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Science News

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Hot and Smoky

Record heat and wildfires starkly show how climate change threatens health

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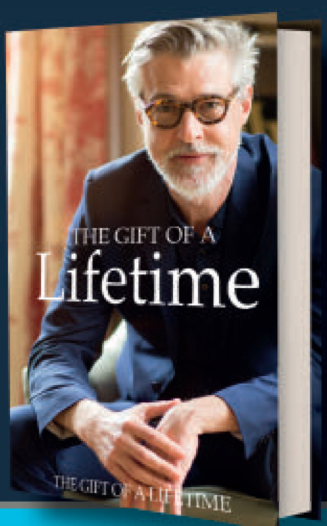

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COVER In June, smoke from Canadian wildfires polluted the sky above Washington, D.C. *Mandel Ngan/AFP via Getty Images*

FROM TOP: NOLAN ZUNK/UNIV. OF TEXAS AT AUSTIN; KATRINA KENNY; GENE J. PUSKAR/AP PHOTO

Extreme weather threatens human health worldwide

Heat waves are synonymous with summer for most people. But this summer's heat has broken records for temperatures and duration. As of late July, Texas had experienced highs over 100° Fahrenheit for more than 30 days straight. China posted its highest temperature ever recorded, and Europe's heat may surpass last year's onslaught, when more than 60,000 people may have died due to excessive heat.

The hot, dry weather helped fuel coast-to-coast wildfires in Canada, with smoke spilling south and blanketing the U.S. Midwest and East Coast. For many people, it was their first experience with dangerous air quality caused by wildfires, a plague that has become all too familiar to people in the western United States.

Scientists know that wildfire smoke can harm human health, staff writer Meghan Rosen reports (Page 6). Tiny particles that can lodge deep in the lungs are a big concern, and smoke can contain chemicals like formaldehyde and benzene. But researchers don't yet know the long-term effects of being exposed to wildfire smoke intermittently over many years and are now focused on answering that question.

The Northern Hemisphere heat waves are being driven by warmer oceans amped up by climate change plus the return of a natural climate cycle called El Niño, staff writer Nikk Ogasa reports (Page 8). Another factor is meandering jet streams, which have pinned hot air in place.

I asked Rosen, Ogasa and earth and climate writer Carolyn Gramling the question we at *Science News* have been asking for a few years now: Is this the year that climate change smacks even the least vulnerable?

When it comes to human capacity to withstand extreme heat and high humidity, "there's this grim feeling like we're pushing the limit, except we don't know what the limit is," Gramling said. She reported last summer that human heat tolerance may be lower than thought (*SN: 8/27/22, p. 6*). People are definitely talking and thinking more about it, Ogasa said. And he's adapting himself, going for runs when it's least humid. Gramling also noted that there's been a decrease in the number of people saying that climate change doesn't exist. "People are considering things now that maybe they were less open to before."

I asked these reporters what questions on climate change and health they'd like to dig into next.

Rosen: "I'd like to know more about how heat and wildfire smoke may affect a developing fetus. Are there particular windows of pregnancy where it's especially dangerous for someone to be inhaling smoke, or living through a heat wave?"

Ogasa: "I'm curious about how we're going to reckon with the growing need for cooling. So many places are starting to face unlivable conditions. How do we deal with that growing energy demand, what alternatives are there for people who can't get traditional AC and in which climates do those alternatives work?"

Gramling: "I'm definitely interested in the limit of human heat tolerance. What even is adaptation?"

As we all travel into what feels like uncharted territory, we'll keep reporting on big questions about climate change, like how much people can adapt and the technological advances that may make a difference. *—Nancy Shute, Editor in Chief*

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Excerpt from the August 11, 1973 issue of *Science News*

50 YEARS AGO

Microtektites in the Caribbean

The debate on tektite origin is more than 100 years old. Some believe that the tektites … formed when an asteroid hit the moon, splashing droplets of molten rocks so high that they escaped the moon's gravity and fell to Earth. However … tektites are more like the elements in the continental crust of the Earth itself.… If the parent material of [newfound Caribbean] microtektites can be determined … the discovery of the origin of the glassy objects might quickly follow suit.

UPDATE: Tektites form when a space rock slams into Earth, blasting liquefied crust into the atmosphere that hardens into glassy particles while falling to the surface. The Caribbean microtektites were traced to a 35-million-year-old crater in Virginia. Researchers think the impact created a blanket of tektites called the North American strewn field. In 2020, tektites from Thailand pointed scientists to the source of the largest known strewn field, which covers a tenth of Earth's surface. A bolide slammed into Laos about 800,000 years ago, and volcanic material has since buried the crater, the team says.

Markings on stone artifacts (a selection shown) from an island in the Philippines suggest the stones were used to make fibers nearly 40,000 years ago.

THE SCIENCE LIFE

Indigenous input reveals hints of early fiber making

On the island of Palawan in the Philippines, a cave has yielded reams of ancient artifacts, including thousands of stone tools. No traces of hewn trees or stripped bark or carved meat remain to hint at what the tools may have been used for. But they do bear signs of wear and tear, prehistoric marks from the tasks they once aided.

To archaeologist Hermine Xhauflair and her colleagues, these marks can serve as fingerprints, identifying the ways past humans used the tools. For

SCIENCE STATS

The Milky Way's heart raced about 200 years ago

Sometime between the American Revolution and the California gold rush, the black hole at the core of the Milky Way woke up. Called Sagittarius A*, the black hole has been quiet and dim since it was discovered in the 1970s. It's thought to have been mostly quiescent for eons. But roughly 200 years ago, the goliath, as seen from Earth, suddenly brightened as it let out a brief flare of X-rays, researchers report in the July 6 *Nature*.

~200

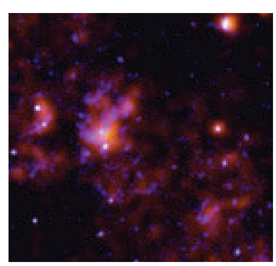
years ago

The last time the Milky Way's central black hole appeared active

At 26,000 light-years away, "Sagittarius A* is the closest supermassive black hole to us," says astronomer Frédéric Marin of the University of Strasbourg in France. "But it's dormant." If the black hole is now accreting material into its surrounding disk, it's at a low rate and therefore difficult to observe (SN: 6/4/22, p. 6).

About 30 years ago, astronomers detected bright X-rays from gas clouds in the galactic center. One idea was that Sagittarius A* spit out an X-ray pulse after eating cosmic material, and the clouds recorded the afterglow. But other X-ray sources were possible.

Marin and colleagues used a NASA satellite to measure the polarization, or direction, of the X-rays. "This direction can act as a compass, pointing to the source," Marin says. And it pointed straight at the black hole. The data suggest that the black hole emitted a pulse about 200 years ago, suddenly growing a million times as bright as it is now. How often such pulses happen and what caused Sagittarius A* to flare is still unclear, Marin says. *— Lisa Grossman*



Gas clouds record the X-ray glow (orange in this satellite image) from when our galaxy's core flared two centuries ago.

FROM TOP: © THE NATIONAL MUSEUM OF THE PHILIPPINES; IXPE: F. MARIN *ET AL*, MSFC, NASA; CHANDRA: SAO/CXC/NASA; IMAGE PROCESSING: L. FRATTARE, J. MAJOR AND K. ARCAND help deciphering these fingerprints, Xhauflair's team turned to the Indigenous Palaw'an people, who live near the site where the artifacts were discovered and share a deep ancestral knowledge of how to process the island's natural resources.

"I wanted to learn from the experts of the forest," says Xhauflair, of the University of the Philippines Diliman.

Thanks to that collaboration, researchers can now say that the tools, dating to about 39,000 years ago, are some of the oldest known evidence of fiber making in the tropics. Access to fiber technologies may have opened up possibilities for nets, traps and boats, the team speculates (*SN: 8/31/19, p. 16*).

Xhauflair presented her plan to the councils of elders of several Palaw'an villages. The councils granted her and her colleagues permission to live with the communities for three months and record craftspeople as they used tools for various tasks, including processing plant-based fibers.

After dissecting the techniques and identifying the 95 plant species that Palaw'an artisans were recorded using, the team created and tested 16 stone tools that resemble those from the cave.

Xhauflair emulated Palaw'an techniques to strip and pull apart layers of plants such as bamboo and palm to make strong, flexible strips and other fibers. Many of the plants and techniques left distinct notches and striations on tool surfaces. Comparing the markings with those on the artifacts revealed striking similarities, which suggests that the ancient tools were used to make fibers, the team reports June 30 in *PLOS ONE*.

Remnants of ancient fibers are particularly rare, since the plant materials used to make them tend to decay quickly, especially in the humid tropics. The oldest known evidence for fiber making anywhere dates to roughly 120,000 years ago in Israel, which is more arid.

Xhauflair's study design gives archaeologist Richard Fullagar confidence in

Archaeologist Hermine Xhauflair (center) and colleagues gather in Palawan, where stone tools probably used to make fibers were found.

the new findings. "The evidence for cutting fibrous plant parts is strong," says Fullagar, of Flinders University in Adelaide, Australia.

Resemblances between markings on the ancient tools and those made using Palaw'an techniques suggest that similar techniques have been used for at least 39,000 years. Whether such techniques have been passed down over generations, or they disappeared and then were independently relearned much later, remains a mystery. *— Luis Melecio-Zambrano*

TEASER

A design for tougher, greener tires

A new material design could reduce pollution where the rubber meets the road. Strategically adding weak points to microscopic chains called polymers actually makes the chains harder to tear, scientists report in the June 23 *Science*. Because polymers are used in car tires, the findings could help reduce plastic pollution as tires wear down over time.

As tires scrape against the road, they drop tiny particles of rubber and plastic polymers that can pollute waterways and contaminate the air. Globally, tires shed about 6 million metric tons of this debris into the environment each year. Stronger polymers that break apart less easily could limit the pollution.

Chemist Stephen Craig of Duke University and colleagues made their tough material by adding easily breakable molecules called cross-linkers to the polymers. The polymers act like a tangle of spaghetti noodles with the cross-linkers holding them all together, helping them retain their shape. Individual cross-linkers broke easily when the team stretched the polymer strands, but ripping the bulk material required more force than expected. The secret to the increased toughness lies in the path the tear takes. The tear propagates through the cross-linkers, following the path of least resistance. But making it through the long polymer strands means breaking many cross-linkers, which requires more force overall. Craig hopes the findings will help extend the lifetimes of car tires. *— Skyler Ware*

Watch a video of tear-resistant rubber in action at **bit.ly/SN_ToughTires**

RETHINK

Lovecraftian critter ate tender prey

One of the freakiest apex predators to ever haunt the sea may have also been a delicate eater.

Scientists have assumed that *Anomalocaris canadensis*, or "abnormal shrimp from Canada," used its spiny facial appendages to grab and crush armored trilobites about 500 million years ago. But a new study suggests the hunter wasn't up to the task. Instead, the creature may have hunted soft prey, a team led by paleobiologist Russell Bicknell reports in the July 12 *Proceedings of the Royal Society B*.

Scads of fossilized injured trilobites hint that something attacked them, but no one has yet found proof that *A. canadensis* could break exoskeletons, says Bicknell, of the American Museum of Natural History in New York City. So his team tested the spiky limbs' vigor via computer simulations. The predator moved most efficiently when its appendages were outstretched. And while the limbs were effective grabbers, they were too fragile to attack armored prey. Together, the results suggest *A. canadensis* was suited for hunting soft creatures. Its limbs could "absolutely pincushion something…squishy," Bicknell says. *— Nikk Ogasa*

Cambrian predator *Anomalocaris canadensis* was the size of a house cat.

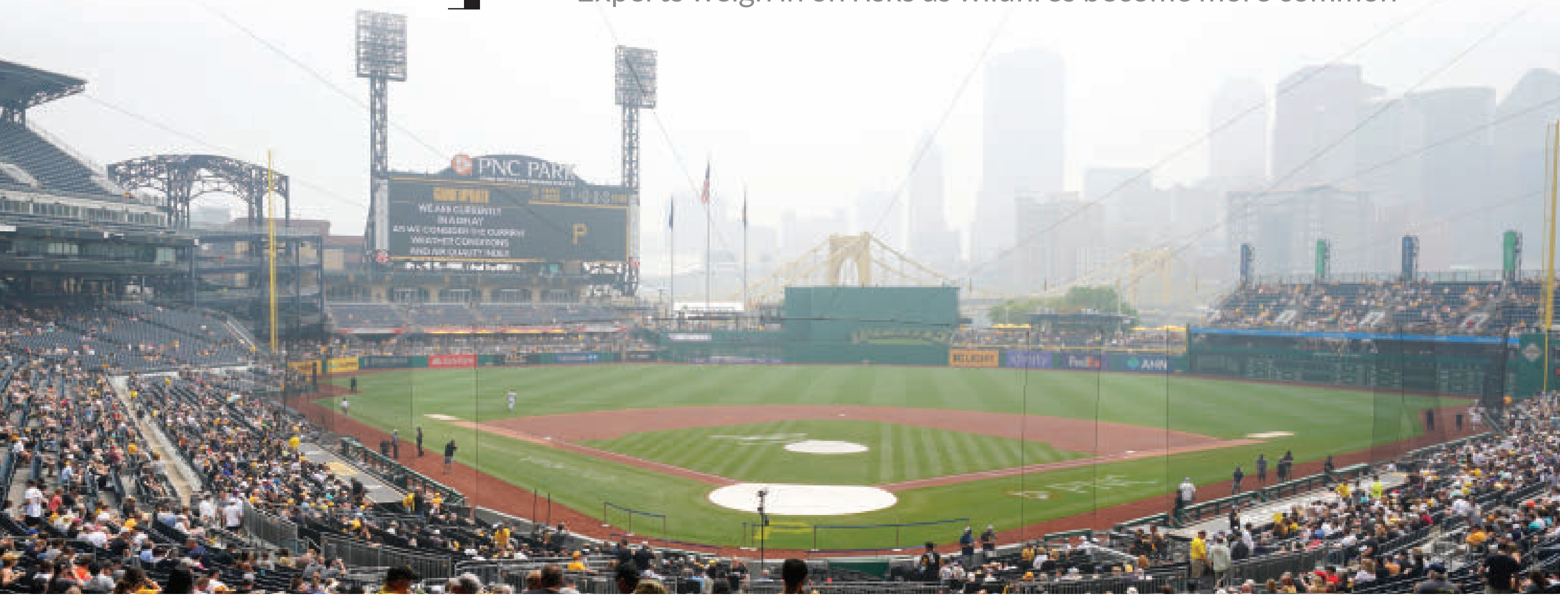
FROM TOP: H. XHAUFLAIR; KATRINA KENNY

News

ENVIRONMENT

How wildfire smoke affects health

Experts weigh in on risks as wildfires become more common



Smoke from Canadian wildfires blankets this baseball stadium in Pittsburgh on June 29. Such hazy, hazardous conditions may become more common as wildfires become more frequent.

GENE J. PUSKAR/AP PHOTO

BY MEGHAN ROSEN

North America's summer of smoke may well be a harbinger of what's to come as the climate continues to change. Record-breaking wildfires in Canada are still sweeping across the land, and smoke has been suffusing the skies for more people, including in the eastern and midwestern United States (SN: 6/18/22, *p.* 16). Frequent fires like these can mean more smoke inhaled, and over longer periods of time.

What are the health consequences of breathing in this fumy miasma? *Science News* spoke with three experts to find out.

Jeffrey Brook is an air pollution exposure scientist at the University of Toronto. His office is roughly 500 kilometers from raging blazes that have engulfed more than 9 million hectares in Canada this year. Even at that distance, the air has been bad, Brook says, shrouding the city in noxious gases and tiny particles of burned biomass. "It's the worst particulate matter air quality I've seen in 30 years or more."

Some 800 kilometers south, where atmospheric scientist Katelyn O'Dell works at George Washington University in Washington, D.C., the scene has been less apocalyptic. But some days you can smell smoke in the air, she says, and "the sky doesn't even look blue."

From across the continent, at the British Columbia Centre for Disease Control in Vancouver, environmental epidemiologist Sarah Henderson says those smoky scenes look all too familiar. "We're no strangers to wildfire smoke," she says. In previous years, the region has seen extreme episodes driven by fires in the Pacific Northwest.

These three scientists have been studying the health effects of wildfire smoke for years. They talked to *Science News* about how smoke impacts human health, what questions remain and what researchers might be able to learn from the current fires. These conversations have been edited for length and clarity.

Why are scientists focusing on wildfire smoke?

O'Dell: The wildfire season has been expanding, so it's impacting us more throughout the year. And wildfire smoke is different than the typical urban smog that has been studied historically.

Emissions from traffic and industry have been decreasing due to successful emissions control policies. Because those are going down and wildfire smoke is going up, it's really important for us to study wildfire smoke and its impacts on health.

How can wildfire smoke affect people's health?

Henderson: Wildfire smoke is a really complex form of air pollution. And we have decades of research that tells us exposure to air pollution isn't good for us.

What we know at this point is that when smoke is occurring, there are measurable effects in the population almost immediately. Respiratory effects, especially for people with preexisting respiratory conditions, such as asthma and COPD [chronic obstructive pulmonary disease], are the first things to happen. We generally see that these people need more of their rescue medications, meaning that their airways are closing up.

The magnitude of that impact in those populations seems to be larger for wildfire smoke than for other types of air pollution. We also see small detriments to cognitive performance.

And then there's quite a bit of evidence around impacts to the developing fetus. There's risk of preterm birth and reductions in birth weight for infants who are exposed in utero.

What's in wildfire smoke?

Brook: It contains some of the same toxicants that we think about all the time as bad ones in air pollution.

O'Dell: The pollutant that we're typically most concerned with is the fine particulate matter, or $PM_{2.5}$.

Henderson: Those are particles that can travel deep into the lungs.

O'Dell: Wildfire smoke has a lot of gases in it too. Things like formaldehyde, benzene and sometimes ozone. Ozone negatively impacts respiratory health. It's unclear right now if benzene and formaldehyde are often at dangerous levels in smoke plumes, but we do know these pollutants at certain levels can negatively impact health.

What questions do researchers still have about health effects?

O'Dell: If you have a wave of wildfire smoke multiple times every summer, how does that affect your health in the long term? It's a very important question and an open area of research right now.

Henderson: It's a challenging question to address because you might have a population that's exposed for a couple of weeks, at a really high magnitude for one summer, and then for the next three summers, there's no smoke and everything's fine.

That intermittent, episodic nature of exposure might mean that [the longer-term effects of wildfire smoke] are quite different from the more steady types of air pollution that affect our air quality.

We're still learning about what that means. We might be seeing kids, if they are exposed very early in life, with a lifelong detriment to their lung function.

Brook: What if you happen to be pregnant and the fetus is at a particularly important part of development? If it's getting really high exposure coupled with stress because the mom is worried…could that alter how certain organs—lungs, brain, heart—develop? We don't know.

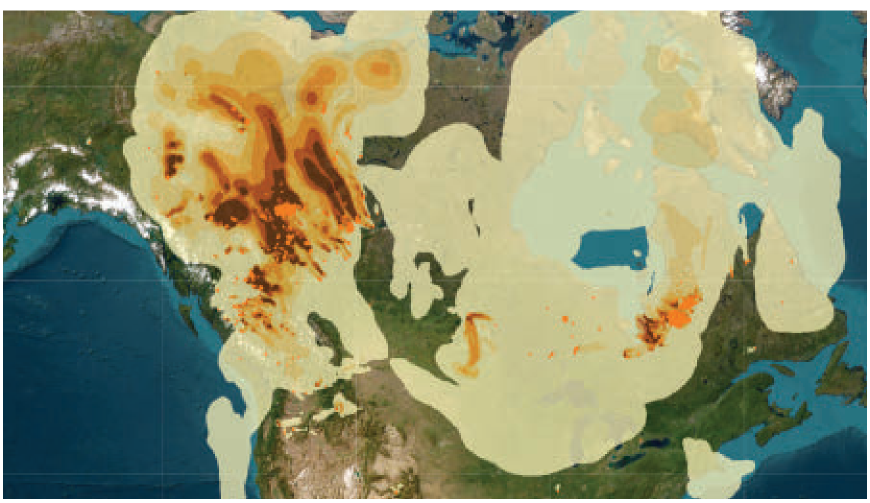
O'Dell: [Another] open question is how the health impacts of fresh smoke differ from old smoke [more than three days old]. There are a few reasons the impacts might be different, one being chemical changes in the smoke itself…as it travels through the atmosphere.

What can we learn from these wildfires?

O'Dell: A lot of the wildfire and health studies have occurred in the western United States. This event…will hopefully allow us to have a greater understanding of how wildfire smoke might impact people in the east.

There are many factors that may lead to a different health response for those out east compared with those out west, including different baseline disease rates or levels of preexisting conditions, different responses to smoke, level of outdoor activity, etc.

Henderson: What we need are populations that know how to take protective measures, and policies that look at how we keep smoke out of the indoor environment.… That's going to allow us to be resilient to the smoke exposures in the decades ahead.



BLUESKY CANADA

This forecast shows where fine particulate matter in smoke from Canadian wildfires was expected to occur on July 10. Darker colors indicate more air pollution.

What can people do to protect themselves?

Henderson: The vast majority of us spend the vast majority of our time inside. If we are effectively reducing smoke in the indoor environment, we are effectively protecting our health for about 90 percent of the time. We highly recommend that you have some sort of air-cleaning device running in at least one room of the home so that you have kind of a smoke-free haven.

O'Dell: Check the local air quality before you undergo any outdoor activity, and then adjust your behavior accordingly. If you really need to be outside, maybe go for a walk instead of a run, and wear [an N95 or KN95] mask if it's really bad. And if you're in an extra-sensitive group—children, the elderly, people with preexisting conditions—you might choose to stay indoors on days that are especially smoky.

At the local government level, it's good to have plans in place for when there is smoke. Do schools cancel recess? Do we open clean-air shelters for people who aren't able to have clean air in their homes—or maybe don't have a home?

How worried should we be about wildfire smoke?

Brook: We should be more worried about climate change. [Canada has] had fire impacts from coast to coast this year.… It's just unprecedented. It's a wake-up call. Like, hey folks, you've been hearing that these things are going to happen. And look, they're happening sooner, they're happening faster. Look at your air. This is not just bad luck. ■

CLIMATE

Earth sizzles in record heat

Converging forces push the planet into uncharted territory

BY NIKK OGASA

Global temperatures are shattering records as El Niño and climate change compound. On July 3, the average global temperature reached 17.01° Celsius (62.6° Fahrenheit), the highest ever recorded, according to the U.S. National Centers for Environmental Prediction. That surpassed the previous record of 16.92° C from August 2016.

By the end of the week, that new record was tied or broken three more times, peaking on July 6 at 17.23° C. And that was after Earth had experienced its hottest June ever recorded.

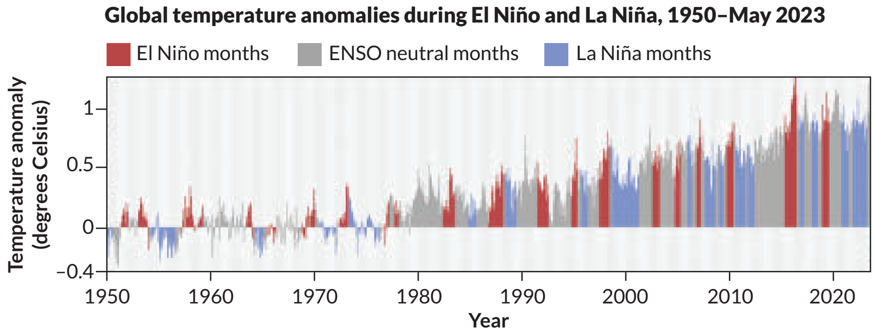
Much of the extreme heat we're seeing goes back to the state of our oceans, says Thomas Di Liberto, a climate scientist at the National Oceanic and Atmospheric Administration in Washington, D.C. Oceans around the world have grown alarmingly warm, due in no small part to human-caused climate change, scientists say. And El Niño, the recurring climate pattern known to temporarily heat the planet, has returned (*SN: 7/1/23, p. 9*).

"We've really never had this set of circumstances before," says atmospheric scientist Jennifer Francis of the Woodwell Climate Research Center in Falmouth, Mass. "We're entering uncharted territory."

Earth's seas have been warming for decades. The most recent decade has been the sea surface's hottest since at least the 1800s. In April, the average surface temperature of the world's oceans reached 21.1° C, the highest ever recorded.

It's been particularly warm in the North Atlantic. In April, sea surface temperatures in some spots surpassed 4 degrees C above what's normal for that time of year. And in the Gulf of Mexico, the average sea surface temperature on July 12 was over 30° C, the highest recorded for that time of year since satellite monitoring began in 1981.

Such marine heat waves have become about 50 percent more common over the last decade. Much of that warming has to do with climate change, Di Liberto says. "We've juiced the system."



Warming up The average global temperature typically fluctuates with the phases of a natural climate cycle called ENSO. Before 1980, El Niño phases (red) were usually linked with temperatures higher than the 20th century average, while La Niña phases (blue) were usually linked with below-average temperatures. But global warming has led temperatures to stay above that average.

NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION/NOAA

As the oceans warm, they become less capable of absorbing heat from the atmosphere, says Marybeth Arcodia, an atmospheric scientist at Colorado State University in Fort Collins. So that's where it remains, raising Earth's air temperature.

Operating on top of this background ocean warming is a natural climate cycle called the El Niño-Southern Oscillation, or ENSO. The phenomenon entails yearslong periods of warming and cooling waters in the equatorial Pacific, controlled by air currents known as the trade winds.

In March, Earth exited a cooler period, called La Niña, that lasted three years. Then in June, El Niño got under way. Much of the tropical Pacific — which at the equator wraps halfway around the planet — becomes swaddled in a warm duvet of water, which can be over 100 meters deep. That balmy layer exudes heat into the atmosphere, where much of it is trapped by greenhouse gases.

El Niño is typically associated with higher global temperatures, while La Niña is often correlated with lower ones. 2016 is currently the hottest year on record, which "lines up with the strongest El Niño event on record," Arcodia says.

But El Niño and La Niña don't always have predictable outcomes. Arcodia points to 2020. That the second hottest year on record occurred during a La Niña underscores the influence of climate warming on record-breaking temperatures, she says.

It's probably safe to say that El Niño is exacerbating climate warming, but just how much the phenomenon's return contributes to the recent unprecedented heat is unclear, Di Liberto and Arcodia agree.

El Niño typically peaks during the Northern Hemisphere's winter, so Earth has yet to feel the full brunt. The planet may experience even higher global temperatures in the near future and unusually warm months later in 2023, Di Liberto says.

The relatively long La Niña might have set the stage for a strong El Niño, packing warm water in the western Pacific, loading it like a spring, says oceanographer Regina Rodrigues of the Federal University of Santa Catarina in Florianópolis, Brazil. Now that spring has been released. With El Niño in play, there's a 20 percent chance that 2023 becomes the hottest year on record and a 97 percent chance it's among the top five, according to the U.S. National Centers for Environmental Information.

Climate change is also behind recent stretches of extreme heat in the United States, Mexico, China and Europe. Without it, China's heat wave would be expected once every 250 years. Now, it's a once-in-five-years phenomenon, scientists report July 25 in a study from the World Weather Attribution network. The European and North American heat waves, which would have been virtually impossible without climate change, are likely to occur once every 10 years and 15 years. The other culprit is the jet stream, a powerful wind that has been meandering and holding hot air over many parts of Earth. Climate change may further destabilize the stream, making long bouts of extreme heat more common. ■

HEALTH & MEDICINE

New Alzheimer's drugs are coming

Three lab-made antibodies help clear sticky plaques in the brain

BY LAURA SANDERS

There are now three drugs that can temporarily hold off the mental decline caused by Alzheimer's disease.

The newest, called donanemab, slowed cognitive decline by about 35 percent over the course of a year and a half, according to clinical trial data published July 17 in *JAMA*.

The finding comes on the heels of the U.S. Food and Drug Administration's full approval of another drug, called lecanemab (brand name Leqembi), that can also slow the disease's progression. Another similar drug, aducanumab (Aduhelm), received accelerated approval in 2021, though access to it is still limited.

All three drugs are monoclonal antibodies. These custom-designed antibodies take inspiration from ones that the body makes to detect harmful substances, a key part of the immune system. In the brain, the lab-made antibodies attach to specific parts of protein aggregates called amyloid plaques, a hallmark of Alzheimer's. Once attached, the antibodies call in other immune cells to take out the trash.

This cleanup job brings mental benefits, clinical trials suggest. And that finding supports the long-standing idea that amyloid is a key part of Alzheimer's disease, says neurologist and neuroscientist Erik Musiek of Washington University in St. Louis.

None of these drugs stop the disease. But they can buy some time, the data suggest. On average, the 588 people who received donanemab, for instance, stayed sharper for a bit over four months longer than the 594 people who received a placebo. Using a different scale to measure symptoms gave an estimate of seven and a half months of extra time due to the drug, made by the pharmaceutical company Eli Lilly, based in Indianapolis. Notably, about 80 percent of participants on the drug no longer had amyloid plaques. Even though some of those people were switched to a placebo once their plaques disappeared, their mental benefits seemed to persist.

Results from studies of aducanumab are more mixed, generating debate about whether the drug, made by Biogen Inc., based in Cambridge, Mass., is effective (*SN: 7/3/21 & 7/17/21, p. 8*).

In an 18-month-long study of lecanemab, made by Biogen and Tokyo-based Eisai Co., people who got the drug spent about five months longer in a mild stage of Alzheimer's than people who got a placebo. That may not sound like a lot. And for some people, it might not be worth the risks, such as brain swelling and bleeding.

But for others, that delay could be meaningful, says geriatric neurologist Aimee Pierce of Oregon Health & Science University in Portland. "Some of my patients are writing memoirs … or still struggling through their last year of teaching," she says. In those circumstances, a five-month reprieve before progressing to more confusion is significant.

So far, the drugs are for people who show mild signs of Alzheimer's disease. Scientists don't expect the drugs to help once Alzheimer's has progressed to more intense stages. What's more, the clinical trials were not representative of the U.S. population, enrolling very few people who are Black or Hispanic, for instance. That leaves a lot to learn.

To be treated with the drugs, a person should have amyloid plaques in their brain, confirmed via a brain scan or a cerebrospinal fluid test. The donanemab trial also required people to have excess tau proteins in their brains, another sign of Alzheimer's.

Autoimmune disorders, medical implants that preclude MRI scans that monitor brain reactions and other health issues may also stop someone from being a candidate. People who carry APOE4, a version of a gene that ups a person's risk of Alzheimer's, seem to be at higher risk of harmful side effects from the drugs too.

The drugs are administered intravenously in medical centers, where health care workers monitor reactions. In the recent trial of donanemab, three deaths were linked to the treatment.

People on the drugs should undergo brain scans that can detect possibly dangerous changes, researchers say. About a quarter of people in the clinical trials who received a drug developed the worrisome condition ARIA, or amyloid-related imaging abnormalities. In a trial of nearly 1,800 people, for instance, about 21 percent of people who received lecanemab had ARIA, while about 9 percent of people who got a placebo did. Most cases do not come with symptoms, such as headache, nausea, dizziness and seizures.

Scientists suspect that ARIA stems from the antibodies working well. Amyloid can be in the walls of blood vessels. Removing it may make the vessels more prone to break.

The new drugs hopefully are a stop-off on the way to even better ones that are more effective, less risky and easier to administer, Musiek says. ■

TEK IMAGE/SCIENCE PHOTO LIBRARY/GETTY IMAGES PLUS

New drugs to treat Alzheimer's disease can lead to dangerous changes in the brain's blood vessels. Scientists recommend that people taking the drugs be monitored with MRI scans (examples shown).

ANTHROPOLOGY

Did hominids eat each other?

Fossil markings may be signs of cannibalism, scientists contend

BY BRUCE BOWER

A 1.45-million-year-old hominid leg fossil sports previously unrecognized evidence of our ancient evolutionary relatives butchering and possibly eating one another, a new study claims.

An ancient individual used a stone tool to make nine incisions on the fossil, which preserves the shin and lower knee. Analyses of 3-D models of these marks peg them as resembling damage produced by stone tools rather than by large predators' bites or by animal trampling, researchers report June 26 in *Scientific Reports*.

Those incisions are the oldest convincing example of such butchery and possibly cannibalism among ancient hominids, says paleoanthropologist Briana Pobiner of the Smithsonian Institution in Washington, D.C. But there's debate about that interpretation.

Pobiner first examined the incised leg bone while studying fossils held at the Nairobi National Museum in Kenya. She wanted to identify which nonhuman predators hunted and ate ancient hominids. But marks on the leg bone looked to her like butchery damage.

Pobiner sent molds of 11 incisions on the fossil to paleoanthropologists Michael Pante of Colorado State University in Fort Collins and Trevor Keevil of Purdue University in West Lafayette, Ind. The pair created 3-D scans of the bone marks and compared them with 898 bone marks known to have been made by stone cutting tools, stone pounding implements, the teeth of crocodiles, lions and other nonhuman predators, or cows trampling the ground (SN: 12/9/17, *p. 7*).

Nine marks closely matched stone-tool damage, Pobiner says. The other two marks resulted from the bite of a big cat, perhaps a saber-toothed feline.

No consensus exists on the species identity of the ancient leg fossil. It might

An ancient hominid leg fossil appears to bear stone-tool incisions (magnified view, inset). The finding hints that some hominids butchered and perhaps ate one another, researchers argue.

represent *Homo erectus*, *H. habilis* or a relatively small-brained species called *Paranthropus boisei*, Pobiner and colleagues say. There is also no way to tell whether a hominid from the same species or a different species left stone-tool marks on the leg fossil.

The incisions on the fossil cluster where a calf muscle attached to bone, consistent with the removal of a chunk of flesh, Pobiner says. Reasons for that act remain hazy, especially with only a single, fragmentary bone in hand. "We assume the intention of whichever [hominid] inflicted the cut marks was simply to cut off meat from the bone to eat it, based on hunger," Pobiner says.

Zooarchaeologist Raphaël Hanon of Wits University in Johannesburg agrees. Cutting into the fleshy part of a lower leg probably reflected a need for food rather than a ritual act of some kind, says Hanon, who was not part of Pobiner's team. There is no way to know whether flesh from meatier body parts, such as the shoulder and upper leg, was also removed, he says.

But stone-tool incisions on a partial leg bone do not provide enough evidence to determine whether hunger motivated flesh removal, counters Palmira Saladié, a zooarchaeologist at the Catalan Institute of Human Paleoecology and Social Evolution in Tarragona, Spain. Pobiner's findings may reflect scenarios such as cannibalism to supplement other food sources, some sort of ritual practice that did not include cannibalism or the consumption of a defeated enemy following a fight between groups, Saladié suggests.

Archaeologist Yonatan Sahle of the University of Cape Town in South Africa agrees with Saladié that the interpretation remains up in the air. Although Stone Age cannibalism may have occurred, "the present evidence is not strong enough to enable such an inference," Sahle says.

Further complicating matters, the original context of the leg fossil is unknown. It was found on the surface of a site in northern Kenya after coming loose from eroding sediment. The fossil's age estimate derives from its position just above a volcanic ash layer that dates to around 1.5 million years ago. Researchers have thus presumed that the leg bone originally rested in sediment slightly younger than that ash deposit.

A possible earlier case of a butchered hominid, reported in 2000, also triggered debate. Researchers described incisions on a partial upper jaw found at a South African site — with age estimates ranging from 2.6 million to 1.5 million years old — as having resulted from slicing through a muscle to remove the lower jaw. But Hanon and colleagues have argued that animal trampling or accidental rubbing of the fossil against jagged rocks before it was excavated could have produced the incisions.

Pobiner's group did a good job of excluding such factors as causes of nine of the 11 incisions on the leg fossil, Hanon says. There is a "very high probability" that a hominid used a stone tool to create those ancient marks, he concludes.

But even if further research strengthens that probability, such evidence falls far short of demonstrating cannibalism, says paleoanthropologist Tim White of the University of California, Berkeley. White, who has long studied skeletal clues to cannibalism, calls the Kenyan fossil "an interesting scientific curiosity that changes nothing of significance." ■

JENNIFER CLARK

PHYSICS

Electrons are almost perfectly round

A new result leaves a mysterious cosmic imbalance unsolved

BY EMILY CONOVER

Electrons are really, really round.

A new measurement confirms the subatomic particle's spherical shape to a record level of exactness, physicists report in the July 7 *Science*.

That near-perfect roundness deepens the mystery behind how the universe came to be filled with matter as opposed to its counterpart, antimatter. Any asymmetry in the electron's shape, namely the distribution of the particle's electric charge, would point to a related asymmetry in the laws of nature, one that could explain this feature of the cosmos.

The measurement — of a property known as the electric dipole moment — is twice as precise as the previous best measurement of the electron's shape (SN: 11/10/18, p. 7). "I don't think Guinness tracks this, but if they did, we'd have a new world record," says physicist Tanya Roussy of the University of Colorado Boulder.

Roussy and colleagues gauged the particle's shape by looking at whether electrons pivoted in an electric field. If electrons were slightly egg-shaped rather than round, an electric field would exert a torque on them, much as gravity topples an egg standing on its end.

To see that torque, the team looked for changes in the energy levels of charged molecules of hafnium fluoride. Any torque on the electrons would give the molecules different energy levels depending on which direction the "egg" was oriented relative to an electric field. The team found no difference in the molecules' energy levels, confirming the electron's roundness.

At their most basic level, electrons are pointlike particles without a definite size and shape. But in quantum field theory, electrons can be thought of as surrounded by temporary "virtual" particles that pop in and out of existence, giving each electron a spherical halo of electric charge. If that halo were found to be just slightly egg-shaped, that could point to how the universe became lopsided toward matter.

The Big Bang should have created matter and antimatter in equal parts. But matter in our universe is common while antimatter is scarce. Scientists have suggested that the existence of certain subatomic particles could have tipped the balance toward matter. If those particles exist, they would also appear and disappear around the electron in such a way as to make it oblong. But they would require so much energy that even the world's biggest particle accelerator could not produce them, so studies of electron roundness are an important test.

The new finding shows no trace of hidden particles, leaving unsolved the mystery of how matter gained the upper hand, says physicist David DeMille of the University of Chicago. That "leaves us with the question of what is out there." ■

ASTRONOMY

Goliath black holes hum as they dance

A new class of gravitational waves may hail from merging galaxies

BY EMILY CONOVER

Beneath the explosions, collisions and other intermittent bangs in the cosmos, scientists suspect a nonstop soundtrack plays, created by ripples in spacetime continuously rolling through the universe. After more than a decade of searching, scientists may have finally heard that background hum.

Teams of researchers from around the world report June 28 the first clear evidence of these gravitational waves. Unlike previously detected gravitational waves, these new ones have ripples that are superlong — on the scale of light-years. The likely source: innumerable pairs of gargantuan black holes that churn the spacetime cauldron as they orbit one another.

If that hunch is correct, the result would provide the first evidence that pairs of black holes with masses billions of times that of the sun can coalesce into one. That would be "extremely interesting, because we have essentially no handle on what the most massive black holes are doing," says astrophysicist Meg Urry of Yale University, who was not involved in the research.

Accelerating massive objects produce gravitational waves that careen through the universe, rumpling the fabric of spacetime upon which reality is embroidered. In 2015, scientists with the U.S. observatory LIGO detected gravitational waves for the first time. Those waves were spawned by mergers of smaller black holes, entirely different beasts than the supermassive ones that lurk at the centers of galaxies.

While LIGO picks up gravitational wave blips that can last mere fractions of a second, orbiting supermassive black holes are expected to pump out waves continuously for millions of years, creating ripples that blanket the cosmos with a constant hum.

Across the universe, galaxies regularly merge. As they do, their supermassive black holes are thought to orbit one another and emit gravitational waves. Many pairs of black holes would be doing this orbital dance at once, in the many merging galaxies throughout the cosmos, all sending out their spacetime ripples.

Detecting this mishmash of waves required scientists to MacGyver the Milky Way. They turned the galaxy into a gravitational wave detector by timing the clocklike ticking of pulsars, spinning remnants of exploded stars that emit beams of radio waves as they twirl. These beams sweep past Earth at regular intervals. Gravitational waves stretching and squeezing the space between the pulsars and Earth cause the ticks, observed with radio telescopes, to come early or late.

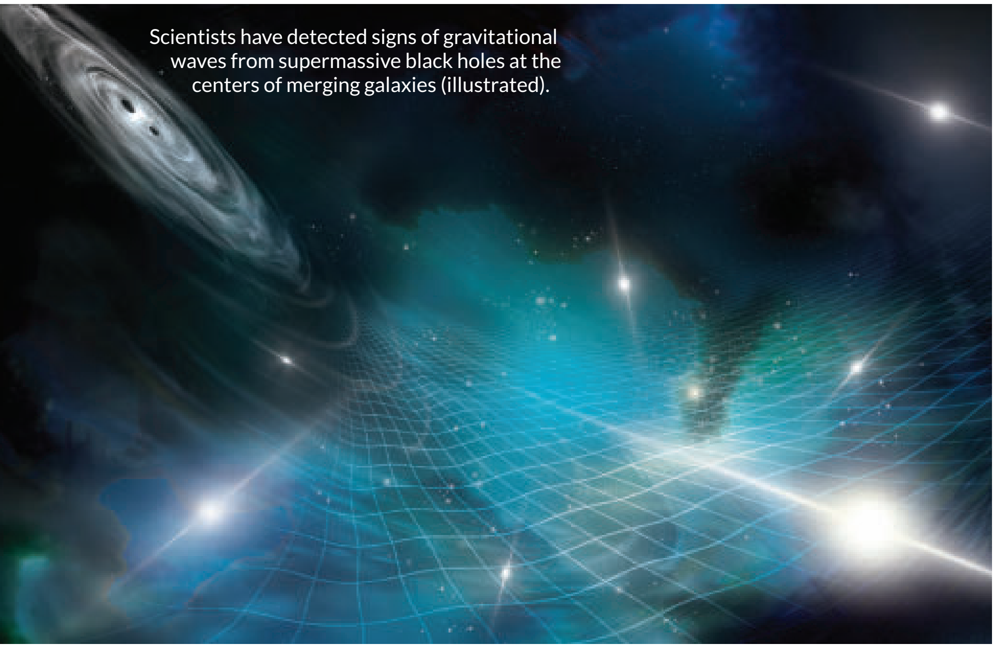
The teams ensured they were detecting the gravitational waves, rather than uninteresting jitters, by looking for a type of correlation between different pulsars. Pulsars near one another on the sky should show similar timing shifts, but those that are at right angles to one another should observe opposite shifts: One pulsar's blips come early while the other's come late.

After 15 years of monitoring dozens of pulsars, that hallmark has finally been observed, scientists with the North American Nanohertz Observatory for Gravitational Waves, or NANOGrav, report in *Astrophysical Journal Letters*. "There's nothing in nature that can mimic this," says Chiara Mingarelli, a Yale astrophysicist and NANOGrav team member.

The telltale correlation was also evident in 25 years of observations by pulsar timing arrays in Europe and India, another team reports in papers accepted in *Astronomy & Astrophysics*. Scientists with the Parkes Pulsar Timing Array in Australia report their results in *Astrophysical Journal Letters* and in a paper accepted in *Publications of the Astronomical Society of Australia*. The Chinese Pulsar Timing Array's team reports its finding in *Research in Astronomy and Astrophysics*.

Some scientists think that supermassive black holes in merging galaxies would never draw close enough to coalesce, or to emit gravitational waves like the ones observed. But the strength of the signal suggests many such black holes "merge happily," says astrophysicist Marta Volonteri of Institut d'Astrophysique de Paris, who did not partake in the research.

Researchers stopped short of declaring an ironclad detection of the hum. Individually, the results don't quite meet physicists' most stringent standards for statistical significance. The teams plan to combine data to try to solidify the detection. ■



Scientists have detected signs of gravitational waves from supermassive black holes at the centers of merging galaxies (illustrated).

AURORE SIMONNET/SONOMA STATE UNIV., NANOGRAV

ASTRONOMY

Neutrinos map the Milky Way

Scientists find ghostly particles from the galactic plane

BY JAMES R. RIORDON

Scientists have made the first image of the Milky Way using neutrinos.

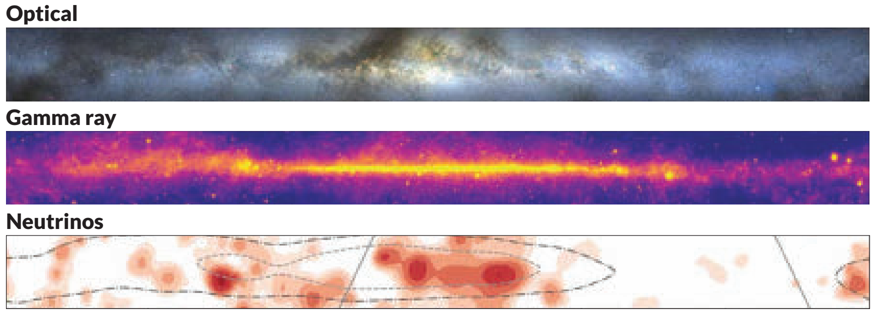
The extremely low-mass subatomic particles have no electric charge, and they pass easily through gas, dust, stars and even Earth, where specialized sensors can detect them (SN: 12/8/18, *p.* 14). High-energy neutrinos zip throughout the cosmos, but where they come from is usually a mystery.

Now, by combining artificial intelligence with data collected by the IceCube detector in Antarctica over the course of a decade, researchers have found the first evidence of high-energy neutrinos that originated from inside the Milky Way and mapped the particles onto an image of the galaxy's plane. It's the first time our galaxy has been imaged with anything other than light.

The map includes signs of specific high-energy neutrino sources within the Milky Way that might be the remnants of past supernova star explosions, the cores of collapsed supergiant stars or other as-yet-unidentified objects, the team reports in the June 30 *Science*. But more research is needed to clearly pick those sorts of features out of the data.

Previously, only a few high-energy neutrinos have been traced to their potential birthplaces, all of which are outside the Milky Way. Those neutrinos include two that appeared to come from black holes shredding their companion stars and others from a highly active galaxy known as a blazar (SN: 6/18/22, *p.* 8; SN: 8/4/18, *p.* 6).

"We're quite unambiguously seeing neutrinos from both galactic and extragalactic space these days," says Kate Scholberg, a physicist at Duke University who was not involved with the research. "There's so much more to learn, and it can be tremendous fun to figure out how to see the universe with neutrino eyes."



Three ways to map the Milky Way These images of the Milky Way show the galactic plane in visible light (top), gamma rays (middle) and particles called high-energy neutrinos (bottom). The particle-based map, made with artificial intelligence and data from a detector in Antarctica, could help researchers pinpoint neutrino birthplaces within the Milky Way.

ICECUBE COLLABORATION/*SCIENCE* 2023

With neutrino astronomy, researchers could potentially see distant objects in a way that no other telescopes can match. That's because neutrinos can cross huge expanses of space without being absorbed or deflected along the way, which could obscure their origins. X-rays, gamma rays, optical light and the charged particles that make up cosmic rays, on the other hand, can be deflected or absorbed.

To physicist Naoko Kurahashi Neilson of Drexel University in Philadelphia, the map that she and her team produced is the latest contribution to a shift in neutrino science. In the past, neutrino observatories like IceCube haven't provided the sorts of views of the sky that telescopes relying on optical light, X-rays or gamma rays offer.

"When I first joined IceCube, I used to do air quotes" when using the phrase neutrino astronomy, Kurahashi Neilson says. "I don't do that anymore.... I don't have to because we're starting to resolve things" in neutrino images that resemble the astronomical images from other telescopes.

The downside is that neutrinos are extremely hard to detect. The IceCube detector is enormous in part to overcome that challenge. It consists of 5,160 sensors embedded within a cubic kilometer of Antarctic ice. The detector's large size increases the odds of seeing a tiny fraction of the neutrinos flying through space from the Milky Way and other places in the cosmos.

Of the 100,000 or so neutrinos that IceCube scientists observe each year, some leave long tracks in the detector that potentially point to where the neutrinos came from. Many of the neutrino signals in IceCube, though, are known as cascade events. They make bursts of light in the detector but don't reveal neutrino origins as well as tracks can.

"This is data we used to throw away in terms of astronomy," Kurahashi Neilson says. There's still information indicating where the neutrinos come from in the data. But it's difficult to identify the promising cascades in the hundreds of thousands of meaningless, background events that IceCube has collected.

Kurahashi Neilson decided to take up the challenge by plowing through a decade of IceCube cascade data with the help of an artificial intelligence method known as a neural network. "You can train the neural nets to identify which events are worth keeping ... [and] which events are more background-like," Kurahashi Neilson says.

It's an approach Kurahashi Neilson pioneered in 2017 and steadily improved until she and her colleagues could identify the neutrinos that the team used in the new map.

"It's an impressive analysis, and the techniques may well not yet be pushed to their limits," Scholberg says. "Clearly a lot more work needs to be done, but it's very exciting to see the basic expectation [of Milky Way neutrinos] verified. This is an important step forward in understanding the high-energy particle sky." ■

ASTRONOMY

Ryugu hints at the solar system's past

Bits of stardust could reveal the history of the sun and its planets

BY LISA GROSSMAN

Samples of the asteroid Ryugu contain bits of stardust that predate the birth of our solar system.

Slivers of Ryugu material, snagged by Japan's Hayabusa2 spacecraft, appear to contain material from stars that died before the sun was born, scientists report in the July 14 *Science Advances*. The foreign stardust could illuminate details of solar system history.

The finding "is really unique," says Ann Nguyen, a cosmochemist at NASA's Johnson Space Center in Houston. "It's showing us a new type of material, but also telling us about the dynamics of material from the outer solar system."

Hayabusa2 brought 5.4 grams of the space rock to Earth in 2020 (SN: 1/16/21, p. 15). In the lab, scientists measured the asteroid's chemical composition. Carbon-rich Ryugu is made of the same material as some of the rarest meteorites found on Earth and was altered by water in its past. Scientists think that the space rock formed from the debris of a larger asteroid, which broke up in a collision and re-formed into a loose pile of rubble.

Nguyen was on the hunt for something different in the Ryugu samples: tiny specks of material that formed from the ashes of dying stars. These presolar grains contain different isotopes — atoms of an element that have different numbers of neutrons — than the isotopes formed by the sun, giving away their alien origins.

Nguyen and colleagues examined two samples of Ryugu, each a few millimeters in size. The team then picked out microscopic slivers of rock called clasts that stood out from the rest.

Scanning electron microscopy and other imaging techniques showed that two of the clasts are chemically different from the rest of Ryugu, with lower oxygen, magnesium and silicon contents, and greater amounts of iron and sulfur. The clasts also have higher concentrations of presolar grains than the rest of the Ryugu material. Since the two clasts' grains contain silicates, which are easily destroyed by water, those slivers could not have been part of Ryugu's parent body.

The team thinks the clasts are bits of a comet that formed in the outer solar system's Kuiper Belt, where the conditions are cool and dry. Then the clasts sprinkled onto the rubble that formed Ryugu sometime between the original asteroid's destruction and the rubble pile's formation. "It kind of collected some other friends that came from other bodies, from different parts of the solar system," Nguyen says. Just how material from the outer solar system found its way to Ryugu is still unclear.

The clasts may be more valuable than the Ryugu samples, says Philipp Heck, a cosmochemist at the Field Museum in Chicago. Such shards can reveal what the unaltered ingredients that formed the solar system were made of.

Think of the disk that formed the planets as bread dough, Heck says. Once the dough is well-mixed, it's hard to tell what went into it. Clasts like those in the Ryugu samples are akin to bits of unmixed flour that survived intact in the final loaf — not delicious, but very informative. To understand the solar system's original ingredients, "we need to find [more of] these very rare, unaltered clasts," Heck says. ■

Bits of stardust in material from the asteroid Ryugu (shown) could reveal details of the solar system's youth.

TORU YADA ET AL/NATURE ASTRONOMY 2021

ANIMALS

Dolphin moms use baby talk

Tweaks to whistles may aid bonding and vocal learning

BY MCKENZIE PRILLAMAN

When speaking to young kids, people often use squeaky, high-pitched baby talk. It turns out that some dolphins do too.

Bottlenose dolphin moms modify their individually distinctive whistles when their babies are nearby, researchers report in the July 4 *Proceedings of the National Academy of Sciences*. This "parentese" might enhance attention, bonding and vocal learning in calves, as it seems to do in humans.

During the first few months of life, each common bottlenose dolphin (*Tursiops truncatus*) develops a unique tune, or signature whistle, akin to a name. The dolphins shout out their own names in the water "likely as a way to keep track of each other," says Laela Sayigh, a marine biologist at Woods Hole Oceanographic Institution in Falmouth, Mass.

But dolphin moms seem to tweak that tune in the presence of their calves, which tend to stick by mom's side for three to six years. It's a change that Sayigh first noticed in a study by one of her students that was published in 2009 in the *Journal of Mammalogy*. That work "was just one little piece of this much larger study," she says.

Sayigh and colleagues followed up on that observation by analyzing signature whistles from 19 female dolphins both with and without their babies close by. Audio recordings were captured from a wild population in Sarasota Bay, Fla., during catch-and-release health assessments that occurred from 1984 to 2018.

The researchers examined 40 instances of each dolphin's signature whistle, verified by the unique way each vocalization's frequency changes over time. Half of each dolphin's whistles were voiced in the presence of her baby.

When youngsters were around, the moms' whistles contained, on average, a higher maximum and slightly lower

Recordings of bottlenose dolphins, including of this mother with her calf in Sarasota Bay, Fla., suggest dolphin moms modify their individually distinctive whistles when their calves are nearby.

minimum pitch compared with whistles uttered in the absence of calves, the team found, contributing to an overall widened pitch range.

These whistle adjustments echo baby talk because human caregivers use the same words they would with adults, just with certain inflections, Sayigh says. The inflections typical of human baby talk — or child-directed communication — involve higher pitches and a wider pitch range, like what was observed in the dolphins.

"Bottlenose dolphins are a prime candidate for child-directed or calf-directed communication," says Quincy Gibson, a marine mammal behavioral ecologist and the director of the University of North Florida Dolphin Research Program in Jacksonville. Similar to humans, these dolphins form strong mother-baby bonds and learn vocalizations.

To confirm the new findings, scientists should analyze signature whistles of freely swimming, unrestrained dolphin moms, says Gibson, who was not involved in the research. "We do need to look at this question in more natural and undisturbed conditions."

Although researchers speculate dolphin parentese could have the same functions as in human speech, no one can be certain "until the day we can ask the dolphins what they're actually doing," says Mauricio Cantor, a behavioral ecologist at the Oregon State University Marine Mammal Institute in Newport who was not involved in the research.

Still, Sayigh says, "the idea that there might be similar forces driving [parentese] in such different species is just really cool." ■

TECHNOLOGY

A detector sniffs the air for coronavirus

The device can sense SARS-CoV-2 in mere minutes, tests show

BY TINA HESMAN SAEY

If you've ever thought it would be great to walk into a room and know whether the virus that causes COVID-19 is hanging around, scientists have a device for you. Researchers have created a machine a little bigger than a toaster that can quickly detect airborne SARS-CoV-2.

It takes only five minutes to detect as few as seven to 35 viral particles per cubic meter of air, scientists report July 10 in *Nature Communications*. That is about as sensitive as PCR nasal swab tests, says aerosol scientist Rajan Chakrabarty of Washington University in St. Louis.

A major challenge when sampling airborne viruses is collecting enough air to concentrate viral particles at detectable levels. Previous attempts have sucked in between 2 and 8 cubic meters per minute. This detector pulls in 1,000 cubic meters per minute.

To trap the virus, Chakrabarty and colleagues swirled liquid at high speed to create "an artificial cyclone inside of the sampler," he says. Viruses get trapped in the wall of the cyclone and concentrated for analysis. Any viruses not captured in the liquid get filtered out of the air with a HEPA filter attached to the device. After five minutes of collection, the liquid is pumped to a biosensor.

The biosensor consists of an electrode attached to a llama nanobody, a specialized immune system protein made by llamas and their relatives. Nanobodies fight infections much the way antibodies do but are smaller and perhaps tougher than human antibodies (SN: 10/10/20 & 10/24/20, p. 7).

The nanobody used in the device grabs any passing coronavirus by its spike protein. Electricity passing through the duo causes certain amino acids in the spike protein to lose electrons. Another device attached to the electrode detects that loss as a change in voltage, signaling that the coronavirus is in the air.

To test the detector, the team sent the device to the apartments of two people who had COVID-19. It detected "even the trace amounts of virus being shed by the patients," Chakrabarty says. Air from an empty, well-ventilated conference room showed no sign of the virus.

"They've demonstrated that it works. It's able to detect the virus at low levels that we would be concerned about in the air," says aerosol scientist Linsey Marr of Virginia Tech in Blacksburg. Her team is working on a detector of its own.

The device that Chakrabarty and colleagues built still has some challenges to overcome. For instance, it is about as noisy as a vacuum cleaner or a ringing phone. That's probably too loud to use continuously in a classroom or office, Marr says, but could be tolerated for 10 minutes.

Such detectors cost up to $1,900 to build in a lab, Chakrabarty says. Commercial versions may initially be too expensive for home use, Marr says, but could be used to monitor hospitals, airports and other public areas. The devices could be linked into HVAC systems that could ramp up ventilation and filtration if the virus is found, Marr suggests. ■

EARTH

A lake may mark a new geologic epoch

Sediments keep pristine records of humans' changes to Earth

BY MCKENZIE PRILLAMAN

Scientists are one step closer to defining a new chapter in geology, one in which humans have become the dominant driver of Earth's climate and environment.

Out of 12 locations around the world, Crawford Lake in Milton, Canada, west of Toronto, has been selected as the site that would mark the official beginning of the Anthropocene, a proposed geologic epoch starting in the 1950s. Researchers made the announcement July 11 at a news conference during the Max Planck Climate Conference for a Sustainable Anthropocene, which was held in Berlin.

The lake bottom's sediments store one of the most precise records of humans' alteration of Earth, including upticks in plutonium from nuclear weapons testing, ash from burning fossil fuels, and heavy metals and microplastics.

But the Anthropocene isn't an official geologic epoch yet. Several more committees of the International Commission on Stratigraphy, the scientific group responsible for defining geologic time, must approve of the proposed epoch before it can be added to the geologic time scale. Doing so would end the nearly 12,000-year-long Holocene Epoch, which encompasses the rise of humankind since the last ice age.

Scientists first started using the term Anthropocene in the early 2000s to refer to the ongoing time of humans altering the planet on a global scale. Although framed in terms of geology, the Anthropocene lacked a formal geologic definition.

Still, the idea spread. "It exploded so quickly into other disciplines without it being defined," says Simon Turner, an earth scientist at University College London. So "that's what we've been trying to do ever since."

In 2009, the International Commission on Stratigraphy convened a committee to characterize the Anthropocene and see whether it deserved a spot on the geologic time scale. That committee has now chosen Crawford Lake from a dozen contenders as the Anthropocene's Global Boundary Stratotype Section and Point. This is a reference site that shows a change in rock, ice or other layers to mark the beginning of a new geologic time period.

From coral reefs to ice cores to peat bogs, each candidate site holds a remarkable record of human activity in its layers. Selecting Crawford Lake was "like choosing a favorite child," says Turner, who is secretary and a voting member of the committee.

Each summer, Crawford Lake's pH and relatively high temperatures cause minerals to crystallize near the top of the water. The crystals fall to the lake's bottom like snow, where they lie undisturbed. "You get these lovely stripes," Turner says. "And you can resolve what year [they're from] pretty much by counting backwards from the surface layer, like a tree ring."

The layers capture a sharp rise in radioactivity and other evidence of human activity starting in the early 1950s (*SN: 10/15/16, p. 14*).

But not all scientists agree that the Anthropocene began merely 70 years ago, or that it should be defined as a geologic epoch at all. "Any time you draw a hard line in the geologic record or in any other system, you're creating a binary — there's a before and there's an after," says paleoecologist Jacquelyn Gill of the University of Maine in Orono. "We know human impacts began well before 1950."

Retaining an informal and flexible concept, like what's used now in disciplines beyond geology, might be more beneficial, Gill adds. "It's more powerful as a tool in that way," she says, "than it is to try to confine it or constrain it to a narrow definition that then creates confusion about everything that came before."

Still, attempting to define the Anthropocene as a formal geologic term underscores humankind's rapid and intense impact on the planet, Turner says. "We've become a geological force." ■

SARAH ROBERTS

Crawford Lake in Milton, Canada, has been selected as the marker for a proposed geologic epoch characterized by humankind's impact on Earth.

1920s Style for a 1920s Price

It was a warm summer afternoon and my wife and I were mingling with the best of them. The occasion was a 1920s-themed party, and everyone was dressed to the nines. Parked on the manse's circular driveway was a beautiful classic convertible. It was here that I got the idea for our new 1920s Retrograde Watch.

Never ones to miss an opportunity, we carefully steadied our glasses of bubbly and climbed into the car's long front seat. Among the many opulent features on display was a series of dashboard dials that accentuated the car's lavish aura. One of those dials inspired our 1920s Retrograde Watch, a genuinely unique timepiece that marries timeless style with modern technology.

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Scientists at the University of Texas at Austin search for distant galaxies in the first deep field image taken by the James Webb Space Telescope, released in July 2022.

EXTRAVAGANCE OF EARLY GALAXIES

The James Webb Space Telescope has turned up big surprises from the distant universe **By Lisa Grossman**

When Brant Robertson saw a new measurement of the distance to a familiar galaxy, he laughed out loud.

For more than a decade, the galaxy had been a contender for the most distant ever observed. In 2012, Robertson and colleagues used data from the Hubble Space Telescope to show that the galaxy's light had shone across the universe from about 13.3 billion years ago — less than 400 million years into the universe's existence.

Not everyone believed it. "We got a lot of flak," recalls Robertson, an astrophysicist at the University of California, Santa Cruz. "It seemed too implausible that it was at such a great distance." It felt like he was going around claiming to have seen the Loch Ness monster.

But in September, the James Webb Space Telescope, JWST for short, aimed its massive mirror and sensitive spectrograph at the same galaxy and showed that Robertson and his colleagues were right. The galaxy's light is indeed incredibly old, dating to just 390 million years after the Big Bang. It was like someone had drained the lake, and the monster was sitting there at the bottom.

And this galactic Nessie is not alone. So far, in its first year of observations, JWST has turned up thousands of distant galaxies dating to the early universe, many more than astronomers had expected. Some of those galaxies are brighter, more massive or more mature than astronomers would have thought. They are now scratching their heads trying to explain how the galaxies could have grown up so fast.

A lot of the extreme distances still need to be confirmed, but initial evidence suggests there's reason to believe that many, if not most, of the galaxies really are that far away.

"I was expecting to find some galaxies at this [distance]. Some people were pessimistic; I wasn't," says Steven Finkelstein, an astrophysicist at the University of Texas at Austin. "But I was not this optimistic. I thought, 'Yeah, yeah, we know what we're going to see.' And I was wrong."

Hubble's surprises

For longtime galaxy hunters, JWST's bounty may feel like déjà vu. In the 1990s, Hubble took a long, deep look at an apparently blank patch of sky, just to see what was there. The result was thousands of galaxies, some captured as they looked when the universe was only a billion years old.

Those galaxies looked mature, like they had already been through multiple rounds of supernova explosions and star formation. Thus, they were not the first to form in the universe, astronomers realized. The first galaxies must date even further back.

The hunt for those original galaxies was part of the motivation for building JWST, says astrophysicist Erica Nelson of the University of Colorado Boulder. "The reason we have JWST is, they launched Hubble and saw that the things in the early universe were very evolved," she says. "They were like, 'Wow! There are galaxies way earlier than we thought'" — even further back in time than Hubble can see.

Hubble wasn't designed to see all the way back to the universe's beginning. The telescope is sensitive to ultraviolet, visible and near-infrared wavelengths of light. But by the time light from the universe's early days reaches us, it has stretched all the way into infrared wavelengths that are longer than Hubble's (or human) eyes can see. That's because the universe is expanding; everything in it is moving away from everything else. And as light sources move away from us, their light stretches — the wavelengths of light grow longer, or redder.

The amount of stretching of that light, known as the redshift, is astronomers' proxy for cosmic distance and age. The present-day universe is at redshift zero. A redshift of 1 corresponds to about 6 billion years after the Big Bang. A redshift of 4 is

OPPOSITE PAGE: NOLAN ZUNK/UNIV. OF TEXAS AT AUSTIN about 1.5 billion years after the Big Bang, and so on.

In 1995, redshift 4 was the furthest back that Hubble could detect. Over the next 20 years, upgrades to the telescope and new observing techniques pushed the frontier back to redshift 7, which corresponds to 800 million years after the Big Bang. In 2012, the galaxy that Robertson studied appeared at a possible, though at the time unconfirmed, redshift of 11.9. Later, a galaxy called GN-z11 clocked in at a redshift of 11.1, or 400 million years after the Big Bang.

These tantalizing discoveries set off a search for even more distant galaxies. "This has kind of become a game in extragalactic astronomy, where everyone wants to find the highest redshift, most distant galaxy," astrophysicist Jeyhan Kartaltepe of the Rochester Institute of Technology in New York said in April in Minneapolis at an American Physical Society meeting. "Become the new record holder, right? It's fun."

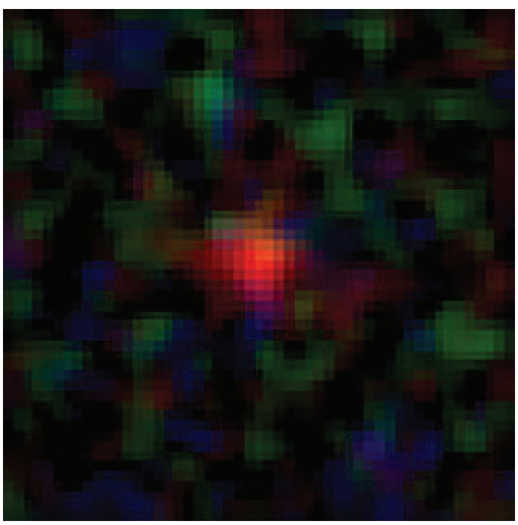
By 2016, when GN-z11 was discovered, the hunt had stalled. Astronomers had wrung everything they could out of existing technology.

"It really requires JWST to push to even earlier times," Kartaltepe said, "which we need to understand the very beginnings of galaxy formation."

The importance of being early

The quest to find the earliest galaxies is about more than just bragging rights. These galaxies could shed light on a key event in the universe's infancy called reionization.

In the beginning, there was the Big Bang. After that initial cataclysm, the universe continued to expand and cool. After about 372,000 years, it had cooled enough for electrons, protons and neutrons to combine into hydrogen atoms. That hydrogen gas was diffuse and opaque, plunging the universe into what astronomers call the cosmic dark ages.



Studying Maisie's Galaxy, which dates to about 400 million years after the Big Bang, helped astronomers gain confidence in distance estimates derived from initial JWST data.

Sometime during these dark ages, the first stars formed and began to clump together into galaxies with the help of an invisible and still mysterious material known as dark matter. But because of the opacity of that neutral hydrogen, all astronomers can really observe is that the universe became transparent again at about 200 million years after the Big Bang, as hydrogen atoms lost their electrons.

"We know there was a transition where the hydrogen was reionized somehow," Robertson says. Thanks to observations with Hubble and other telescopes, "we think galaxies are very likely the agents of that process," he says. Light from the youngest, most massive stars in those early galaxies might have knocked electrons off atoms in the hydrogen gas between galaxies. "But how that process unfolds, we have relatively little information on," Robertson says.

JWST can help fill in those details. Taking a census of the galaxies that were around during the era of reionization could help illuminate how it got started.

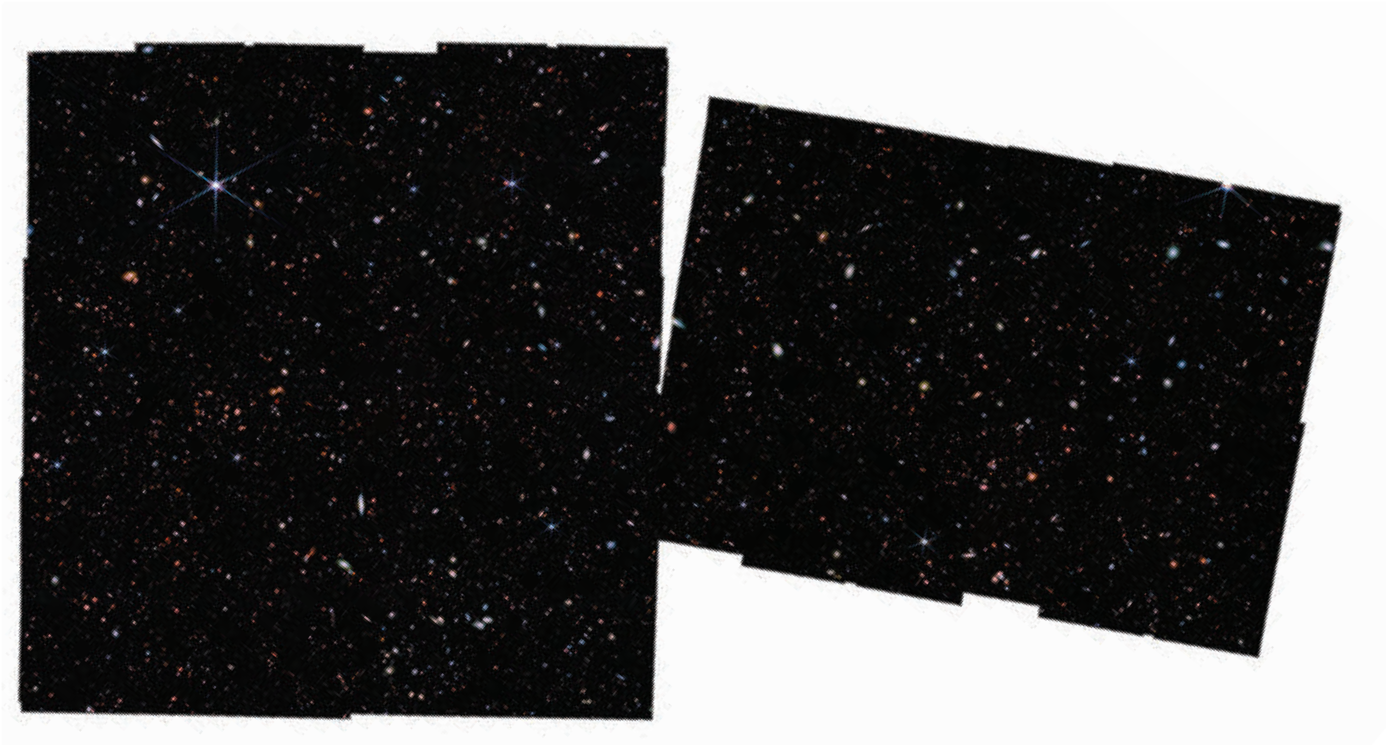
And so, astronomers were giddy with excitement when JWST launched on Christmas Day in 2021 and started collecting data about six months later. The first images were unveiled with great fanfare on July 12, 2022 (SN: 8/13/22, *p.* 30). But astronomers had to wait until the next day to download the rest of the data the telescope had acquired while getting up and running.

"We knew, somewhere, on some computer, our photons were sitting there, waiting for us to see them," Kartaltepe said. "As soon as the data were released in July, we jumped on it and started analyzing."

Astronomers sifted through the images like a cosmic Where's Waldo, picking the reddest-looking candidate galaxies out of the pack.

Extremely distant candidates popped out quickly. In several different regions of the sky, JWST found little red dots corresponding to galaxies that appeared to be at astonishing redshifts: 10, 13, even 17. Some of the galaxies seemed small and dim, as expected. But others looked big and bright, suggesting they were heftier than astronomers would expect for such early galaxies.

"These galaxies, they're just at phenomenal distances. It's a little hard to swallow," Robertson said in June in Cambridge, Mass., at the JWST First Light Conference. "But it's really important to actually confirm the distances to these very, very distant galaxies, and then learn about their properties."



The JWST Advanced Deep Extragalactic Survey, or JADES, scanned a swath of sky (shown) that has turned up hundreds of galaxies that appear to date to within 650 million years of the Big Bang (reddish dots are the most distant galaxies).

NASA, ESA, CSA, M. ZAMANI/ESA AND WEBB

One for the record books

Most of the cosmic distances reported for JWST galaxies so far have been preliminary estimates based on data from the telescope's cameras. The cameras scan broad areas of sky and use filters to let in certain wavelengths of light. These filters allow astronomers to estimate "photometric" redshifts.

But to know for sure how far away a galaxy really is, astronomers need to use JWST's spectrograph. A redshift calculated from a galaxy's full spectrum of light uses 1,000 data points compared with a photometric redshift's seven data points.

"Until we have spectra, nothing is ironclad," Nelson says.

As part of a project called the JWST Advanced Deep Extragalactic Survey, or JADES, Robertson and colleagues collected spectra for four galaxies with photometric redshifts higher than 10 — likely close to the beginning of the era of reionization. One of the galaxies was the one Robertson studied in 2012. The distance of that galaxy, now known as JADES-GS-z11-0, was downgraded a bit, from a redshift of 11.9 to 11.58. But with one of the other galaxies, the team claimed a new record for most distant galaxy ever confirmed, with a redshift of 13.2, just 325 million years after the Big Bang.

The spectra the team analyzed were detailed enough to reveal some properties of the galaxies, Robertson and colleagues reported in April in *Nature Astronomy*. They're all about a hundredth the size and mass of the Milky Way, but they are forming stars at a comparable rate — a lot of stars for galaxies this small. All those newborn stars produce a lot of ionizing radiation, meaning it's possible these galaxies could be some of the earliest agents of reionization, Robertson says.

JADES has since reported about 700 more galaxies whose photometric redshifts place them at redshift 8 or greater, or less than 650 million years after the Big Bang, Robertson said at the June First Light meeting. Those galaxies' distances still need to be confirmed, but the sheer numbers are amazing. "We're really in a remarkable age," Robertson said.

Truly far, far away

The huge galaxy haul raises another question: How many of them are likely to be at such great distances?

A potential record-breaking galaxy called CEERS-93316 is a cautionary tale. The galaxy was identified in JWST images taken for the Cosmic Evolution Early Release Science, or CEERS, survey. Those images put the galaxy at a photometric redshift of 16.4, or just 240 million years after the Big Bang.

"That was higher redshift than we expected to see with CEERS," says Finkelstein, the survey's lead researcher. CEERS was designed to practice using JWST in its different observing modes and give astronomers some data to play with, not necessarily to set new records.

In its first chunk of data, CEERS contained a surprising number of apparently high-redshift galaxies. So Finkelstein and colleagues asked the director of the Space Telescope Science Institute in Baltimore, which operates JWST, for some extra telescope time to chase down the spectra of CEERS-93316, as well as a galaxy that Finkelstein had found with a photometric redshift of about 12. He named that galaxy Maisie's Galaxy in honor of his daughter, because he found it on her ninth birthday. (Maisie didn't mind that her dad had to work that day—"I got other birthday presents," she says, though she did wish her galaxy was the potential record holder.)

When the spectral data came through, Finkelstein's colleague Pablo Arrabal Haro, an astrophysicist at the National Science Foundation's NOIRLab, based in Tucson, worked through the weekend to write up results before anyone else.

CEERS-93316's 16.4 redshift turned out to be wrong. The galaxy was actually at a redshift of 4.9, putting it 1.2 billion years after the Big Bang—practically modern compared with some of JWST's other finds.

The galaxy's photometric redshift was so high because of a weird coincidence. Light streaming from hydrogen in the galaxy was redshifted such that it looked like it jumped in brightness at a wavelength suggestive of the huge distance. But when the full spectrum came in, that single jump was revealed to be several separate peaks, suggesting a smaller redshift.

Maisie's Galaxy, however, is almost as distant as the photometric redshift implied, Arrabal Haro and colleagues reported in a paper posted in March to arXiv.org. And in an April paper posted to arXiv.org, the team reported spectra for more than 30 other galaxies with redshifts of roughly between 8 and 10. So photometric redshift estimates are generally reliable, Finkelstein says.

"Although we have this notable failure case, that's a pathological case," he says. It's "not devastating."

That's good news for JWST's observing schedule: Astronomers won't have to follow up with the full spectrum for every distant galaxy. They can believe that most of the redshifts are legit and save the extra effort of taking the full spectrum for the really interesting ones. "It is exciting that the photometric redshifts tend to hold up," Robertson says. "It gives us some hope that some of these really distant things could be real."

Too bright to explain

Another outcome of JWST analyses so far is that there are more bright galaxies around redshift 10 than expected. Galaxy brightness is an indicator of galaxy mass, and thus star abundance. The brighter the galaxy, the more stars it must have to produce all that light.

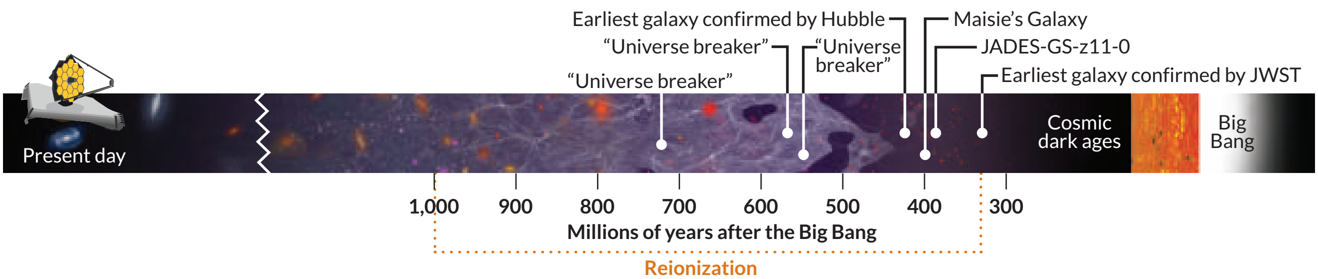
Galaxies are born in halos of dark matter, whose gravity pulls in and concentrates ordinary matter. Cosmologists know from simulations and theory how many dark matter halos the universe would have had when the first galaxies formed. They also have a decent idea of how massive those halos were in the universe's first 500 million years and how much of that mass ended up in the form of hydrogen and helium, the raw material for making stars. Theoretically, if all that gas turned into stars, the largest a galaxy could get would be about 10 billion times the mass of the sun.

In reality, researchers expect early galaxies to be much less massive, because modern galaxies never convert all their gas into stars.

JWST has not turned up any galaxy near the theoretical upper limit. But it has found many more hefty early galaxies than predicted. The confirmed JADES galaxies weigh in at about 100 million solar masses, just 330 million years after the Big Bang. Some of the CEERS galaxies seem to have over a billion suns' worth of stars as early as 450 million years after the Big Bang. Two galaxies discovered in another JWST survey, called COSMOS-Web, appear to be about 5 billion solar masses as early as 350 million years after the Big Bang, astronomer Caitlin Casey of the University of Texas at Austin said at the June First Light meeting.

"With these massive beacons, you can test the limits of how fast you can assemble that much

Early galaxy quest
JWST has detected many galaxies from the early universe (a few are shown on this timeline). These galaxies could shed light on reionization, the process that ended the cosmic dark ages, when the universe was shrouded in darkness. Some of these galaxies, the "universe breakers," appear to be more massive than theory can explain.



JWST: ESA; BACKGROUND: NASA, ESA, P. OESCH AND B. ROBERTSON/UNIV. OF CALIFORNIA, SANTA CRUZ, A. FEILD/STSCI, ADAPTED BY C. CHANG matter in the short time between the Big Bang and the time that we're observing them in," she says.

What astronomers find from these galaxies could point to where our existing understanding of galaxy formation is wrong. Or researchers might discover that some of the galaxies' light doesn't come directly from stars but instead from the ionized gas in between stars that are actively forming, Casey says. That would mean the galaxies aren't actually as massive as they look.

Finding out how early galaxies were put together is the first step to understanding our own galaxy, Robertson says. "That's ultimately what drives a lot of galaxy formation research, is trying to understand how our home, the thing that's important to us, the place that we live, came to be," he says. "We're never going to complete that full story without looking at how galaxies at redshift 10 were put together.... That's the starting place for how we got here."

Breaking the universe ... or not

One set of galaxies has sparked debate over not just galaxy formation, but the theoretical foundations of the universe itself.

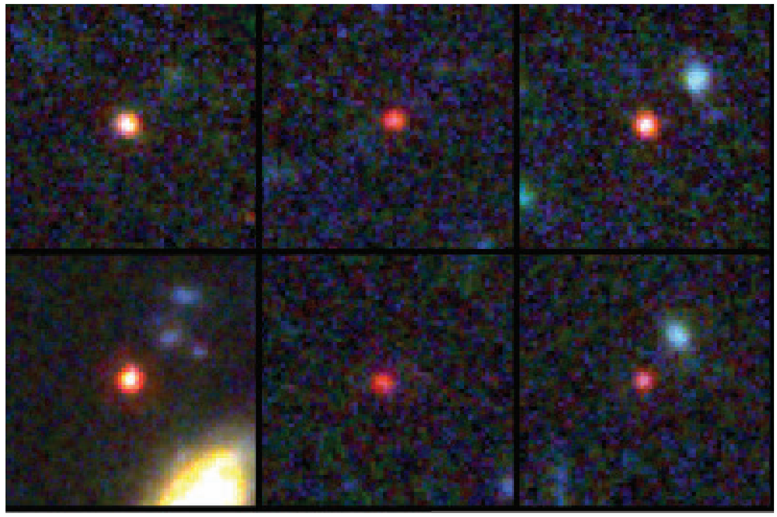
In February, Nelson and colleagues reported six galaxies spotted with CEERS that seem to have grown so big, so fast that they directly challenge the standard theory of how structure forms in the universe (*SN: 3/25/23, p. 14*). These galaxies have photometric redshifts between about 7 and 9, meaning they grew up in the first 800 million years of the universe. But their stellar masses appear to rival or exceed that of the Milky Way, about 60 billion solar masses.

Nelson affectionately calls them the "universe breakers." Nothing that massive should have been able to form that fast, she says. "As soon as we saw it, we were like, this is bananas."

Barely enough ordinary matter is even believed to have existed back then to create the universe breakers, says astrophysicist Mike Boylan-Kolchin of the University of Texas at Austin. Regions where budding galaxies formed would have had to turn all their atoms into stars.

"We have this reservoir of atoms," he says. "Almost every single one of them has to be in stars or in galaxies" if the universe breakers are for real. "If these observations and their interpretation is correct ... it's very hard to accommodate them in our current models," he says.

Over the last few months, theorists have come up with several ways to explain the universe breakers. One of the most dramatic options would be to add some extra dark energy, the mysterious substance that drives the universe to expand faster and faster, to the early universe, which would speed up all sorts of cosmic processes.



Six distant galaxies (red dots, above) spotted by the Cosmic Evolution Early Release Science, or CEERS, survey appear to be too massive for standard cosmological theories to explain, though one of these "universe breakers" (top row, middle image) is not as distant as originally thought.

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

"That would go in the right direction here, in the sense that there'd be bigger reservoirs [of atoms] and maybe more of them at earlier times," Boylan-Kolchin says. "These early dark energy models do predict faster evolution of structure at early times."

More mundane options include super-compact early galaxies that could have converted all their gas into stars before the oldest stars had a chance to go supernova and blow it away. Such efficient star formation could explain the universe breakers without breaking the universe, physicist Avishai Dekel of the Hebrew University in Jerusalem and colleagues suggested in a paper published May 25 in the *Monthly Notices of the Royal Astronomical Society*.

And there's still the question of whether the universe breakers' masses and distances will hold up. A spectrum of one of them has already revealed it to be a galaxy at redshift 5.6 with an actively feeding black hole creating extra light — so not a universe breaker after all.

JWST's second observing cycle began in July, and Nelson will take spectra of the rest of the universe breakers to find out if they are truly abounding with stars, filled with black holes or something else.

Meanwhile, another group of astronomers will test JWST's limits, hunting for galaxies at redshift 15 or greater. So by the telescope's second birthday next summer, there may be new distance records. ■

Explore more

- Ivo Labbé *et al*. "A population of red candidate massive galaxies ~600 Myr after the Big Bang." *Nature*. February 22, 2023.

ESSAY

The Telescope *Whisperer*

Jane Rigby says being part of the LGBTQ+ community made her a better scientist **By Lisa Grossman**

Jane Rigby is the senior project scientist for the James Webb Space Telescope. Her expertise and enthusiasm have made her a public face for the telescope, but she is quick to remind the world that the telescope's success is a true team effort involving tens of thousands of people.

BRITT GRISWOLD AND JAY FRIEDLANDER/NASA

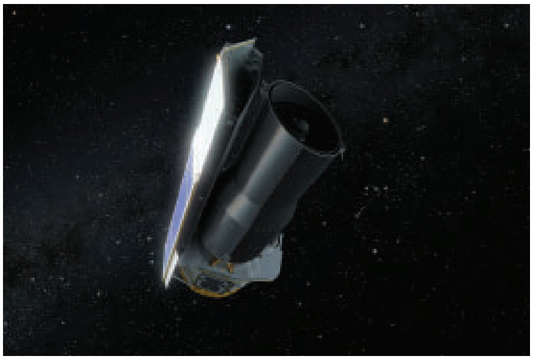
One of a telescope operator's primary jobs is to keep any stray light out of the instrument. Earthly and other unwelcome photons can swamp the cosmic light from distant stars and galaxies. During more than a decade as a project scientist for the James Webb Space Telescope, Jane Rigby obsessed over minimizing light leaks—with extraordinary success. The sky looks darker to JWST than most anyone had hoped.

Rigby herself, now the senior project scientist for JWST, is a source of light.

"I remember the light in her eyes," says astrophysicist Jane Charlton, who met Rigby the summer before her freshman year at Penn State and later advised her research. "Jane had incredible grades, but that's not necessarily what I look for. The love of astronomy, and passion for that, is what I look for."

Nearly three decades later, Rigby's palpable joy in discussing the success of JWST, which launched on December 25, 2021, has made her one of the public faces of the telescope. She presented the telescope's first images at the White House and has given keynote speeches at some of the biggest astronomy meetings (SN: 8/13/22, p. 30). During public appearances, she often wears JWST-themed socks, scarves and pins. "I have JWST socks for pretty much every day of the week," she says.

She has also lit a path for queer astronomers, as well as others who are historically underrepresented in astronomy. Rigby has been out as part of the LGBTQ+ community since 2000, when she met her now-wife when they were both astronomy graduate students at the University of Arizona in



Rigby has used many notable telescopes around the world and beyond including (clockwise from top left) the Spitzer Space Telescope (illustrated), the Magellan telescopes in Chile, the Hubble Space Telescope and the telescopes at the Keck Observatory in Hawaii.

Tucson. She has devoted much of her career to holding the door open for others.

"I didn't grow up with any queer role models," she says. "I hope I'm the last generation for which that's true."

A focus on the instruments

Rigby remembers being asked to draw a favorite TV show in preschool. She used up an entire black crayon drawing Carl Sagan's *Cosmos*.

Her interest in space crystallized into a career plan at about age 12, after she saw Sally Ride speak at a local college. Ride, the first American woman in space, made Rigby want to be an astronaut.

"I knew there were two paths to becoming an astronaut: a test pilot or a scientist," she says. "And it was pretty clear that I was never going to be tall enough to fly the shuttle." At 5 feet, 2 inches tall, she's still two inches too short to have been a space shuttle pilot. If she couldn't make it to space, she saw more potential in science than in flying planes.

Rigby's first experience using a telescope for research, as an undergraduate student at Penn State, was stymied by light leaks. She, Charlton and another student traveled to western Texas to use the telescope at the McDonald Observatory. They were looking to catch light from a distant quasar filtering through a diffuse and mysterious cloud of cosmic gas. These small, dense clouds appear to be packed with heavy elements from supernova explosions, but surprisingly, they're not found in galaxies' centers where a lot of stars are born and dying. "We were, at that time, trying to figure out what they were," Charlton says. "As we still are."

After a night of guiding the telescope by hand, the group realized that light from something other than the quasar — maybe an alert light on an instrument panel — had flooded the telescope. The trio tracked it down, covered it with tape and tried again. The same thing happened night after night. Ultimately, they returned to Pennsylvania with no quasar data.

"It didn't work," Rigby says. "But it was really fun. I was learning everything, trying to learn how the telescope worked."

Since then, Rigby has used many major telescopes, from those at the Keck Observatory in Hawaii to the Magellan telescopes in Chile to the Spitzer and Hubble space telescopes. Along the way, her research developed a theme: investigating how galaxies grow and change along with the supermassive black holes hiding within.

But her approach is less "How can I answer this burning question?" and more "What can I do with this shiny new instrument?"

UNSUNG CHARACTERS

This article is part of a *Science News* series highlighting people of science — past and present — who we believe should be better known. Watch for more of these stories, and send your ideas to editors@sciencenews.org

"I'm a very observational astronomer," she says. "I will use any telescope I can get my hands on."

All that telescope time meant she was ready to join the JWST team when the opportunity came.

"Because she had seen data from Spitzer and Hubble," JWST's precursors, says astronomer Matt Mountain of the Association of Universities for Research in Astronomy in Washington, D.C., "she knew what she was looking for."

Meeting JWST

Rigby began working on JWST in 2010, when she took a job at NASA's Goddard Space Flight Center in Greenbelt, Md., as the telescope's deputy operations project scientist.

One of the first things she did was read the report of an independent review panel that found that the telescope was mismanaged, over budget by billions of dollars and would launch years later than originally planned. "I've certainly been four years from launch multiple times," she says.

> "I will use any telescope I can get my hands on."
> JANE RIGBY

Before launch, most of her time was devoted to making sure that changes to the telescope's design wouldn't mess up the science. She imagined possible ways to use JWST and met with other team members to make sure the final telescope would deliver on those goals. Would the telescope materials glow or release gases that could freeze to the machine? Could JWST use two cameras simultaneously? Could it study moving targets, like asteroids within the solar system (*SN: 11/5/22, p. 14*)?

"Because she is a working scientist who really wanted to use the data," Mountain says, "she was an ideal choice for operations scientist," a job she moved up to in 2018. "In these complex spaces, with all the engineering, the personalities, the politics at NASA, working with contractors, she always keeps her eye on the prize: What science are we trying to do?"

Rigby bridged the divide between the science and engineering teams, helping them speak a common language. Her job has been "a lot of active listening and soft power, a lot of synthesizing and a dose of specialized technical expertise," she says. "Oftentimes I'm the big-picture person in a room full of specialists."

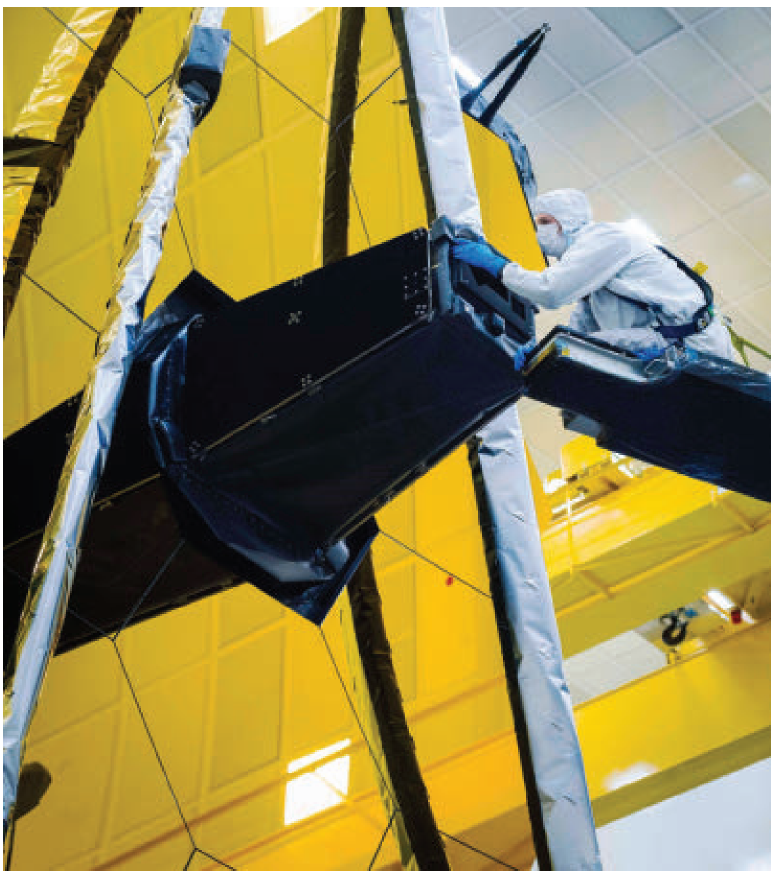
After the telescope launched, got in position and unfolded itself—"the six-month unwrapping of the Christmas present," Rigby says—her job shifted to characterizing how well the telescope works. In practically every metric, it's a dream come true.

There's better-than-expected image quality, higher sensitivity, faster response times and a longer potential mission lifetime than predicted before launch—and practically no light leaks. The telescope's great golden mirrors are exposed to space, and light can scatter off dust grains on the mirrors, registering on images as faint, diffuse patterns the team calls "wisps" and "claws," or a ghostly streak dubbed "the lightsaber." But the mirrors proved remarkably dust-free, meaning the sky appears incredibly dark.

"It's not an accident that the telescope works so well," she says. "That was careful work beforehand."

When asked about such successes, and her own, Rigby points to a huge amount of work by tens of thousands of people. "I understand the desire to humanize something that can seem really big and impersonal. But I don't like the singling out," she says. "I try to reflect it back to the team." It took thousands of people and tasks to ensure JWST's success. Engineer Larkin Carey, with Ball Aerospace, for example, cleaned every square centimeter of the telescope's mirrors by hand with a tool like a shaving brush, Rigby says.

With the telescope working so well, Rigby could turn her attention to the scientific questions. She



Before JWST's launch in 2021, engineer Larkin Carey cleaned every square centimeter of the telescope's mirrors by hand. Here, he removes the cover that kept the telescope's instruments safe from contaminants and stray light while it was being assembled and tested.

CHRIS GUNN/NASA

helps lead an observing program called TEMPLATES, looking at galaxies whose light has been magnified by foreground objects to get a glimpse at how the galaxies form stars. At a June meeting in Albuquerque of the American Astronomical Society, Rigby shared how the TEMPLATES team found hydrocarbons, "the same stuff that smoke is made of," in a galaxy whose light dates back more than 12 billion years — the furthest back in time such molecules had ever been seen.

Early in July, Rigby became the senior project scientist for JWST; it's her job to figure out how to get the most and best science out of the telescope.

Research colleagues describe her as superhuman. "I don't know how she does everything that she does, and does everything well," says TEMPLATES collaborator Keren Sharon of the University of Michigan in Ann Arbor. And Rigby's enthusiasm is abundant: "She gets giddy," Sharon says. "It could be about figuring out a bug, or discovering this super exciting thing about a galaxy that we didn't know before … and she's literally bouncing. Her face lights up."

Opening doors for others

Rigby wants anyone to be able to experience and pursue that enthusiasm. When she started attending American Astronomical Society meetings in the 1990s, she didn't know there was a secret LGBTQ+ networking dinner. "You had to know it existed. That was a little closety. But it's where people were."

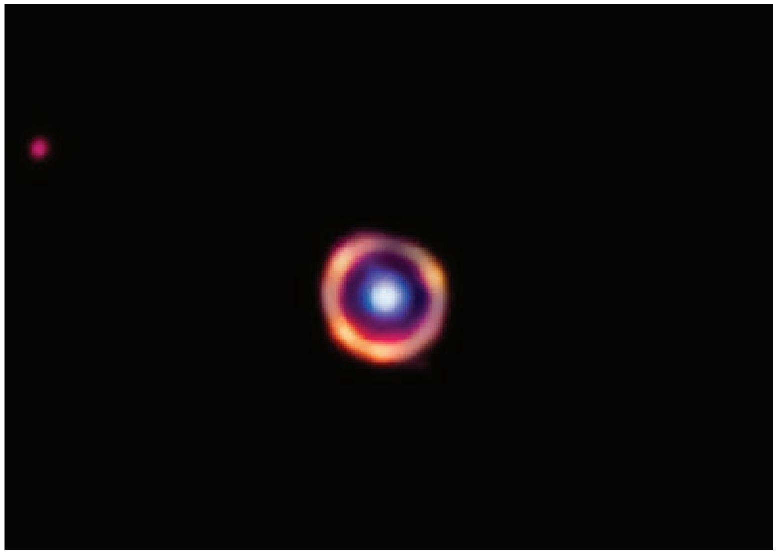
At the time, there was a lack of protection from employment discrimination and no guarantee of institutional support for astronomers with same-sex partners. Rigby recalls accepting a fellowship at Carnegie Observatories in Pasadena, Calif., and immediately having to request health insurance benefits to cover her partner.

"That's awkward," she says. "You want to be talking about your science and your telescope proposals, not how can I get health insurance for my family because we're different." Finding other LGBTQ+ astronomers was "a lifeline," she says.

These days, the meet-up at AAS is too big to go out to dinner. At a January 2023 meeting in Seattle, "we lost count at 120 people. We had to spill out into the hallway," Rigby says. "That feels good."

Seeing queer astronomers like Rigby so far along in their careers was helpful to Traci Johnson, a data scientist who was a graduate student in astronomy in Sharon's lab at the University of Michigan. Johnson identifies as lesbian and nonbinary and came out during graduate school. "I realized it is possible to be out, and be happy, and also have a really amazing career," Johnson says.

J. SPILKER, S. DOYLE, NASA, ESA, CSA



With data from JWST, Rigby and colleagues found signs of hydrocarbons in this galaxy (red ring, shown in false color) more than 12 billion light-years from Earth. A second, closer galaxy (blue) lined up perfectly to magnify the light from the more distant one.

Rigby has taken an active role in encouraging inclusivity, though she seems to be up against the legacy of JWST's namesake. Many astronomers have called for the telescope to be renamed because James Webb was NASA administrator at a time when the U.S. government fired employees for being gay.

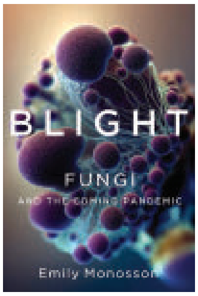
Rigby won't comment on the telescope's name. But her support for LGBTQ+ astronomers is clear. Rigby was a founding member of the AAS Committee for Sexual-Orientation and Gender Minorities in Astronomy, which works to promote equality for LGBTQ+ astronomers within the field; has co-organized conferences on making astronomy more inclusive; and authored a recent white paper urging the astronomy community to address diversity, inclusion and harassment. A current priority is making sure trans people feel safe and welcome.

Rigby doesn't want to be pigeonholed as "the gay astronomer." She knows her contributions to astronomy extend far beyond any particular group. But she says the leadership skills, resilience and ability to shift her perspective that she has learned through living and organizing as a member of the LGBTQ+ community have made her a better astronomer. They're skills she transfers to her role as a leader at NASA.

"The whole vision is, you get to bring your authentic self to work," she says. "And work embraces your authentic self." ■

Explore more

- Jane Rigby *et al*. "The science performance of JWST as characterized in commissioning." *Publications of the Astronomical Society of the Pacific*. April 2023.



Blight
Emily Monosson
W.W. NORTON & CO., $28.95

BOOKSHELF

The next big pandemic could start with a fungus

In the summer of 1904, American chestnut trees in the Bronx were in trouble. Leaves, normally slender and brilliantly green, were curling at the edges and turning yellow. Some tree limbs and trunks sported rust-colored splotches. By the next summer, almost every chestnut tree in the New York Zoological Park, now the Bronx Zoo, was dead or dying. By around 1940, almost every American chestnut across its native range, the eastern United States, was gone. The trees had been felled by a microscopic fiend: *Cryphonectria parasitica*, a fungus that causes chestnut blight.

That fungus had been imported on Japanese chestnut trees. Once it arrived on U.S. soil, it spread like wildfire, driving the American chestnut (*Castanea dentata*) to functional extinction. Today, some still grow, though only as immature trees popping up from the still-living roots of long-gone trees. But these shoots have no hope of towering over the forest as chestnut trees once did, standing as tall as a nine-story building. Because *C. parasitica* persists in the environment, the saplings are doomed to die from the moment they sprout.

The fate of the American chestnut is only one example of the devastation fungi can spawn. In her new book, *Blight: Fungi and the Coming Pandemic*, author Emily Monosson presents an eye-opening, and at times grisly, account of fungal diseases that threaten pine trees, bananas, frogs, bats and, increasingly, people.

Not all fungi are bad. In fact, "most fungi give life," Monosson explains. By helping to decompose dead organisms, fungi recycle essential nutrients. But as people travel or trade plants and animals around the globe, foreign fungi hitch a ride to places they don't belong and come into contact with organisms not accustomed to living with them — sometimes with deadly consequences.

Those consequences are the focus of the first half of the book. Monosson kicks off with the topic that might seem most pressing: Do fungi pose a threat to people? Fortunately, humans — and other mammals — run too hot for most fungi. "Our bodies are like Death Valley," Monosson writes. An internal temperature of 98.6° Fahrenheit (37° Celsius) is white-hot for organisms that prefer 54° to 86° F (12° to 30° C). What's more, our immune systems are quite adept at fending off potential fungal foes. So while people who are immunocompromised are at higher risk for fungal infections, serious cases are relatively uncommon compared with other infectious diseases.

But climate change could push fungi to adapt to higher temperatures. Monosson highlights *Candida auris*, which evolved in the last decade or so to infect people and is spreading fast in health care facilities (SN: 4/22/23, p. 5). Other fungal infections in people, such as valley fever, might also spread to new places alongside higher temperatures (SN: 12/4/21, p. 16).

Fungal pandemics in other species offer lessons for how devastating fungal diseases can be. Monosson describes these outbreaks in morbid detail.

Fusarium wilt strangles the plants that provide the world with yellow bananas. Carcasses of bats, starved to death by *Pseudogymnoascus destructans*, the cause of white nose syndrome, litter caves across the United States. Researchers studying frogs in Central America and elsewhere watch in horror as populations dwindle and disappear, suffocated by *Batrachochytrium dendrobatidis*, or chytrid.

At this point in the book, I felt hopeless. Perhaps HBO's hit series *The Last of Us* is a real glimpse into the future. But never fear, evolution can step in and provide "glimmers of hope," Monosson writes. Affected plants and animals can adapt to better handle fungal foes. (Contrary to what Monosson says, however, pathogens don't evolve for their own good in ways that make them more benevolent to their hosts. They change in ways that ensure spread.)

A handful of frog populations flattened by chytrid are appearing again (SN: 12/3/22, p. 6). In Yosemite National Park, frogs infected with the fungus show no sign of disease. Trees may be building resistance too. Some whitebark pine trees (*Pinus albicaulis*) in the western United States have genes that render them resistant to white pine blister rust, a disease that has been afflicting the trees for more than a century.

People are also stepping in to help. And given our role in spreading fungal diseases, maybe we have an obligation to, Monosson argues. Fattening up bats in the fall, for example, could help them survive white nose syndrome, which robs the animals of fat stores during winter hibernation. Some researchers are even looking to natural resistance to find solutions, including efforts to resurrect American chestnuts (SN: 5/3/03, p. 282). Botanists hope that by genetically altering the trees, "someday the chestnut may rise again, taking its place among the oak and hemlock," Monosson writes.

For now, the best hope may be preventing fungal diseases in the first place. "When humans first began moving animals and plants, cut forests, expanded agricultural lands, there was no thought to planetary protection," Monosson writes. "Now we know better."

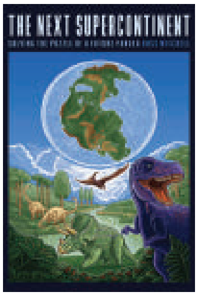
— *Erin Garcia de Jesús*


A young American chestnut tree grows on a research farm, where scientists are searching for ways to protect the tree against blight.

BRENDAN SMIALOWSKI/AFP VIA GETTY IMAGES

BOOKSHELF

Predicting the future of Earth's landmasses



The Next Supercontinent
Ross Mitchell
UNIV. OF CHICAGO, $30

Today, there are seven continents. Some 200 million years from now, there will be just one. In *The Next Supercontinent*, geophysicist Ross Mitchell previews what the world might look like when Earth's continents amalgamate into a single landmass.

Although Mitchell's destination is the distant future, don't be fooled. His book is as much a romp through the past as it is a look ahead, complete with references unique to the present (like Dwayne "The Rock" Johnson helming a speedboat as it crests a highly improbable tsunami that ravages the Golden Gate Bridge in the movie *San Andreas*).

On the journey back in time, Mitchell visits how the continents came together in the past to form the previous supercontinents. He begins with lush, dinosaur-laden Pangaea, which existed about 300 million to 200 million years ago and was centered on present-day Africa. He then goes back to about a billion years ago to barren Rodinia, whose center consisted of much of today's North America plus Greenland. Roughly 2 billion years ago, there was what some scientists call Columbia — the Siberia-centric first supercontinent.

Tracking the paths of today's continents through history takes some serious scientific sleuthing. This often begins with fieldwork to collect samples that constrain when a rock formed and its latitude at that time. To give readers a taste of such (mis)adventures, Mitchell shares how he lost half his right thumb in the Australian Outback while unearthing some of Rodinia's mysteries, and when he and a colleague were nearly stranded with their samples on a frigid lake in Canada's Northwest Territories.

Clues to why supercontinents form in the first place and what causes their repeated rending also reside in a different field of study — one in which scientists simulate how the "solid but pliable" mantle might have behaved to coax continents along. The mantle regulates the relationship between the crust and Earth's core, which stores primordial heat. The supercontinent cycle, Mitchell argues, is linked to mantle movement that transfers Earth's interior heat upward so the crust can release it.

Scientists suspect that as heat rises, continents drift toward regions where the mantle is cold. These cold spots exist where oceanic plates subduct, or sink below more buoyant tectonic plates, into the mantle. Inch by inch, subducting ocean floor will disappear and bring continents closer together, resulting in collisions that will eventually culminate in a new supercontinent. Mantle simulations suggest that after the supersized landmass has formed, the incessant inward pull ceases as new subduction zones initiate at the coastlines of the supercontinent. Somewhere in the interior of the supercontinent, hot mantle rises, eventually causing the supercontinent to tear, forming new oceans and beginning another cycle.

The next supercontinent, dubbed Amasia, is expected to form in a couple hundred million years (predicted configuration, illustrated).

Using the past to predict the future and understanding the mechanics of the mantle, Mitchell presents his vision of Amasia — the next supercontinent (*SN: 1/21/17, p. 18*). Some researchers have suggested it will form from either the closing of the Pacific or Atlantic oceans. But Mitchell posits Amasia will form via the disappearance of the Arctic Ocean as the Americas and Eurasia meet near the North Pole, dragging the other continents along for the ride.

Throughout the book, Mitchell's clear explanations and carefully chosen images help make sense of even the most complicated concepts (take it from me, a trained geologist who always had trouble with the particulars of the study of Earth's past magnetic field — paleomagnetism — which often drives supercontinent reconstructions).

But whether Mitchell's predictions are correct is something no reader will live long enough to find out, though maybe our descendants will. That will require humankind to survive far longer than any other known mammal. But given all our achievements as a species, Mitchell is hopeful we can beat the odds. "While such longevity may seem far-fetched," he writes, "doesn't it also sound a lot like us?" — *Alka Tripathy-Lang*

AN ASSEMBLY OF ADVOCATES

The Society's Advocate Program is a yearlong professional development program that provides educators across the country with training and resources to engage their students in scientific research. Advocates encourage students from underrepresented races and ethnicities and/or low-income households to enter STEM research competitions.

As the 2022–2023 school year drew to a close, Advocates were already preparing for a fall of STEM exploration. In June, the newest cohort of 100 educators (shown above) met in Washington, D.C., on an all-expenses-paid trip to the Advocate Training Institute.

During the weekend-long conference, the Advocates set goals for the year, took part in peer-led sessions to share best practices and created connections that will underpin a network of support for the coming academic year.

As the program enters its ninth year, more than 4,400 students have entered science competitions under the guidance of Society Advocates.

Learn more about the Society's Advocate Program: www.societyforscience.org/advocate-program

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Pondering resistance

Microwaving deltamethrin can renew the insecticide's ability to kill mosquitoes that have become resistant to it. Scientists are working to add the improved insecticide to bed nets, ***Tina Hesman Saey*** *reported in "Restoring an insecticide's mosquito-killing power"* (SN: 6/17/23, p. 4).

Although the finding "sounds like a welcome discovery," reader **Linda Ferrazzara** wrote, "might the newer, more effective version of the insecticide also have more serious adverse effects on the human beings it's supposed to protect?"

Deltamethrin is so commonly used as an insecticide because it's much more lethal for insects than it is for mammals, says **Bart Kahr**, a crystallographer at New York University. The lethal dose for a human, which is based on toxicology data for rats, would be more than 100 billion times what it is for a mosquito, he says.

Since microwaving deltamethrin changes its crystal structure but not its chemical composition, the lethal dose would not be expected to change, **Kahr** says. The new form might be faster at delivering deltamethrin to both humans and mosquitoes, but it would still take incredibly prolonged contact with a high amount of the insecticide to be consequential to a mammal. "Of course, no one has made such an experiment, but it stands to reason from the data that we have," he says.

Understanding pain

Brain implants in four people with chronic pain revealed a potential biomarker of the debilitating condition. The brain signal could one day help doctors track treatment responses, ***Laura Sanders*** *reported in "Implants track chronic pain in the brain"* (SN: 6/17/23, p. 10).

Some readers on social media wondered what the discovery might mean for other types of long-lasting pain. "Am SO hoping that this will one day be expanded to those of us who have [the autoimmune disorder lupus]," Twitter user **@SusanFi84657717** wrote. Meanwhile, Facebook user **Wernell Loell** hoped the finding might apply to pain associated with grief.

The study gave researchers a glimpse of just one specific type of chronic pain: neuropathic pain, which is rooted in the nervous system, **Sanders** says. Three people in the study had neuropathic pain after a stroke, and one person had phantom limb pain in an amputated leg.

"So far, researchers don't have this detailed view of other types of long-lasting pain," **Sanders** says. But the brain implant study, while small, has provided some hints. Scientists found patterns of activity in the brain shared by all four participants when their pain was high. But the research also turned up brain activity patterns that were unique to each person.

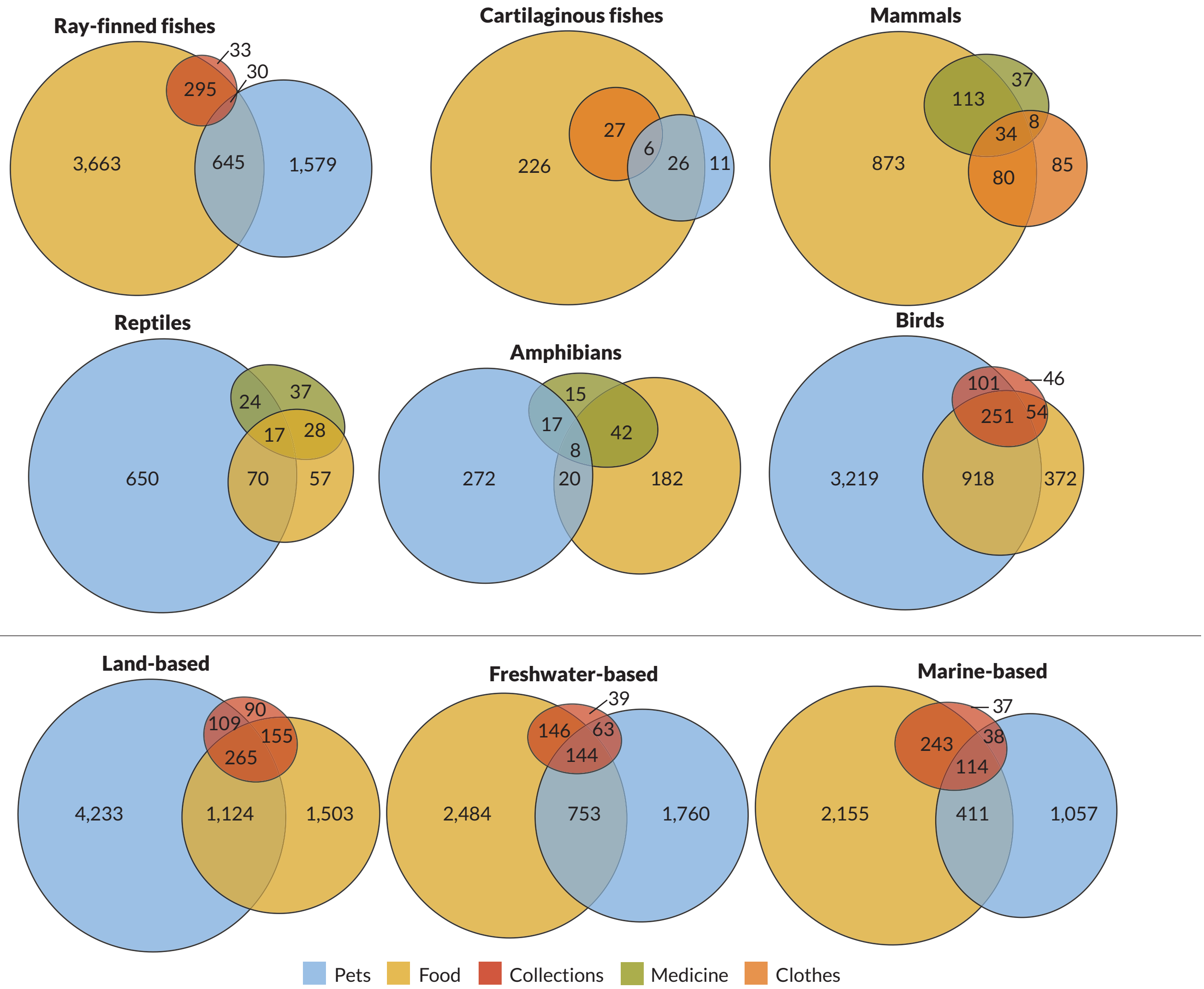
"Figuring out the neural signals — both common and unique — that come with various sorts of chronic pain is the first step," **Sanders** says. "The bigger goal is to interfere with those signals. Scientists are now testing whether brain stimulation can short-circuit these particular pain signals."

Correction

"Ancient molecules tied to complex life" (SN: 7/15/23 & 7/29/23, *p.* 6) stated incorrectly that the oldest known eukaryotic fossils date to 800 million years ago. Instead, the sentence should say that the oldest known steroid fossils date to 800 million years ago. The oldest known eukaryotic fossils actually date to nearly 3 billion years ago.

Tallies of the most common ways humans use wild vertebrates, by number of species

Numbers within circle intersections denote species used for two or more purposes



C.T. DARIMONT *ET AL*/*COMMUNICATIONS BIOLOGY* 2023; ADAPTED BY T. TIBBITTS

How humans exploit wild vertebrates

The resplendent quetzal is prized for its plumage. Golden poison frogs are popular pets. Pangolin meat is considered a delicacy, and their scales are used in traditional medicine.

Those animals are among the roughly one-third of all wild vertebrate species that people eat, trade or otherwise use, a new study reveals. Out of nearly 47,000 vertebrate species around the world, humans exploit about 14,600, researchers report June 29 in *Communications Biology*.

Some species, like most fishes trawled for food, are abundant. But human activities are helping push many others of these exploited species toward extinction, marine ecologist Boris Worm of Dalhousie University in Halifax, Canada, and colleagues say.

The team collated data compiled by the International Union for Conservation of Nature, or IUCN, which tracks the trade, use and vulnerability of species worldwide. The researchers considered species from the six classes of vertebrates that contain more than 100 species each: mammals, birds, reptiles, amphibians, ray-finned fishes (such as tuna and salmon) and cartilaginous fishes (such as sharks and rays).

The graphs above show the top three ways, by number of species, in which each of these classes are used (top), as well as a breakdown by land, freshwater and marine vertebrates (bottom). Mammals and fishes are mainly used for food, the team finds, a purpose for which more than half the vertebrates that humans use are killed. Birds, reptiles and amphibians are primarily targeted for the pet trade. The IUCN considers human use to be a threat for nearly 40 percent of exploited vertebrate species — roughly 5,800 in total.

Some scientists, including Worm and his colleagues, think of humans as predators. But predators find a natural balance with prey in their ecosystems, says Daniel Pauly, a fisheries biologist at the University of British Columbia in Vancouver. Humans, he notes, do not. — *Sid Perkins*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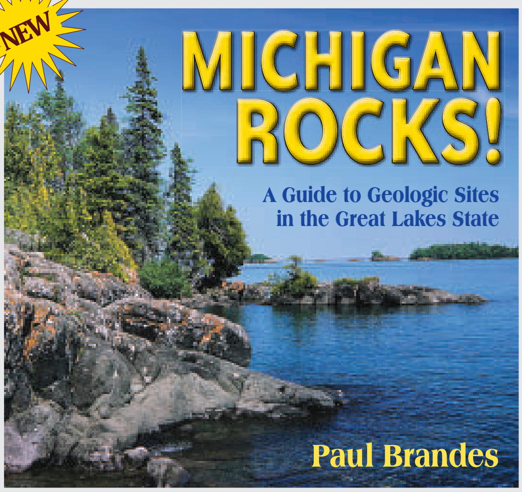

MICHIGAN ROCKS!

A Guide to Geologic Sites in the Great Lakes State

Paul Brandes

A good map, an urge to discover, and this guidebook are all you need to explore and become well-versed in the distinct geology of Michigan.

Michigan is the only state in the nation to border four of the five Great Lakes. This abundance of shoreline translates to a multitude of rock exposed by waves and currents. Nearly the entire history of Earth is on display in Michigan, from 3.6-billion-year-old gneisses to potholes drilled by modern rivers.

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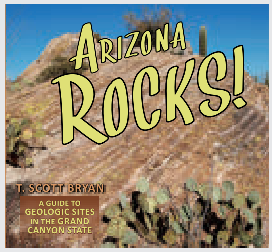

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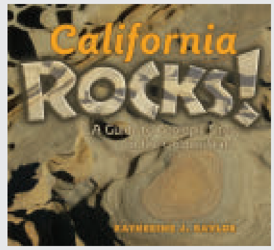

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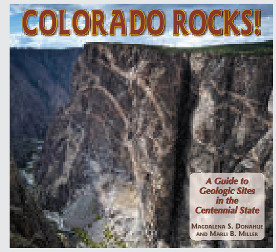

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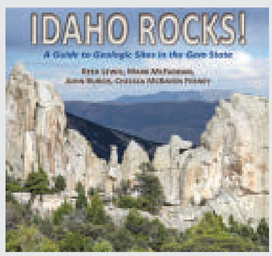

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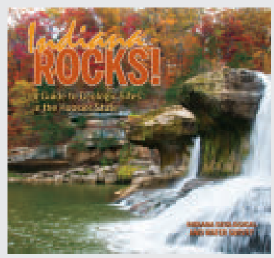

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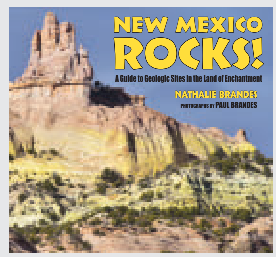

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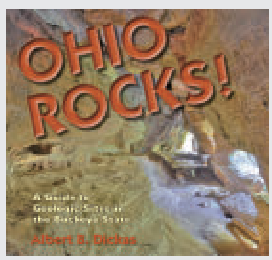

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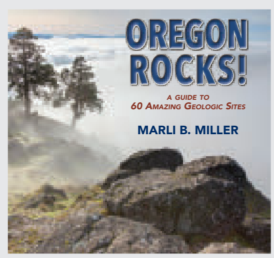

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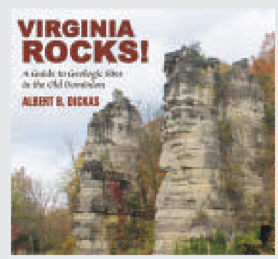

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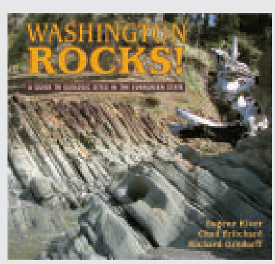

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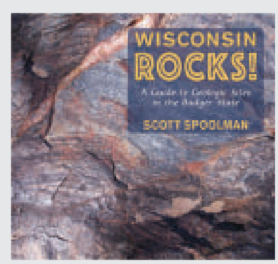

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