaments in the cosmic web emit faint radio signals (pink in this simulation). Combining radio images of filament-connected galaxy clusters (inset) strengthens the signals.



Though filaments contain most of the universe's mass, they are much harder to spot than galaxy clusters. Scientists have observed shock waves around clusters before but have never seen shock waves around filaments, says astronomer Reinout van Weeren of Leiden University in the Netherlands. "They should be … all around."

Such shock waves would accelerate charged particles through the magnetic fields suffusing the cosmic web (*SN: 7/6/19 & 7/20/19, p. 10*). When charged particles accelerate, they emit light at wavelengths that radio telescopes can detect. For shock waves along filaments, the signals are weak. A single shock wave would "look like noise," says radio astronomer Tessa Vernstrom of the International Centre for Radio Astronomy Research in Crawley, Australia.

So Vernstrom and colleagues combined radio images of more than 600,000 pairs of galaxy clusters connected by filaments to create a single "stacked" image. This amplified weak signals and revealed that, on average, there is a faint radio glow from the filaments between clusters.

The faint signal is highly polarized, meaning that the radio waves are mostly aligned with one another. Highly polarized light is unusual in the cosmos, but it is expected from radio light cast by shock waves, van Weeren says. "So that's really, I think, very good evidence for the fact that the shocks are likely indeed present."

Besides confirming predictions of cosmic web simulations, the polarized radio emissions offer a rare, indirect peek at the magnetic fields permeating the web.

"There are large-scale magnetic fields that form [something] like a sheath around these filaments," Brüggen says. But how cosmic magnetic fields arose in the first place and the role they play in shaping the cosmic web are still open questions.

"It's one of the four fundamental forces of nature, right? Magnetism," Vernstrom says. "On these large scales, we don't really know how important it is." ■

ASTRONOMY

Early galaxies have a lot of heft

Their masses raise questions about how they got big so fast

BY LISA GROSSMAN

The James Webb Space Telescope's first peek at the distant universe unveiled galaxies that appear too big to exist.

Six galaxies that formed in the universe's first 700 million years seem to be up to 100 times as massive as standard cosmological theories predict, astronomer Ivo Labbé and colleagues report February 22 in *Nature*. "Adding up the stars in those galaxies, it would exceed the total amount of mass available in the universe at that time," says Labbé, of the Swinburne University of Technology in Melbourne, Australia. "Something is afoot."

The telescope, also called JWST, released its first view of the early cosmos in July 2022 (*SN: 8/13/22, p. 30*). Within days, Labbé and colleagues had spotted about a dozen objects that looked particularly bright and red, a sign that they could be massive and far away.

"They stand out immediately. You see them as soon as you look at these images," says astrophysicist Erica Nelson of the University of Colorado Boulder.

Measuring the amount of light each object emits in various wavelengths can give astronomers an idea of how far away each galaxy is, and how many stars it must have to emit all that light. The light of six objects that Nelson, Labbé and colleagues identified looks like it comes from no later than about 700 million years after the Big Bang. Each of those galaxies appears to hold up to at least 10 billion times the mass of our sun in stars. One of the galaxies might contain the mass of 100 billion suns.

"You shouldn't have had time to make things that have as many stars as the Milky Way that fast," Nelson says. Our galaxy contains about 60 billion suns' worth of stars — and it's had more than 13 billion years to grow them. "It's just crazy that these things seem to exist," she says.

According to standard cosmological

T. VERNSTROM ET AL/*SCIENCE ADVANCES* 2023 theories, matter in the universe clumped together slowly, with small structures gradually merging to form larger ones. “If there are all these massive galaxies at early times, that’s just not happening,” Nelson says.

One possible explanation is that there’s another, unknown way to form galaxies, Labbé says. “It seems like there’s a channel that’s a fast track, and the fast track creates monsters.”

But it could also be that some of these galaxies host supermassive black holes, says Emma Curtis-Lake, an astronomer at the University of Hertfordshire in England. What looks like starlight could instead be light from the gas and dust those black holes are devouring. JWST has already seen a candidate for an active supermassive black hole that appears to predate these galaxies, she says, so it’s not impossible.

These images from the James Webb Space Telescope zoom in on six bright, red, extremely distant galaxies that appear to be too massive to exist so early in the universe.

Finding a lot of supermassive black holes at such an early era would also be challenging to explain. But it wouldn’t require rewriting the standard model of cosmology the way extra-massive galaxies would.

To know for sure what these distant objects are, Curtis-Lake says, astronomers need to confirm the galaxies’ distances and masses using precise measurements of the galaxies’ light across many more wavelengths.

JWST has taken spectra for a few of these galaxies already, and more should be coming, Labbé says. “With luck, a year from now, we’ll know a lot more.” ■

QUANTUM PHYSICS

Google reaches a computing milestone

Error correction improved as quantum computer scaled up

BY EMILY CONOVER

To shrink error rates in quantum computers, sometimes more is better. More qubits, that is.

The quantum bits, or qubits, that make up a quantum computer are prone to mistakes that could render a calculation useless if not corrected. To reduce that error rate, scientists aim to build a computer that can correct its own errors. Such a machine would combine the powers of multiple fallible qubits into one improved qubit, called a “logical qubit,” that can be used to make calculations.

Scientists now have reached a key milestone in quantum error correction. Scaling up the number of qubits in a logical qubit has made it less error-prone, researchers at Google report in the Feb. 23 *Nature*.

Future quantum computers could solve problems impossible for even the most powerful traditional computers. To build those mighty quantum machines, researchers agree that they’ll need to use error correction to dramatically shrink error rates. While scientists have previously demonstrated that they can detect and correct simple errors in small-scale quantum computers, error correction is still in its early stages (*SN: 11/6/21, p. 8*).

Though the new advance doesn’t mean scientists are ready to build a fully error-corrected quantum computer, it demonstrates that “error correction fundamentally works,” physicist Julian Kelly of Google Quantum AI said in a news briefing February 21.

Logical qubits store information redundantly in multiple physical qubits. That redundancy allows a quantum computer to check if any mistakes have cropped up and fix them on the fly. Ideally, the larger the logical qubit, the smaller the error rate should be. But if the original qubits are too faulty, adding in more of them will cause more problems than it solves.

Using Google’s Sycamore quantum chip, Kelly and colleagues studied two different sizes of logical qubits, one consisting of 17 qubits and the other of 49 qubits. After steadily improving the performance of the original physical qubits that make up the device, the researchers tallied up the errors that still slipped through. The larger logical qubit had a lower error rate, about 2.9 percent per round of error correction, compared with the smaller logical qubit’s rate of about 3 percent.

That small improvement suggests scientists are finally tiptoeing into the regime where error correction can begin to squelch errors by scaling up. “It’s a major goal to achieve,” says physicist Andreas Wallraff of ETH Zurich.

But the result is only on the cusp of showing that error correction improves as scientists scale up. A simulation of the quantum computer’s performance suggests that, if the logical qubit’s size were increased even more, its error rate would get worse. Further improving the original faulty qubits is needed to enable scientists to reap the benefits of error correction.

Still, quantum computing milestones are so difficult to achieve that they’re treated like pole jumping, Wallraff says. You aim to barely clear the bar. ■

I. LABBÉ/SWINBURNE UNIV. OF TECHNOLOGY, CSA, ESA, NASA. IMAGE PROCESSING: G. BRAMMER/NIELS BOHR INSTITUTE’S COSMIC DAWN CENTER/UNIV. OF COPENHAGEN

Stone Age Cuisine

The realization that people have long eaten putrid meat has archaeologists rethinking ancient diets

By Bruce Bower, illustrations by Emile Holmewood

In a book about his travels in Africa published in 1907, British explorer Arnold Henry Savage Landor recounted witnessing an impromptu meal that his companions relished but that he found unimaginably revolting.

As he coasted down a river in the Congo Basin with several local hunter-gatherers, a dead rodent floated near their canoe. Its decomposing body had bloated to the size of a small pig.

Stench from the swollen corpse left Landor gasping for breath. Unable to speak, he tried to signal his companions to steer the canoe away from the fetid creature. Instead, they hauled the supersize rodent aboard and ate it.

"The odour when they dug their knives into it was enough to kill the strongest of men," Landor wrote. "When I recovered, my admiration for the digestive powers of these people was intense. They were smacking their lips and they said the [rodent] had provided most excellent eating."

Starting in the 1500s, European and then later American explorers, traders, missionaries, government officials and others who lived among Indigenous peoples in many parts of the world wrote of similar food practices. Hunter-gatherers and small-scale farmers everywhere commonly ate putrid meat, fish and fatty parts of a wide range of animals. From arctic tundra to tropical rainforests, native populations consumed rotten remains, either raw, fermented or cooked just enough to singe off fur and create a more chewable texture. Many groups treated maggots as a meaty bonus.

Descriptions of these practices, which still occur in some present-day Indigenous groups and among northern Europeans who occasionally eat fermented fish, aren't likely to inspire any new Food Network shows or cookbooks from celebrity chefs.

Case in point: Some Indigenous communities feasted on huge decomposing beasts, including hippos that had been trapped in dug-out pits in Africa and beached whales on Australia's coast. Hunters in those groups typically smeared themselves with the fat of the animal before gorging on greasy innards. After slicing open animals' midsections, both adults and children climbed into massive, rotting body cavities to remove meat and fat.

Or consider that Native Americans in Missouri in the late 1800s made a prized soup from the greenish, decaying flesh of dead bison. Animal bodies were buried whole in winter and unearthed in spring after ripening enough to achieve peak tastiness.

But such accounts provide a valuable window into a way of life that existed long before Western industrialization and the war against germs went global, says anthropological archaeologist John Speth of the University of Michigan in Ann Arbor. Intriguingly, no reports of botulism and other potentially fatal reactions to microorganisms festering in rotting meat appear in writings about Indigenous groups before the early 1900s. Instead, decayed flesh and fat represented valued and tasty parts of a healthy diet.

Many travelers such as Landor considered such eating habits to be "disgusting." But "a gold mine of

ethnohistorical accounts makes it clear that the revulsion Westerners feel toward putrid meat and maggots is not hardwired in our genome but is instead culturally learned," Speth says.

This dietary revelation also challenges an influential scientific idea that cooking originated among our ancient relatives as a way to make meat more digestible, thus providing a rich calorie source for brain growth in the *Homo* genus. It's possible, Speth argues, that Stone Age hominids such as Neandertals first used cooking for certain plants that, when heated, provided an energy-boosting, carbohydrate punch to the diet. Animals held packets of fat and protein that, after decay set in, rounded out nutritional needs without needing to be heated.

Northern rot

Speth's curiosity about a human taste for putrid meat was originally piqued by present-day hunter-gatherers in polar regions. North American Inuit, Siberians and other far-north populations still regularly eat fermented or rotten meat and fish.

Fermented fish heads, also known as "stinkhead," are one popular munchy among northern groups. Chukchi herders in the Russian Far East, for instance, bury whole fish in the ground in early fall and let the bodies naturally ferment during periods of freezing and thawing. Fish heads the consistency of hard ice cream are then unearthed and eaten whole.

Speth has suspected for several decades that consumption of fermented and putrid meat, fish, fat and internal organs has a long and probably ancient history among northern Indigenous groups. Consulting mainly online sources such as Google Scholar and universities' digital library catalogs, he found many ethnohistorical descriptions of such behavior going back to the 1500s. Putrid walrus, seals, caribou, reindeer, musk oxen, polar bears, moose, arctic hares and ptarmigans had all been fair game. Speth reported much of this evidence in 2017 in *PaleoAnthropology*.

In one recorded incident from late-1800s Greenland, a well-intentioned hunter brought what he had claimed in advance was excellent food to a team led by American explorer Robert Peary. A stench filled the air as the hunter approached Peary's vessel carrying a rotting seal dripping with maggots. The Greenlander had found the seal where a local group had buried it, possibly a couple of years earlier, so that the body could reach a state of tasty decomposition. Peary ordered the man to keep the reeking seal off his boat.

Miffed at this unexpected rejection, the hunter "told us that the more decayed the seal the finer the eating, and he could not understand why we should object," Peary's wife wrote of the encounter.

Even in temperate and tropical areas, where animal bodies decompose within hours or days, Indigenous peoples have appreciated rot as much as Peary's seal-delivery man did. Speth and anthropological archaeologist Eugène Morin of Trent University in Peterborough, Canada, described some of those obscure ethnohistorical accounts last October in *PaleoAnthropology*.

Raw scavenging

These accounts undermine some of scientists' food-related sacred cows, Speth says. For instance, European explorers and other travelers consistently wrote that traditional groups not only ate putrid meat raw or lightly cooked but suffered no ill aftereffects. A protective gut microbiome may explain why, Speth suspects. Indigenous peoples encountered a variety of microorganisms from infancy on, unlike people today who grow up in sanitized settings. Early exposures to pathogens may have prompted the development of an array of gut microbes and immune responses that protected against potential harms of ingesting putrid meat.

That idea requires further investigation; little is known about the bacterial makeup of rotten meat eaten by traditional groups or of their gut microbiomes. But studies conducted over the last few decades do indicate that putrefaction, the process of decay, offers many of cooking's nutritional benefits with far less effort. Putrefaction predigests meat and fish, softening the flesh and chemically breaking down proteins and fats so they are more easily absorbed and converted to energy by the body.

Given the ethnohistorical evidence, hominids living 3 million years ago or more could have scavenged meat from decomposing carcasses, even without stone tools for hunting or butchery, and eaten their raw haul safely long before fire was used for cooking, Speth contends. If simple stone tools appeared as early as 3.4 million years ago, as some researchers have controversially suggested, those implements may have been made by hominids seeking raw meat and marrow (SN: 9/11/10, *p.* 8). Researchers suspect regular use of fire for cooking, light and warmth emerged no earlier than around 400,000 years ago (SN: 5/5/12, *p.* 18).

"Recognizing that eating rotten meat is possible, even without fire, highlights how easy it would have been to incorporate scavenged food into the diet long before our ancestors learned to hunt or process [meat] with stone tools," says paleoanthropologist Jessica Thompson of Yale University.

Thompson and colleagues suggested in *Current Anthropology* in 2019 that before about 2 million years ago, hominids were primarily scavengers who used rocks to smash open animal bones and eat nutritious, fat-rich marrow and brains. That conclusion, stemming from a review of fossil and archaeological evidence, challenged a common assumption that early hominids — whether as hunters or scavengers — primarily ate meat off the bone.

Certainly, ancient hominids were eating more than just the meaty steaks we think of today, says archaeologist Manuel Domínguez-Rodrigo of Rice University in Houston. In East Africa's Olduvai Gorge, butchered animal bones at sites dating to nearly 2 million years ago indicate that hominids ate most parts of carcasses, including brains and internal organs.

"But Speth's argument about eating putrid carcasses is very speculative and untestable," Domínguez-Rodrigo says.

Untangling whether ancient hominids truly had a taste for rot will require research that spans many fields, including microbiology, genetics and food science, Speth says.

But if his contention holds up, it suggests that ancient cooks were not turning out meat dishes. Instead, Speth speculates, cooking's primary value at first lay in making starchy and oily plants softer, more chewable and easily digestible. Edible plants contain carbohydrates, sugar molecules that can be converted to energy in the body. Heating over a fire converts starch in tubers and other plants to glucose, a vital energy source for the body and brain. Crushing or grinding of plants might have yielded at least some of those energy benefits to hungry hominids who lacked the ability to light fires.

Whether hominids controlled fire well enough to cook plants or any other food regularly before around 400,000 to 300,000 years ago is unknown.

Fat hunting

Despite their nutritional benefits, plants often get viewed as secondary menu items for Stone Age folks. It doesn't help that plants preserve poorly at archaeological sites.

Neandertals, in particular, have a long-standing reputation as plant shunners. Popular opinion views Neandertals as burly, shaggy individuals who huddled around fires chomping on mammoth steaks.

That's not far from an influential scientific view of what Neandertals ate. Elevated levels of a diet-related form of nitrogen in Neandertal bones and teeth hint that they were committed carnivores, eating large amounts of protein-rich lean meat, several research teams have concluded over nearly the last 30 years.

But consuming that much protein from meat, especially from cuts above the front and hind limbs now referred to as steaks, would have been a recipe for nutritional disaster, Speth argues. Meat from wild, hoofed animals and smaller creatures such as rabbits contains almost no fat, or marbling, unlike meat from modern domestic animals, he says. Ethnohistorical accounts, especially for northern hunters including the Inuit, include warnings about weight loss, ill health and even death that can result from eating too much lean meat. This form of malnutrition is known as rabbit starvation. Evidence indicates that people can safely consume between about 25 and 35 percent of daily calories as protein, Speth says. Above that threshold, several investigations have indicated that the liver becomes unable to break down chemical wastes from ingested proteins, which then accumulate in the blood and contribute to rabbit starvation. Limits to the amount of daily protein that can be safely consumed meant that ancient hunting groups, like those today, needed animal fats and carbohydrates from plants to fulfill daily calorie and other nutritional needs.

Modern "Paleo diets" emphasize eating lean meats, fruits and vegetables. But that omits what past and present Indigenous peoples most wanted from animal carcasses. Accounts describe Inuit people eating much larger amounts of fatty body parts than lean meat, Speth says. Over the last few centuries, they have favored tongue, fat deposits, brisket, ribs, fatty tissue around intestines and internal organs, and marrow. Internal organs, especially adrenal glands, have provided vitamin C — nearly absent in lean muscle — that prevented anemia and other symptoms of scurvy.

Western explorers noted that the Inuit also ate chyme, the stomach contents of reindeer and other plant-eating animals. Chyme provided at least a side course of plant carbohydrates. Likewise, Neandertals in Ice Age Europe probably subsisted on a fat- and chyme-supplemented diet, Speth contends.

Large numbers of animal bones found at northern European Neandertal sites — often viewed as the residue of ravenous meat eaters — may instead reflect overhunting of animals to obtain enough fat to meet daily calorie needs. Because wild game typically has a small percentage of body fat, northern hunting groups today and over the last few centuries frequently killed prey in large numbers, either discarding most lean meat from carcasses or feeding it to their dogs, ethnographic studies show.

If Neandertals followed that playbook, eating putrid foods might explain why their bones carry a carnivore-like nitrogen signature, Speth suggests. An unpublished study of decomposing human bodies kept at a University of Tennessee research facility in Knoxville called the Body Farm tested that possibility. Biological anthropologist Melanie Beasley, now at Purdue University in West Lafayette, Ind., found moderately elevated tissue nitrogen levels in 10 deceased bodies sampled regularly for about six months. Tissue from those bodies served as a stand-in for animal meat consumed by Neandertals. Human flesh is an imperfect substitute for, say, reindeer or elephant carcasses. But Beasley's findings suggest that decomposition's effects on a range of animals need to be studied. Intriguingly, she also found that maggots in the decaying tissue displayed extremely elevated nitrogen levels.

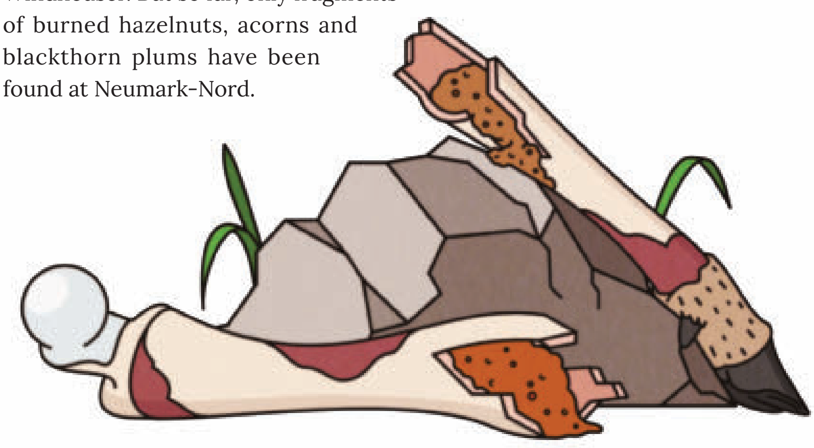
Like arctic hunters did a few hundred years ago, Neandertals may have eaten putrid meat and fish studded with maggots, Speth says. That would explain elevated nitrogen levels in Neandertal fossils.

But Neandertal dining habits are poorly understood. Unusually extensive evidence of Neandertal big-game consumption has come from a new analysis of fossil remains at a roughly 125,000-year-old site in northern Germany called Neumark-Nord. There, Neandertals periodically hunted straight-tusked elephants weighing up to 13 metric tons, say archaeologist Sabine Gaudzinski-Windheuser of Johannes Gutenberg University of Mainz in Germany and colleagues.

In a study reported February 1 in *Science Advances*, her group analyzed patterns of stone-tool incisions on bones of at least 57 elephants from 27 spots near an ancient lake basin where Neandertals lit campfires and constructed shelters (*SN: 1/29/22, p. 8*). Evidence suggests that Neandertal butchers — much like Inuit hunters — removed fat deposits under the skin and fatty body parts such as the tongue, internal organs, brain and thick layers of fat in the feet. Lean meat from elephants would have been eaten in smaller quantities to avoid rabbit starvation, the researchers argue.

Further research needs to examine whether the Neandertals cooked elephant meat or boiled the bones to extract nutritious grease, Speth says. Mealtime options would have expanded for hominids who could not only consume putrid meat and fat but also heat animal parts over fires, he suspects.

Neandertals who hunted elephants must also have eaten a variety of plants to meet their considerable energy requirements, says Gaudzinski-Windheuser. But so far, only fragments of burned hazelnuts, acorns and blackthorn plums have been found at Neumark-Nord.



Carb loading

Better evidence of Neandertals' plant preferences comes from sites in warm Mediterranean and Middle Eastern settings. At a site in coastal Spain, Neandertals probably ate fruits, nuts and seeds of a variety of plants (SN: 3/27/21, *p.* 32).

Neandertals in a range of environments must have consumed lots of starchy plants, argues archaeologist Karen Hardy of the University of Glasgow in Scotland. Even Stone Age northern European and Asian regions included plants with starch-rich appendages that grew underground, such as tubers.

Neandertals could also have obtained starchy carbs from the edible, inner bark of many trees and from seaweed along coastlines. Cooking, as suggested by Speth, would have greatly increased the nutritional value of plants, Hardy says. Not so for rotten meat and fat, though Neandertals such as those at Neumark-Nord may have cooked what they gleaned from fresh elephant remains.

There is direct evidence that Neandertals munched on plants. Microscopic remnants of edible and medicinal plants have been found in the tartar on Neandertal teeth (SN: 4/1/17, *p.* 16), Hardy says.

Carbohydrate-fueled energy helped to maintain large brains, enable strenuous physical activity and ensure healthy pregnancies for both Neandertals and ancient *Homo sapiens*, Hardy concludes in the January 2022 *Journal of Human Evolution*. (Researchers disagree over whether Neandertals, which lived from around 400,000 to 40,000 years ago, were a variant of *H. sapiens* or a separate species.)

Paleo cuisine

Like Hardy, Speth suspects that plants provided a large share of the energy and nutrients Stone Age folks needed. Plants represented a more predictable, readily available food source than hunted or scavenged meat and fat, he contends.

Plants also offered Neandertals and ancient *H. sapiens* — whose diets probably didn't differ dramatically from Neandertals', Hardy says — a chance to stretch their taste buds and cook up tangy meals.

Paleolithic plant cooking included preplanned steps aimed at adding dashes of specific flavors to basic dishes, a recent investigation suggests. In at least some places, Stone Age people apparently cooked to experience pleasing tastes and not just to fill their stomachs. Charred plant food fragments from Shanidar Cave in Iraqi Kurdistan and Franchthi Cave in Greece consisted of crushed pulse seeds, possibly from starchy pea species, combined with wild plants that would have provided a pungent, somewhat bitter taste, microscopic analyses show.

Added ingredients included wild mustard, wild almonds, wild pistachio and fruits such as hackberry, archaeobotanist Ceren Kabukcu of the University of Liverpool in England and colleagues reported last November in *Antiquity*.

Four Shanidar food bits date to about 40,000 years ago or more and originated in sediment that included stone tools attributed to *H. sapiens*. Another food fragment, likely from a cooked Neandertal meal, dates to between 70,000 and 75,000 years ago. Neandertal fossils found in Shanidar Cave are also about 70,000 years old. So it appears that Shanidar Neandertals spiced up cooked plant foods before Shanidar *H. sapiens* did, Kabukcu says.

Franchthi food remains date to between 13,100 and 11,400 years ago, when *H. sapiens* lived there. Wild pulses in food from both caves display microscopic signs of having been soaked, a way to dilute poisons in seeds and moderate their bitterness.

These new findings "suggest that cuisine, or the combination of different ingredients for pleasure, has a very long history indeed," says Hardy, who was not part of Kabukcu's team.

There's a hefty dollop of irony in the possibility that original Paleo diets mixed what people in many societies today regard as gross-sounding portions of putrid meat and fat with vegetarian dishes that still seem appealing. ■

Explore more

- John D. Speth and Eugène Morin. "Putrid meat in the tropics: It wasn't just for Inuit." *PaleoAnthropology*. October 27, 2022.

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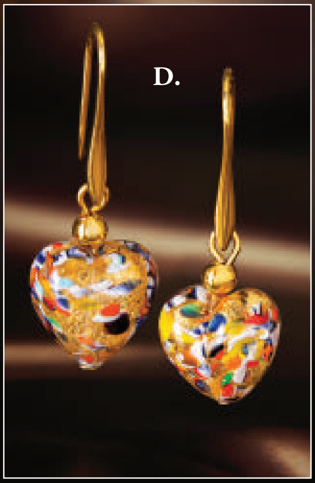

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LISA SHEEHAN

Invisible Invaders

Tiny plastic particles have infiltrated the human body. The potential health risks are not yet clear

By Anne Pinto-Rodrigues

Tiny particles of plastic have been found everywhere — from the deepest place on the planet, the Mariana Trench, to the top of Mount Everest. And now more and more studies are finding that microplastics, defined as plastic pieces less than 5 millimeters across, are also in our bodies.

"What we are looking at is the biggest oil spill ever," says Maria Westerbos, founder of the Plastic Soup Foundation, an Amsterdam-based nonprofit advocacy organization that works to reduce plastic pollution around the world. Nearly all plastics are made from fossil fuel sources. And microplastics are "everywhere," she adds, "even in our bodies."

In recent years, microplastics have been documented in all parts of the human lung, in maternal and fetal placental tissues, in human breast milk and in human blood. Microplastics scientist Heather Leslie, formerly of Vrije Universiteit Amsterdam, and colleagues found microplastics in blood samples from 17 of 22 healthy adult volunteers in the Netherlands. The finding, published last year in *Environment International*, confirms what many scientists have long suspected: These tiny bits can get absorbed into the human bloodstream.

"We went from expecting plastic particles to be

absorbable and present in the human bloodstream to knowing that they are," Leslie says.

The findings aren't entirely surprising; plastics are all around us. Durable, versatile and cheap to manufacture, they are in our clothes, cosmetics, electronics, tires, packaging and so many more items of daily use. And the types of plastic materials on the market continues to increase. "There were around 3,000 [plastic materials] when I started researching microplastics over a decade ago," Leslie says. "Now there are over 9,600. That's a huge number, each with its own chemical makeup and potential toxicity."

Though durable, plastics do degrade, by weathering from water, wind, sunlight or heat—as in ocean environments or in landfills—or by friction, in the case of car tires, which release plastic particles along roadways during motion and braking.

In addition to studying microplastic particles, researchers are also trying to get a handle on nanoplastics, particles which are less than 1 micrometer in length. "The large plastic objects in the environment will break down into micro- and nanoplastics, constantly raising particle numbers," says toxicologist Dick Vethaak of the Institute for Risk Assessment Sciences at Utrecht University in

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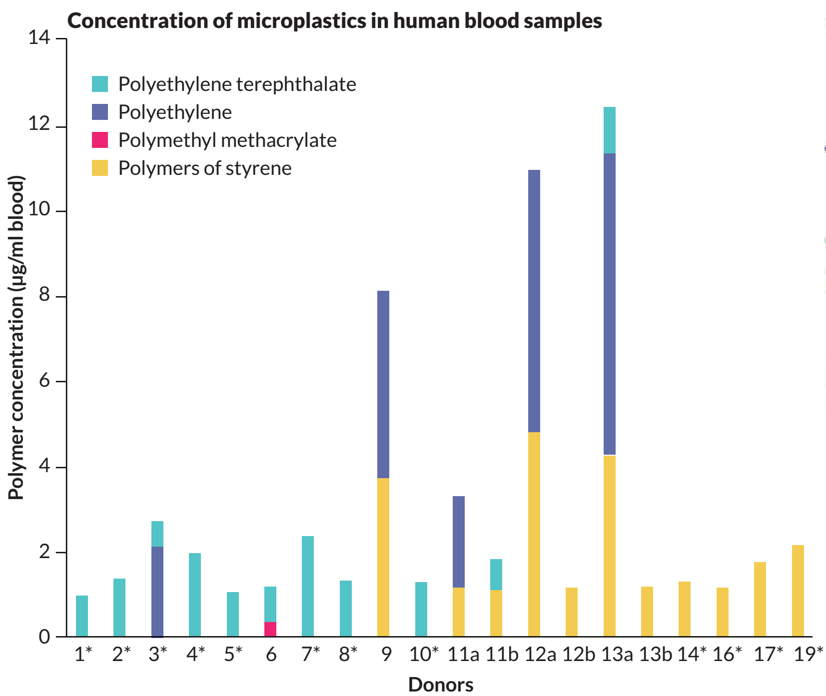
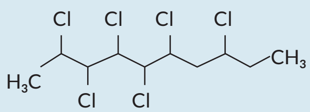


In the blood Microplastic particles were detected in blood samples from 17 of 22 healthy adult volunteers in the Netherlands. The types of polymer present varied across the group—as did the concentrations. Donors 11, 12 and 13 contributed two samples, both with microplastics. For many others (starred), one sample had microplastics and a second did not. SOURCE: H. LESLIE *ET AL/ENVIRONMENT INTERNATIONAL* 2022

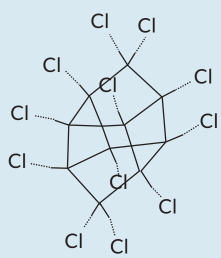
Concerning chemicals

Bits of plastic floating in the world's air and water contain chemicals that may pose risks to human health. A 2021 study identified more than 2,400 chemicals of potential concern found in plastics or used in their processing. Here are a few of the most worrisome.

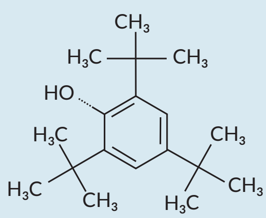
SOURCE: H. WIESINGER, Z. WANG AND S. HELLWEG/*ENVIRONMENTAL SCIENCE & TECHNOLOGY* 2021



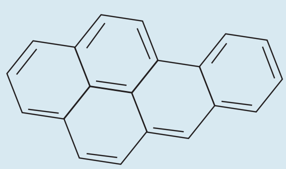
Short-chain chlorinated paraffins are used as lubricants, flame retardants and plasticizers. They can cause cancer in lab rodents, but the mechanisms may not be relevant for human health.



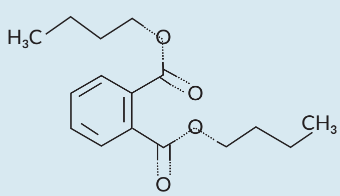
The chlorinated compound mirex was once used as a flame retardant and can persist in the environment. It's suspected of being a human carcinogen and may affect fertility.



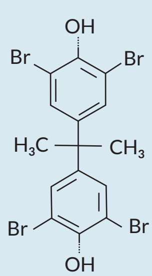
2,4,6-Tri-tert-butylphenol is an antioxidant and ultraviolet stabilizer, added to plastics to prevent degradation. There's evidence that it causes liver damage in lab animals with prolonged or repeated exposure.



Benzo(a)pyrene is a polyaromatic hydrocarbon that can be released when organic matter such as coal or wood burns. It is also produced in grilled meats. It has been shown to cause cancer, damage fertility and affect development in lab animals.



Dibutyl phthalate is a plasticizer that is known to cause endocrine disruption, may interfere with male fertility and has been shown to affect fetal development in lab animals.



Tetrabromobisphenol-A is a flame retardant that can cause cancer in lab animals and may be an endocrine disruptor. It is chemically related to bisphenol A, which has been linked to developmental effects in children.

the Netherlands, who collaborated with Leslie on the study finding microplastics in human blood.

Nearly two decades ago, marine biologists began drawing attention to the accumulation of microplastics in the ocean and their potential to interfere with organism and ecosystem health (*SN: 2/20/16, p. 20*). But only in recent years have scientists started focusing on microplastics in people's food and drinking water—as well as in indoor air.

Plastic particles are also intentionally added to cosmetics like lipstick, lip gloss and eye makeup to improve their feel and finish, and to personal care products, such as face scrubs, toothpastes and shower gels, for the cleansing and exfoliating properties. When washed off, these microplastics enter the sewage system. They can end up in the sewage sludge from wastewater treatment plants, which is used to fertilize agricultural lands, or even in treated water released into waterways.

What if any damage microplastics may do when they get into our bodies is not clear, but a growing community of researchers investigating these questions thinks there is reason for concern. Inhaled particles might irritate and damage the lungs, akin to the damage caused by other particulate matter. And although the composition of plastic particles varies, some contain chemicals that are known to interfere with the body's hormones.

Currently there are huge knowledge gaps in our understanding of how these particles are processed by the human body.

How do microplastics get in?

Research points to two main entry routes into the human body: We swallow them and we breathe them in.

Evidence is growing that our food and water is contaminated with microplastics. A study in Italy, reported in 2020, found microplastics in everyday fruits and vegetables. Wheat and lettuce plants have been observed taking up microplastic particles in the lab; uptake from soil containing the particles is probably how they get into our produce in the first place.

Sewage sludge can contain microplastics not only from personal care products, but also from washing machines. One study looking at sludge from a wastewater treatment plant in southwest England found that if all the treated sludge produced there were used to fertilize soils, a volume of microplastic particles equivalent to what is found in more than 20,000 plastic credit cards could potentially be released into the environment each month.

On top of that, fertilizers are coated with plastic for controlled release, plastic mulch film is used

T. TIBBITTS

as a protective layer for crops and water containing microplastics is used for irrigation, says Sophie Vonk, a researcher at the Plastic Soup Foundation.

"Agricultural fields in Europe and North America are estimated to receive far higher quantities of microplastics than global oceans," Vonk says.

A recent pilot study commissioned by the Plastic Soup Foundation found microplastics in all blood samples collected from pigs and cows on Dutch farms, showing livestock are capable of absorbing some of the plastic particles from their feed, water or air. Of the beef and pork samples collected from farms and supermarkets as part of the same study, 75 percent showed the presence of microplastics. Multiple studies document that microplastic particles are also in fish muscle, not just the gut, and so are likely to be consumed when people eat seafood.

Microplastics are in our drinking water, whether it's from the tap or bottled. The particles may enter the water at the source, during treatment and distribution, or, in the case of bottled water, from its packaging.

Results from studies attempting to quantify levels of human ingestion vary dramatically, but they suggest people might be consuming on the order of tens of thousands of microplastic particles per person per year. These estimates may change as more data come in, and they will likely vary depending on people's diets and where they live. Plus, it is not yet clear how these particles are absorbed, distributed, metabolized and excreted by the human body, and if not excreted immediately, how long they might stick around.

Babies might face particularly high exposures. A small study of six infants and 10 adults found that the infants had more microplastic particles in their feces than the adults did. Research suggests microplastics can enter the fetus via the placenta, and babies could also ingest the particles via breast milk. The use of plastic feeding bottles and teething toys adds to children's microplastics exposure.

Microplastic particles are also floating in the air. Research conducted in Paris to document microplastic levels in indoor air found concentrations ranging from three to 15 particles per cubic meter of air. Outdoor concentrations were much lower.

Airborne particles may turn out to be more of a concern than those in food. One study reported in 2018 compared the amount of microplastics present within mussels harvested off Scotland's coasts with the amount of microplastics present in indoor air. Exposure to microplastic fibers from the air during the meal was far higher than the risk of ingesting microplastics from the mussels themselves.

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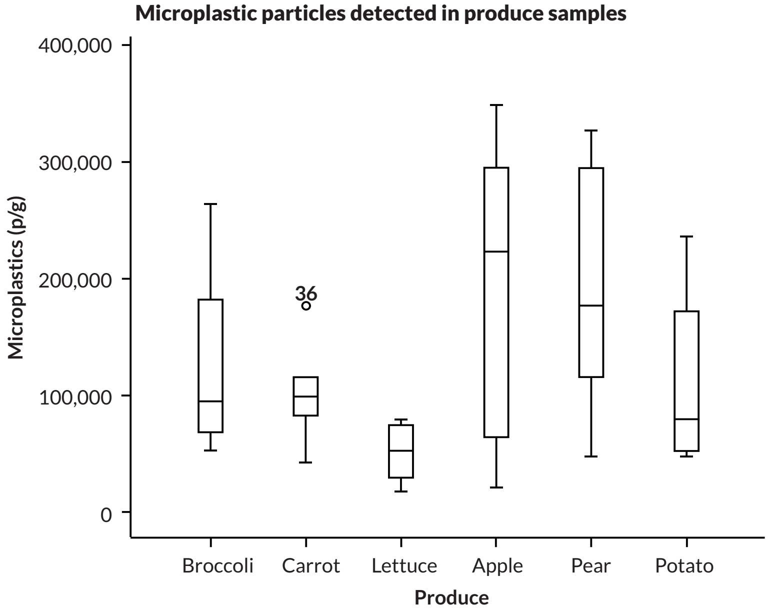


Probing produce Fruits and vegetables purchased at local markets in Catania, Italy, showed wide variability in the numbers of microplastic particles present. The research highlights the need for more studies on the sources of microplastic exposure.
SOURCE: G.O. CONTI *ET AL/ENVIRONMENTAL RESEARCH* 2020

Extrapolating from this research, immunologist Nienke Vrisekoop of the University Medical Center Utrecht says, "If I keep a piece of fish on the table for an hour, it has probably gathered more microplastics from the ambient air than it has from the ocean."

What's more, a study of human lung tissue reported last year offers solid evidence that we are breathing in plastic particles. Microplastics showed up in 11 of 13 samples, including those from the upper, middle and lower lobes, researchers in England reported.

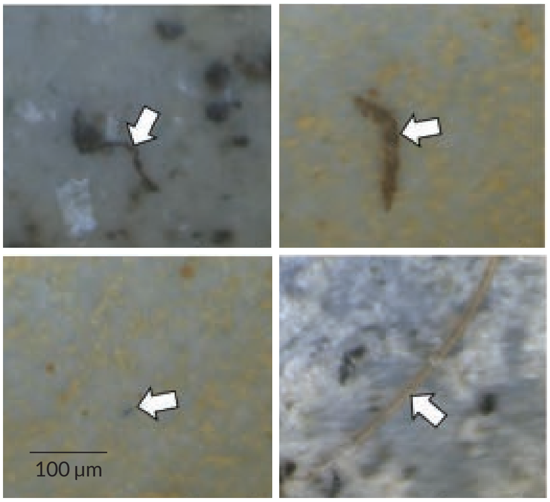
Perhaps good news: Microplastics seem unable to penetrate the skin. "The epidermis holds off quite a lot of stuff from the outside world, including [nano]particles," Leslie says. "Particles can go deep into your skin, but so far we haven't observed them passing the barrier, unless the skin is damaged."

What are the potential concerns?

Studies in mice suggest microplastics are not benign. Research in these test animals shows that lab exposure to microplastics can disrupt the gut microbiome, lead to inflammation, lower sperm quality and testosterone levels, and negatively affect learning and memory.

But some of these studies used concentrations that may not be relevant to real-world scenarios. Studies on the health effects of exposure in humans are just getting under way, so it could be years before scientists understand the actual impact in people.

A study reported last year identified microplastic particles in 11 of 13 samples of human lung tissue (examples shown). The plastics were found throughout the lungs, and their presence suggests that inhalation is one route for the particles to enter the body.



L.C. JENNER *ET AL*/*SCIENCE OF THE TOTAL ENVIRONMENT* 2022

Immunologist Barbro Melgert of the University of Groningen in the Netherlands has studied the effects of nylon microfibers on human tissue grown to resemble lungs. Exposure to nylon fibers reduced both the number and size of airways that formed in these tissues by 67 percent and 50 percent, respectively. “We found that the cause was not the microfibers themselves but rather the chemicals released from them,” Melgert says.

“Microplastics could be considered a form of air pollution,” she says. “We know air pollution particles tend to induce stress in our lungs, and it will probably be the same for microplastics.”

> “Before you purchase something, think if you really need it, and if it needs to be plastic.”
> HEATHER LESLIE

Vrisekoop is studying how the human immune system responds to microplastics. Her unpublished lab experiments suggest immune cells don’t recognize microplastic particles unless they have blood proteins, viruses, bacteria or other contaminants attached. But it is likely that such bits will attach to microplastic particles out in the environment and inside the body. “If the microplastics are not clean … the immune cells [engulf] the particle and die faster because of it,” Vrisekoop says. “More immune cells then rush in.” This marks the start of an immune response to the particle, which could potentially trigger a strong inflammatory reaction or possibly aggravate existing inflammatory diseases of the lungs or gastrointestinal tract.

Some of the chemicals added to make plastic suitable for particular uses are also known to cause problems for humans: Bisphenol A, or BPA, is used to harden plastic and is a known endocrine disruptor that has been linked to developmental effects in children and problems with reproductive systems and metabolism in adults (SN: 7/18/09, *p.* 5). Phthalates, used to make plastic soft and flexible, are associated with adverse effects on fetal development and reproductive problems in adults along with insulin resistance and obesity. And flame retardants that make electronics less flammable are associated with endocrine, reproductive and behavioral effects.

“Some of these chemical products that I worked on in the past [like the polybrominated diphenyl ethers used as flame retardants] have been phased out or are prohibited to use in new products now [in the European Union and the United States] because of their neurotoxic or disrupting effects,” Leslie says.

The remaining questions

The first step in determining the risk of microplastics to human health is to better understand and quantify human exposure. Polyrisk — one of five large-scale research projects under CUSP, a multidisciplinary group of researchers and experts from 75 organizations across 21 European countries studying micro- and nanoplastics — is doing exactly that.

Immunotoxicologist Raymond Pieters, of the Institute for Risk Assessment Sciences at Utrecht University and coordinator of Polyrisk, and colleagues are studying people’s inhalation exposure in a number of real-life scenarios: near a traffic light, for example, where cars are likely to be braking, versus a highway, where vehicles are continuously moving. Other scenarios under study include an indoor sports stadium, as well as occupational scenarios like the textile and rubber industry.

Melgert wants to know how much microplastic is in our houses, what the particle sizes are and how much we breathe in. “There are very few studies looking at indoor levels [of microplastics],” she says. “We all have stuff in our houses — carpets, insulation made of plastic materials, curtains, clothes — that all give off fibers.”

Vethaak, who co-coordinates MOMENTUM, a consortium of 27 research and industry partners from the Netherlands and seven other countries studying microplastics’ potential effects on human health, is quick to point out that “any measurement of the degree of exposure to plastic particles is likely an underestimation.” In addition to research on the impact of microplastics, the group is also looking at nanoplastics. Studying and analyzing these smallest of plastics in the environment and in our bodies is extremely challenging. “The analytical tools and techniques required for this are still being developed," Vethaak says.

Vethaak also wants to understand whether microplastic particles coated with bacteria and viruses found in the environment could spread these pathogens and increase infection rates in people. Studies have suggested that microplastics in the ocean can serve as safe havens for germs.

Alongside knowing people's level of exposure to microplastics, the second big question scientists want to understand is what if any level of real-world exposure is harmful. "This work is confounded by the multitude of different plastic particle types, given their variations in size, shape and chemical composition, which can affect uptake and toxicity," Leslie says. "In the case of microplastics, it will take several more years to determine what the threshold dose for toxicity is."

Several countries have banned the use of microbeads in specific categories of products, including rinse-off cosmetics and toothpastes. But there are no regulations or policies anywhere in the world that address the release or concentrations of other microplastics — and there are very few consistent monitoring efforts. California has recently taken a step toward monitoring by approving the world's first requirements for testing microplastics in drinking water sources. The testing will happen over the next several years.

Pieters is very pragmatic in his outlook: "We know 'a' and 'b,'" he says. "So we can expect 'c,' and 'c' would [imply] a risk for human health."

He is inclined to find ways to protect people now even if there is limited or uncertain scientific knowledge. "Why not take a stand for the precautionary principle?" he asks.

For people who want to follow Pieters' lead, there are ways to reduce exposure.

"Ventilate, ventilate, ventilate," Melgert says. She recommends not only proper ventilation, including opening your windows at home, but also regular vacuum cleaning and air purification. That can remove dust, which often contains microplastics, from surfaces and the air.

Consumers can also choose to avoid cosmetics and personal care products containing microbeads. Buying clothes made from natural fabrics like cotton, linen and hemp, instead of from synthetic materials like acrylic and polyester, helps reduce the shedding of microplastics during wear and during the washing process.

Specialized microplastics-removal devices, including laundry balls, laundry bags and filters that attach to washing machines, are designed to reduce the number of microfibers making it into waterways.

Vethaak recommends not heating plastic containers in the microwave, even if they claim to be food grade, and not leaving plastic water bottles in the sun.

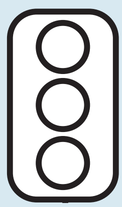
Perhaps the biggest thing people can do is rely on plastics less. Reducing overall consumption will reduce plastic pollution, and so reduce microplastics sloughing into the air and water.

Leslie recommends functional substitution: "Before you purchase something, think if you really need it, and if it needs to be plastic."

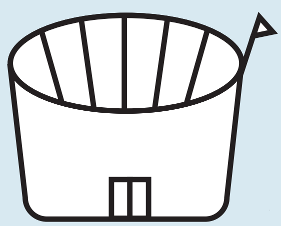
Westerbos remains hopeful that researchers and scientists from around the world can come together to find a solution. "We need all the brainpower we have to connect and work together to find a substitute to plastic that is not toxic and doesn't last [in the environment] as long as plastic does," she says. ■

Where in the air?

Concentrations of microplastics and nanoplastics in the air likely vary with location. Researchers are interested in studying various settings to better understand human exposure and risk.

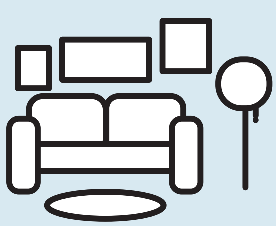


Traffic lights



Indoor sports stadium

Textile factory



Living room

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Anne Pinto-Rodrigues is a Netherlands-based independent journalist reporting on social and environmental issues.

Many ethical questions need to be answered before people move to other worlds, a new book argues.

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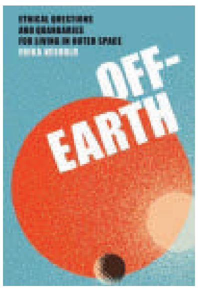

Off-Earth
Erika Nesvold
MIT PRESS, $27.95

BOOKSHELF

How to build a better future in space

Astrophysicist Erika Nesvold once asked an executive of a company aiming to mine the moon how he planned to address risks that mining equipment might carry microbes from Earth and contaminate the moon. His response: “We’ll worry about that later.”

That’s a reckless mind-set when it comes to preparing for people to live and work in space, Nesvold argues in her new book, *Off-Earth*. It means making decisions with your eyes closed. History is full of cautionary tales of mutinies, exploitation, and humanitarian and ecological disasters that would be all too easy to reproduce in space.

“Space settlement advocates often advertise space as a blank slate where we can build utopian societies free from the crowded territory and bloodied history of our terrestrial home,” Nesvold writes. “But adopting a ‘worry about it later’ attitude toward human rights and ethics strikes me as a path to repeating the tragedies of that history through ignorance.”

Nesvold is a developer for the education software/video game *Universe Sandbox*. In the last several years, she has shifted her focus to how to build a fair and just future in space, cofounding the JustSpace Alliance, a nonprofit working to do just that. *Off-Earth* is an extension of her 2017 podcast, *Making New Worlds*, which asked ethical questions about space settlement. The book takes some of the same questions and expands on them. Each chapter title is a question: “Why are we going?” “Who gets to go?” “Who’s in charge?” “What if I get sick?” “Which way is Mecca?”

Most chapters start with three vignettes, usually from different time periods. A chapter outlining debates over whether to settle space at all starts by asking the reader to imagine being in the 1600s and deciding to uproot your family and head to the New World. A chapter on how land usage and ownership rights might work in space imagines a person recently freed from slavery in the U.S. South in 1865 and worrying that the new president will take back the land they finally own. A chapter on the ethical questions that will arise when people get sick in space conjures a hospital worker in 2020 making gut-wrenching triage decisions during the COVID-19 pandemic. The third vignette is usually set in the year 2100, on a space settlement.

Then Nesvold examines how various ethical scenarios related to the chapter’s theme might play out in space. She quotes experts in fields that don’t often come up in space science: ethics, philosophy, Indigenous history, law.

This approach is a departure from many books about the future of life on the final frontier, forcing readers to confront hard realities and possible points of friction. A lot of arguments for moving humankind off Earth assume space is a land of infinite resources. But at least at first, settlers will have much more limited resources than they did on Earth. And situations where humans are isolated with limited resources, like on ships or in colonial settlements, have often been recipes for disaster.

So how will space settlers share what little they have? How will they decide who lives and dies, and what quality of life and death they’ll have? Will living in the harsh conditions of an early space settlement nurture innovation and creative progress, or encourage humankind’s worst tendencies toward exploitation and tyranny?

Most of these questions don’t have clear answers. That’s partly because ethical questions rarely do. The book “has undoubtedly revealed much about my own political opinions and priorities, not to mention the influence of my personal background and the culture in which I was raised,” Nesvold writes. “In the same way, your position on these issues is likely deeply connected with your own values and beliefs.”

Finding answers is also challenging because it requires anticipating what our descendants, who will live in the space communities we are already creating, will want, need and believe. To have the best chance of avoiding disaster, the time to consider these questions is now, not later, even though space settlement may be decades or centuries away, Nesvold argues.

Off-Earth should be required reading for anyone who dreams about living in space. Space is not a blank slate, but imagining a better world there can help us build one — and can help make our earthbound civilizations better too. — *Lisa Grossman*

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SOCIETY FOR SCIENCE

FEBRUARY 11, 2023

Bodily waste is cool, actually

Snot bubbles may help a short-beaked echidna cool off by coating the critter's nose with moisture, which evaporates and draws heat from a blood-filled sinus, helping to cool the blood, ***Elise Cutts*** *reported in "Adorable spike-balls beat the heat with snot bubbles"* (SN: 2/11/23, p. 32).

Other animals also have creative ways of using fluids to stay cool. Some birds, for example, urinate on themselves to survive hot days, **Cutts** wrote. Reader **James Wilson** noted that the word "urinate" might be misleading, since bird waste is typically a mix of urine and feces.

It's true that bird droppings are a mix of urine and feces that goes through one opening called the cloaca. So "excrete" might be a more appropriate term, says ornithologist **Julián Cabello-Vergel** of the University of Extremadura in Badajoz, Spain. For birds that cool off via waste elimination, a phenomenon called urohidrosis, the liquid component of bird droppings is key. When storks, herons, boobies and some other types of birds excrete extra-juicy waste on their legs, "it is the evaporation of the water contained in the excreta which produces heat loss from the [body] to the environment," **Cabello-Vergel** says.

When gene flow runs afowl

About 20 to 50 percent of modern jungle fowl DNA comes from domesticated chickens due to interbreeding, threatening the genetic diversity and long-term survival of the wild birds, which live in South and Southeast Asia, ***Jake Buehler*** *reported in "Chicken DNA runs amok in wild birds"* (SN: 2/11/23, p. 14).

Reader **Van Snyder** asked if wild jungle fowl transfer any of their genetic material to chickens.

Evolutionary biologist **Frank Rheindt** has "no doubt that gene flow between domestic chickens and wild jungle fowl is bidirectional." Many free-ranging domestic village chickens in South and Southeast Asia are probably regularly exposed to genes from wild red jungle fowl that they encounter near the boundaries between villages and forests.

But the flow of genetic material from wild red jungle fowl to chickens overall would be marginal, says **Rheindt**, of the National University of Singapore. "The vast global majority of domestic chickens are battery chickens kept in tight enclosures, mostly outside tropical Asia, and those chickens would remain unaffected."

Defining depression

Depression is often blamed on a chemical imbalance in the brain. In reality, scientists don't have a great explanation of what depression is or what causes it, despite decades of research, ***Laura Sanders*** *reported in "No simple answers"* (SN: 2/11/23, p. 18).

Many readers expressed their appreciation for **Sanders'** reporting.

"It's a fantastic example of popular science writing for the public about an urgent and difficult issue concerning human suffering," reader **R. Michael Johnson** wrote. "I was particularly impressed and gratified by your assurances that depression isn't one-size-fits-all, and that the geographical/cultural nuances are not to be slighted."

Why "Y"?

Ice Age hunter-gatherers may have used cave art to track the mating and birthing seasons of local fauna, ***Anna Gibbs*** *reported in "Ice Age cave art may be a calendar"* (SN: 2/11/23, p. 16). *For instance, "Y" symbols in the art could signify birth, researchers suspect.*

Reader **Richard Delaware** wondered why the "Y" symbol developed that meaning.

"We will probably never know," says **Ben Bacon**, an independent researcher based in London who helped decipher the cave art. One possible explanation could be that the symbol represents the female pubic area. In Paleolithic art, including in small carved figurines and wall paintings, this area was often depicted with a pronounced Y-shaped outline, **Bacon** says.

Another possible interpretation relies on the fact that the symbol is a line that splits into two. "One becomes two, which describes perfectly the process of birth," **Bacon** speculates.

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Rear end renewal in young sea spiders

No backside, no problem. Some young sea spiders can regenerate much of their bottom halves — including muscles, reproductive organs and the anus — or make do without, researchers report in the Jan. 31 *Proceedings of the National Academy of Sciences*.

Researchers thought sea spiders and other arthropods could regrow only parts of their legs. But several months after evolutionary biologist Georg Brenneis accidentally injured a young sea spider in the lab, it had an extra leg. So Brenneis, of the University of Vienna, and colleagues put 19 young sea spiders (*Pycnogonum litorale*) and four adults to the test by amputating one or two segments from the critters' lower halves.

The microscope images above show one juvenile's recovery. Amputation (top left) removed two legs and the anal tubercle, which contains the hindgut and anus. After shedding its exoskeleton for the first time, the animal's anal tubercle and legs had started to re-form (top right). After the second molt, the tubercle and legs continued to take shape (bottom left). After the third molt, the spider looked normal again (bottom right). The changing scale bars in the images highlight the young spider's growth.

Most juveniles recovered, though some ended up with just six or seven legs. No adults regenerated, possibly because they no longer shed their exoskeleton. Two juveniles also didn't regenerate, surviving with four legs and no anus, regurgitating waste out of their mouths. Next up, Brenneis says, is seeing if other arthropods also regenerate more than scientists thought and learning how sea spiders do it. —*Erin Garcia de Jesús*

G. BRENNEIS *ET AL*/*PNAS* 2023

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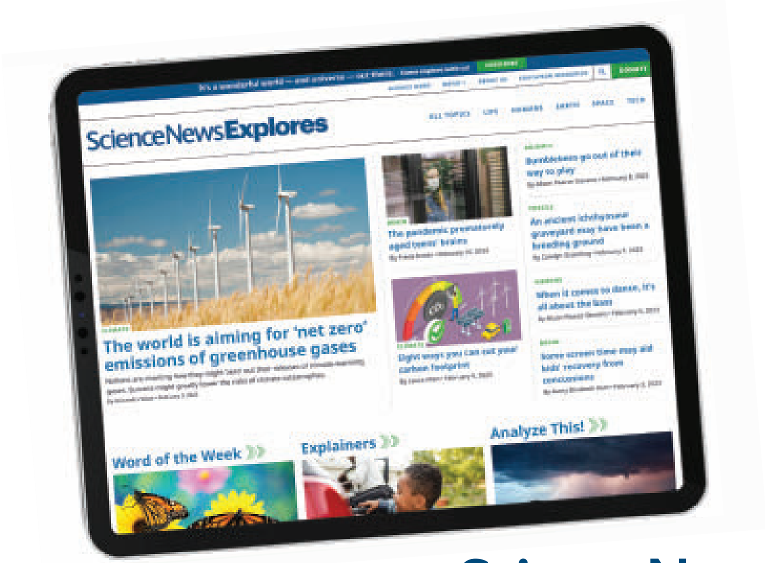

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