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ScienceNews

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Big Creatures, Big Questions

A marine biologist in Sri Lanka shows there's a lot to learn about blue whales

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COVER A blue whale dives into the deep off the southern coast of Sri Lanka. *Franco Banfi/Nature Picture Library/Alamy Stock Photo*

FROM TOP: CARLA LEWIS; TYLER SLOAN AND AMY STERLING/FLYWIRE, PRINCETON UNIV.; S. DORKENWALD *ET AL*/*NATURE* 2024; TREVOR WALLACE

Rethinking archaeology and place

Pompeii. Machu Picchu. Stonehenge. Angkor Wat. The Great Pyramid of Giza.

Those of us who grew up in Western cultures tend to think of archaeology as the study of a place—a point on the map where edifices or artifacts tell us something important about past people and cultures.

Archaeologists have tended to think this way, too. A site is identified; excavation ensues. Artifacts are discovered. The artifacts are studied, inventoried and carefully stored so that they will be available to the archaeologists of the future.

But what if the sacred relic that illuminates the past was neither a building nor an object? What if it was a trail?

In this issue, we explore the efforts of Indigenous people in British Columbia to document and preserve trails that are records of their history and culture—records created through millennia of movement across the landscape. Social sciences writer Sujata Gupta traveled to northwestern Canada to observe efforts to mark the ancient Babine Trail network, which people used to carry goods from the coast to inland communities (Page 22). Participants in the project include members of the local Gitxsan people, archaeologists and graduate students.

"It's a part of the world I've never been to, and it's absolutely stunning," Gupta told me. "Because it's so far north, white settlers arrived late, and Indigenous communities remain strong."

It was an apt assignment for Gupta; before becoming a journalist, she worked at national parks and preserves including Haleakala National Park on Maui, Acadia National Park in Maine and the Mojave National Preserve in California, where she became fascinated by the parks' human history. "My park rangering days were very long ago," she says, "but I was always very interested in culture and anthropology."

In British Columbia, the mapping group used very old and very new technologies to locate the overgrown trail. The old: using oral history to spot and tag vestiges of trail markers, including blazes cut into tree bark. The new: maps made using lidar, a remote sensing technology that uses lasers on aircraft or satellites to reveal subtle differences in Earth's surface. The ease of mapping remote areas with lidar (compared with, say, thrashing through the wilderness on foot) has accelerated a shift in archaeology's focus from individual sites to landscapes, even as the technology also proved to be a boon for research at traditional sites such as the ancient Maya city of Caracol in Belize (SN: 12/2/23, p. 24).

There's more at stake here than a deeper understanding of the Indigenous people and their ancestral land. A planned natural gas pipeline would run through the Babine Trail, and access roads and construction would impact the landscape far beyond the trail itself. Participants in the trail-mapping project hope that their work will help persuade the provincial government to block, reroute or delay pipeline construction. But that may hinge on whether the government sees the region's cultural heritage as an artifact or as something much bigger: a landscape where people wrote history with their feet.

—Nancy Shute, Editor in Chief

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I have always been confused by the luxury watch market. Classic guilloche faced watches often sell for $25,000 or more. But who spends that? I understand the collector who wants to own rarities, but many of those high end watches are simply mass produced. Plus, every billionaire that I know (I only know 4) wears a watch that cost under $300. It seems if you really have it, you don't need to show it off. It is in that vein that we have designed the Newport Chronograph. A classic dual coin edged watch with a guilloche patterned face and Breguet styled hands that have all the hallmarks of a classic vintage timepiece. As a test, I put this watch and a $25,000 watch into the hands of 10 friends and told them each watch cost $1,000 and asked them which would they go for. It was a tie. But the Newport team just saved $24,941 dollars!

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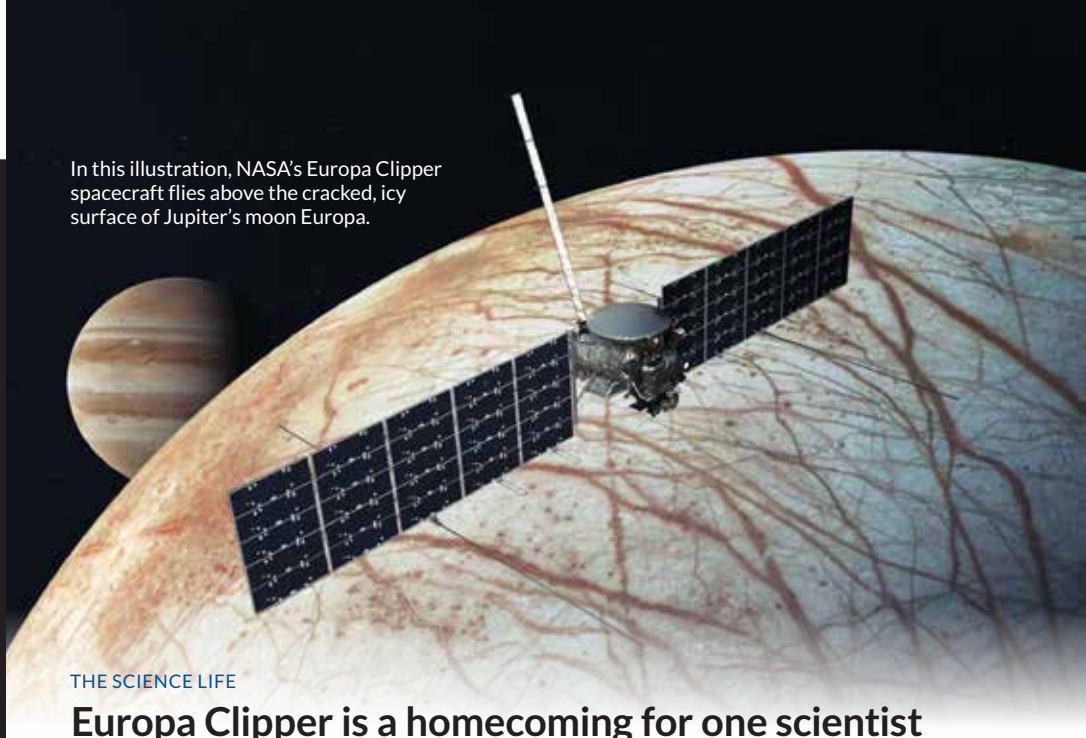
Excerpt from the November 2, 1974 issue of *Science News*

50 YEARS AGO

Jupiter's new moon

Jupiter's tentatively identified 13th moon, discovered in September by California Institute of Technology astronomer Charles Kowal, now appears almost certain to be the real thing.... So far known only as J-XIII, the object appears to orbit the planet in the same direction as its rotation.

UPDATE: J-XIII, now known as Leda, was just the beginning. Scientists now recognize a bounteous 95 moons of Jupiter. And thousands of smaller objects orbit the planet, too. A few moons were uncovered by the Voyager spacecraft in 1979. In recent years, telescope surveys have unveiled a dozen moons at a time (*SN: 8/18/18 & 9/1/18, p. 12*). Detailed studies of the largest moons have revealed Io's lava lakes and Europa's icy surface. NASA's Europa Clipper mission is slated to arrive at the icy moon in 2030 to search for signs of habitability (see "Europa Clipper is a homecoming for one scientist," right). And the European Space Agency's Juice mission will scrutinize Europa, Callisto and Ganymede beginning in 2031.



In this illustration, NASA's Europa Clipper spacecraft flies above the cracked, icy surface of Jupiter's moon Europa.

JPL-CALTECH/NASA

THE SCIENCE LIFE

Europa Clipper is a homecoming for one scientist

Planetary astronomer Bonnie Buratti remembers exactly where she was the first time she heard that Jupiter's icy moon Europa might host life.

It was the 1980s, and Buratti was a graduate student at Cornell University studying images of Jupiter's moons taken during the Voyager 1 and 2 flybys in 1979. Even in those first low-resolution snapshots, Europa was intriguing.

"It looked like a cracked egg," she says.

Those cracks — in a snow-covered, icy shell — were probably filled with material that had welled up from below, Buratti and a colleague found. That meant there had to be something underneath the ice.

Buratti recalls fellow grad student Steven Squyres giving a talk about the possibility that Europa's ice hid a liquid ocean. "He said, 'Well, there's an ocean underneath, and where there's water, there's life,'" she recalls. "And people laughed at him."

They're not laughing anymore.

Over the last four decades, Buratti has seen the search for life in the solar system go from a joke to a flagship mission. She is now a deputy project scientist for NASA's Europa Clipper mission, which launched October 14 to find out if Europa is a habitable world. "I'm kind of coming home," she says.

Space captured Buratti's imagination in childhood, which coincided with the dawn of the space age. She was a child when the Soviet Union launched Sputnik and a teenager when Apollo 11 landed on Earth's moon.

In college, planetary science drew her in with the field's larger-than-life personalities, including Frank Drake and Carl Sagan, who were spearheading efforts to seriously search for extraterrestrial life. That gave her a sense that the universe could be teeming with life. She ended up working with less famous but equally charismatic astronomer Joe Veverka on the Voyager data.

Buratti joined NASA's Jet Propulsion Lab in Pasadena, Calif., in 1985 and has been there ever since. But while NASA's Galileo spacecraft was finding evidence of Europa's subsurface ocean in the 1990s, Buratti was busy aiming for Saturn with the Cassini mission (*SN: 9/2/17, p. 16*).

Saturn's moons were full of surprises, including hydrocarbon lakes on Titan, watery plumes from Enceladus and a mysterious ridge that makes Iapetus look like a walnut. Those discoveries helped advance the notion that subsurface oceans in the solar system might not be so strange after all.

Once Clipper reaches Europa, it will make at least 49 flybys of the moon, measuring the icy body's surface composition, gravity and internal structure to assess how suitable the small world is for life. "We're pretty certain there's a habitable environment," Buratti says. On Earth, "wherever you see water, you see life. So, I think it's a really good place to look." — *Lisa Grossman*

TEASER

X-rays from nuclear blasts could defend Earth from asteroids

An asteroid hurtling toward Earth could be deflected without a spacecraft ever touching it.

The trick is using X-rays to divert the space rock, physicist Nathan Moore of Sandia National Laboratories in Albuquerque and colleagues report September 23 in *Nature Physics*. Lab experiments and computer simulations suggest that X-rays emitted by a nuclear blast could deflect some asteroids that are about as wide as the National Mall in Washington, D.C., is long. Such blasts would, in theory, occur at safe distances from Earth.

The team used the world's most powerful X-ray generator to blast a blueberry-sized quartz in a vacuum chamber for 6.6 nanoseconds. The pulse vaporized the foil supports suspending the quartz, releasing the mineral into a free fall. It also vaporized the falling quartz's surface, generating a gas plume that pushed on the mineral like a rocket's exhaust, Moore says, propelling it away from the X-ray source at roughly 250 kilometers per hour. Based on those results, computer simulations suggest that X-rays from a nuclear blast a couple kilometers away could deflect an asteroid up to 4 kilometers wide. —*Nikk Ogasa*

INTRODUCING

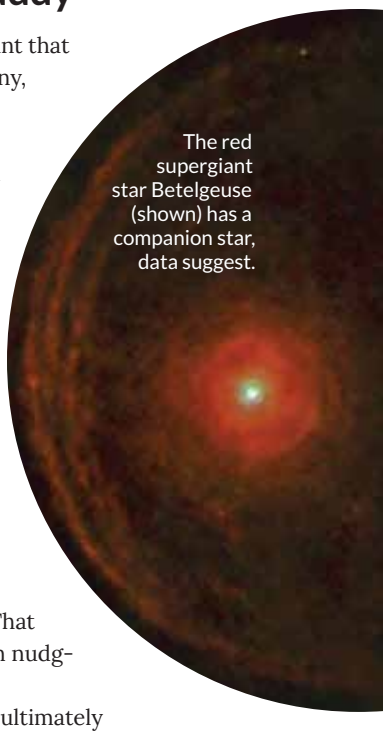
Betelgeuse's invisible buddy

Betelgeuse, Betelgeuse! The red supergiant that marks Orion's left shoulder may have a tiny, unseen companion.

Two independent studies posted in August and September at arXiv.org found evidence of a sun-sized star orbiting Betelgeuse about once every 2,100 days.

Examining 128 years of global measurements, astrophysicist Morgan MacLeod of the Harvard & Smithsonian Center for Astrophysics in Cambridge, Mass., and colleagues linked a six-year cycle of Betelgeuse brightening and dimming to a companion star tweaking its orbit.

Separately, Jared Goldberg of the Flatiron Institute in New York City and colleagues used the last 20-odd years of data on Betelgeuse's motion on the sky. That team also found evidence of a companion nudging the bigger star.



The red supergiant star Betelgeuse (shown) has a companion star, data suggest.

If Betelgeuse's buddy is confirmed, it's ultimately doomed. The apparent star's orbit is shrinking, and Betelgeuse will swallow it altogether in about 10,000 years. —*Lisa Grossman*

SCIENCE STATS

Starlink satellites' leaky radio waves obscure the cosmos

While SpaceX's Starlink satellites are enabling internet access and cell phone communications around the globe, they're also posing a threat to radio astronomy, a new study suggests.

In some wavelength bands, unintended leakage of electromagnetic radiation from the latest generation of the satellites is more than 30 times as bright as emissions from previous versions, Cees Bassa, a radio astronomer at the Netherlands Institute for Radio Astronomy in Dwingeloo and colleagues report September 18 in *Astronomy & Astrophysics*.

Because the latest generation of Starlink satellites will orbit as much as 200 kilometers lower than earlier satellites, they'll seem even brighter to ground-based telescopes. Their brightness could easily mask observations of dimmer objects like distant galaxies or stars.

Radio telescopes, rather than gathering visible light, collect lower-energy waves from sources that emit radiation at longer wavelengths. Bassa's team used radio telescopes at an observatory near Exloo, Netherlands, to characterize the emissions from Starlink satellites during two hour-long sessions in July. Although the satellites passed through the telescopes' field of view for between only 12 and 40 seconds, they were very bright. Compared with the faintest astronomical sources that can be observed by those telescopes, Starlink satellites are about 10 million times as bright, the team notes.

And the problem will probably get worse: SpaceX is launching about 40 second-generation Starlink satellites each week, the researchers say, with more than 6,000 already in orbit (SN: 4/8/23, p. 5). Bassa and colleagues have found that satellites belonging to other private companies are detectable by radio telescopes too, and the team is working to measure those emissions as well.

The researchers hope that their continuing observations will spur the satellite developers to redesign their equipment where possible to reduce unintended radio emissions. —*Sid Perkins*

Unintentional radio emissions from Starlink satellites (a group of which are shown here crossing the sky) threaten radio astronomy.

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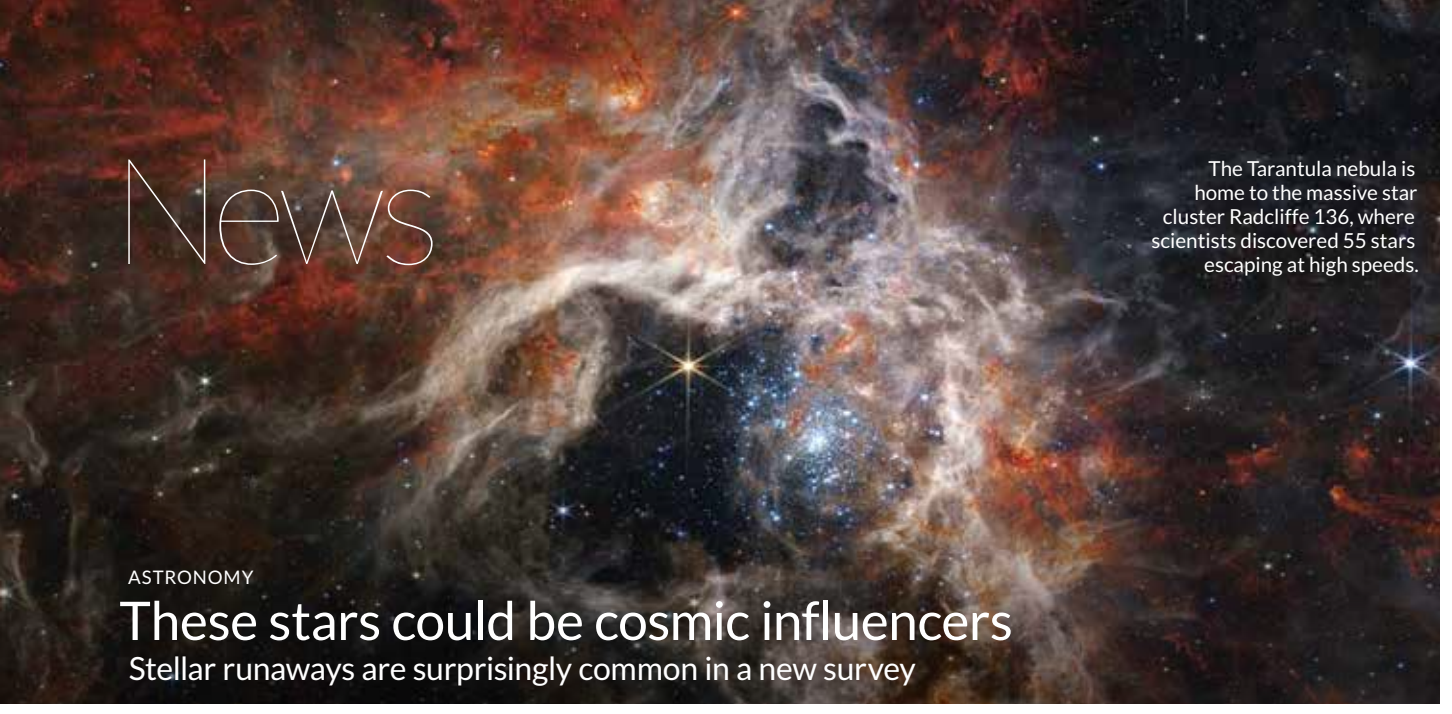


The Tarantula nebula is home to the massive star cluster Radcliffe 136, where scientists discovered 55 stars escaping at high speeds.

ASTRONOMY

These stars could be cosmic influencers

Stellar runaways are surprisingly common in a new survey

BY LISA GROSSMAN

Astronomers have spotted dozens of fugitive stars fleeing a dense star cluster in a satellite galaxy of the Milky Way. The swarm of speeding stars could mean that such runaways had a bigger influence on cosmic evolution than previously thought, the scientists report October 9 in *Nature*.

Massive stars are born in young clusters, packed so closely together that they can jostle each other out of place. Sometimes neighboring supernova explosions or encounters between massive stars can send a star zipping out of the cluster altogether to seek its fortune in the wider galaxy and beyond.

Astronomer Mitchel Stoop of the University of Amsterdam and colleagues searched for runaway stars around a huge cluster of massive stars called Radcliffe 136, which is located about 170,000 light-years from Earth in the Large Magellanic Cloud, a dwarf galaxy that orbits the Milky Way.

The cluster, also known as R136, "is an iconic object," says astrophysicist Sally Oey of the University of Michigan in Ann Arbor. The view from Earth's neighborhood is so clear, "we can really look at things up close and personal."

Previous studies had found a few stars fleeing the cluster (*SN: 6/5/10, p. 11*). But in a wider search of the speeds and positions of billions of stars recorded by the Gaia spacecraft, Stoop's group found an astonishing 55 stars had fled at speeds faster than roughly 100,000 kilometers per hour in the last 3 million years.

"That is an incredible number to think about," Stoop says. As many as a third of the brightest, most massive stars born in the cluster may have left home.

Runaway stars could be an underappreciated force in the universe. These massive stars, about five to 140 times the mass of the sun, emit ultraviolet radiation and supersonic stellar winds that can sculpt the gas and dust around them. At the end of their lives, the heavyweight stars explode as supernovas, spreading heavy elements around the galaxy.

"Before, we'd expect maybe there are a handful of runaways," Stoop says. Because of that assumption, he says, these stars would be left out of studies and simulations. If each cluster actually loses about a third of its stars, he says, "they can maybe have a major contribution to dumping all these ultraviolet photons into the intergalactic medium."

Such escapees could also have had a profound influence on the evolution of the early universe. Within a few hundred million years of the Big Bang, more than 13 billion years ago, some source of ultraviolet radiation stripped electrons from a pervasive fog of hydrogen atoms, a phenomenon called reionization.

Astronomers think most of the photons, or particles of light, that cleared the cosmic fog came from dwarf galaxies (*SN: 3/4/17, p. 10*). But simulations have found that only a fraction of the photons needed could escape the environments of those galaxies. Runaway stars may help account for the difference.

"Maybe this happened in [early universe] galaxies as well, during the epoch of reionization," Stoop says.

Runaway stars aren't the only way to get ionizing radiation out of galaxies, Oey says. So it's not clear how much of a difference runaway stars would make.

The timing of the stars' escape from R136 might also throw a wrench in the broader relevance of runaway stars to reionization.

The fleeing stars didn't all migrate in one wave. Most of the runaways, 37 of the 55, fled R136 in multiple directions about 1.8 million years ago, when the cluster was forming. That's what you'd expect if they were booted out by encounters with other massive stars. But 16 escapees left the cluster more recently, just 200,000 or so years ago, and all in the same direction. Stoop's team thinks those stars' escape might have been triggered by a merger with another cluster.

"That seems like a fairly unique occurrence," says astrophysicist Kaitlin Kratter of the University of Arizona in Tucson. If R136's double ejection is unusual, then it might be hard to extrapolate how many stars other clusters lose to their cosmic surroundings. Finding evidence of similar waves in other clusters would help resolve the question. ■

WEBB ERO PRODUCTION TEAM, STSCI/NASA, ESA, CSA

HEALTH & MEDICINE

Radioactive beam zeroes in on cancer

Mouse study shows promise of a precise tumor treatment

BY EMILY CONOVER

Cancer-busting particle beams have been caught in the act.

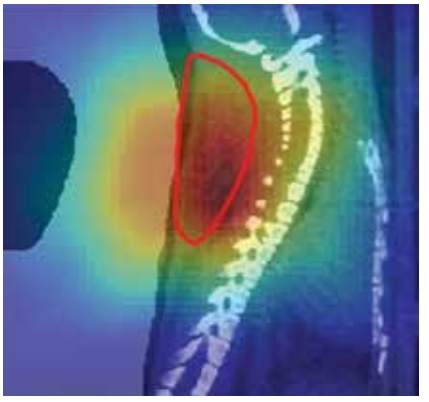
Particle beams can provide a blast of destructive energy directly to tumors — if the beam is in the right place. Now, using a radioactive ion beam, scientists pinpointed the beam's location while treating tumors in mice. It's the first successful treatment of tumors with a radioactive beam, scientists report September 23 at arXiv.org.

The technique could eventually allow scientists to treat human patients with millimeter precision, which is important when a tumor is nestled next to a sensitive organ such as the spinal cord or brain stem.

Various types of radiation can treat cancer. The most common is X-rays, high-energy light that can destroy the DNA in tumor cells. But X-rays deposit their energy all along the path of the beam, resulting in potential collateral damage in other parts of the body. More precise tumor targeting is possible with particles such as protons or ions — electrically charged atoms — which dump most of their energy in one spot.

Ion treatment is currently performed at more than a dozen centers worldwide. Treatments use nonradioactive ions — typically carbon-12, a variety of carbon with six protons and six neutrons in its nucleus. The particles in the beam have their electrons stripped off, giving them a positive charge.

The tumor is targeted based on calculations of how deep a beam will penetrate, coupled with previous imaging of the patient, for example, a CT scan. But bodies are not rigid, and organs can shift between imaging and treatment. Ideally, the beam's position would be confirmed in real time. That's just what the new technique allows.



GIULIO LOVATTI/LMU

Scientists used a beam of radioactive carbon-11 ions to treat a mouse's tumor (region circled in red). Red colors indicate where most of the ions stopped and decayed.

"If you use a radioactive ion, you can simultaneously kill the tumor and see the beam," says physicist Marco Durante of GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, Germany.

Durante and colleagues used carbon-11 ions, which have one fewer neutron in their atomic nuclei than carbon-12 ions do, making them radioactive. When carbon-11 decays, it releases a positron, an electron's positively charged antimatter partner. Scientists can detect that positron annihilating with an electron in the body, via positron emission tomography, or PET. That identifies where the beam dumps its particles.

Durante's group treated mice with tumors near the spine and was able to check the position of the beam during treatment and confirm that it was spot-on. Sure enough, the tumors shrunk.

Scientists had already tried to use PET to measure the location of a beam of nonradioactive ions. Those ions don't emit positrons, but some of the atomic nuclei break apart as they pass through material. Those fragments can make radioactive ions that release positrons in their decays. But the technique is difficult as the number of such particles is small.

With radioactive ion beams, many more positrons are emitted. "That allows [you] to get a very crisp and beautiful image of where the particle stops," says radiation physicist Mitra Safavi-Naeini of Australia's Nuclear Science and Technology Organisation in Sydney. ■

NEUROSCIENCE

Hair pulling prompts one of the fastest known pain signals

CHICAGO — Big news for fighting sisters: Scientists have found the sensors that signal the painful zing of a hair pull. This pain message can rip along a nerve fiber at about 160 kilometers per hour, placing it among the fastest known pain signals.

The discovery, presented October 8 at the annual meeting of the Society for Neuroscience, offers insight into the diverse ways the body senses and responds to different sorts of pain.

Laboratory tests showed a hair pull to be about 10 times as painful as a pinprick, neuroscientist Emma Kindström of Linköping University in Sweden and colleagues found. The pain of the pull relies on a large, propeller-shaped protein called PIEZO2, further tests showed. That sensor was known to detect mechanical forces, including light touches, but wasn't thought to detect pain signals. People who lack this protein don't feel hair-pull pain.

A hair-pull signal moves along nerve fibers much faster than other sorts of pain, Kindström says, traveling in bursts along an insulated conduit called an Aß nerve fiber. Other kinds of pain signals, such as a burn from a hot stove, travel more slowly along different kinds of fibers.

People probably vary in their pain responses to hair pulls, Kindström says. "Some people enjoy taking a very, very hot shower, while some people find it very painful. I don't see why hair pulling would be different."

She sees that variability in her pet dogs. Harry, her white Pomeranian, doesn't mind getting brushed. But Norton, her Chihuahua, is very sensitive to fur pulling, so he inflicts pain back, with a bite.

— Laura Sanders

NEUROSCIENCE

Semaglutide may sap motivation to run

A new study hints at a link between diabetes drugs and exercise

BY LAURA SANDERS

CHICAGO—Mice love to run. But not when they're taking semaglutide, the diabetes and weight-loss drug sold as Ozempic and Wegovy. While on the drug, mice ran less on a wheel in a cage, a new study shows.

The results, presented October 7 at the annual meeting of the Society for Neuroscience, are preliminary. Still, the finding raises questions about whether such increasingly popular drugs, which mimic a hormone called GLP-1, might be tinkering with people's motivation to exercise (SN: 9/23/23, *p.* 8).

The new results fit with what's known about these drugs' abilities to change brain behavior, says neuroscientist Karolina Skibicka of Penn State University and the University of Gothenburg in Sweden. "I think it's really important," she says. "I've spent most of my career looking at these drugs. But I still think we don't know everything."

Captive mice with unfettered access to a wheel will use it extensively, running a whopping 10 kilometers a day, says Ralph DiLeone, a neuroscientist at Yale University. "If you look at how much they're running, it's just nuts," he says.

But mice given semaglutide for seven days ran significantly less than their usual mileage, DiLeone and colleagues found. These mice—both males and females—reduced their average daily distance by about 38 percent. When the mice went off semaglutide, their running distance snapped back to normal.

As expected, the mice on semaglutide lost weight. But mice on restricted diets that lost about the same amount of weight without the drug didn't change their running habits, the researchers found. That suggests that weight loss isn't causing the sedentary behavior.

38
percent
Reduction in the average daily running distance of mice on semaglutide

Instead, this reduced running reflected a lack of motivation, further experiments suggest. Researchers trained the mice to unlock their running wheel by poking their noses into a slot, working for their workout, essentially. Mice would usually be willing to poke multiple times to unlock their running wheel. But mice on semaglutide poked less, suggesting that they were less eager to unlock their wheel.

It's too soon to say whether the mice's altered running habits actually relate to the more complicated exercise decisions that people make. If these drugs do make people less motivated to exercise, doctors might need to change how they talk with patients about these drugs, Skibicka says. A doctor might consider saying, "'Hey, you might feel like you don't want to exercise. But it's really important that you do,'" she says.

GLP-1 drugs help people lose weight, but part of that weight is muscle, Skibicka says. "If you add reduced exercise to this, now that's a problem," she says. "Muscle mass is important for health. Being lean without muscle mass is not a healthy state either."

But it could be that the mice's running is more like a compulsion. "It is possible that the mice are also exercising compulsively," DiLeone says, and that semaglutide may reduce this urge. That fits with other results that suggest the drug may ease addictions, perhaps by affecting the brain's reward systems (SN: 10/19/24, *p.* 6). Some people taking semaglutide have reported less desire for food, alcohol and nicotine.

It's tricky to know whether these results apply to people, says exercise physiologist Glenn Gaesser of Arizona State University in Phoenix. He is not aware of any evidence that people exercise less while on these drugs. "That said, fatigue, low energy and nausea are reported side effects," he says, and those symptoms could sap people's motivation to be active.

"Physical activity and fitness have a greater impact on life span and health span than weight loss," Gaesser says. He is concerned that people who view exercise only as a weight-loss strategy "might be less inclined to be physically active after taking one of the new GLP-1 drugs by thinking, 'Why exercise since I can lose weight with a drug?' That would be a big mistake." ■

In lab experiments, mice on the drug semaglutide ran shorter distances on a wheel than mice not on the drug. The behavior change was linked with a lack of motivation rather than weight loss.

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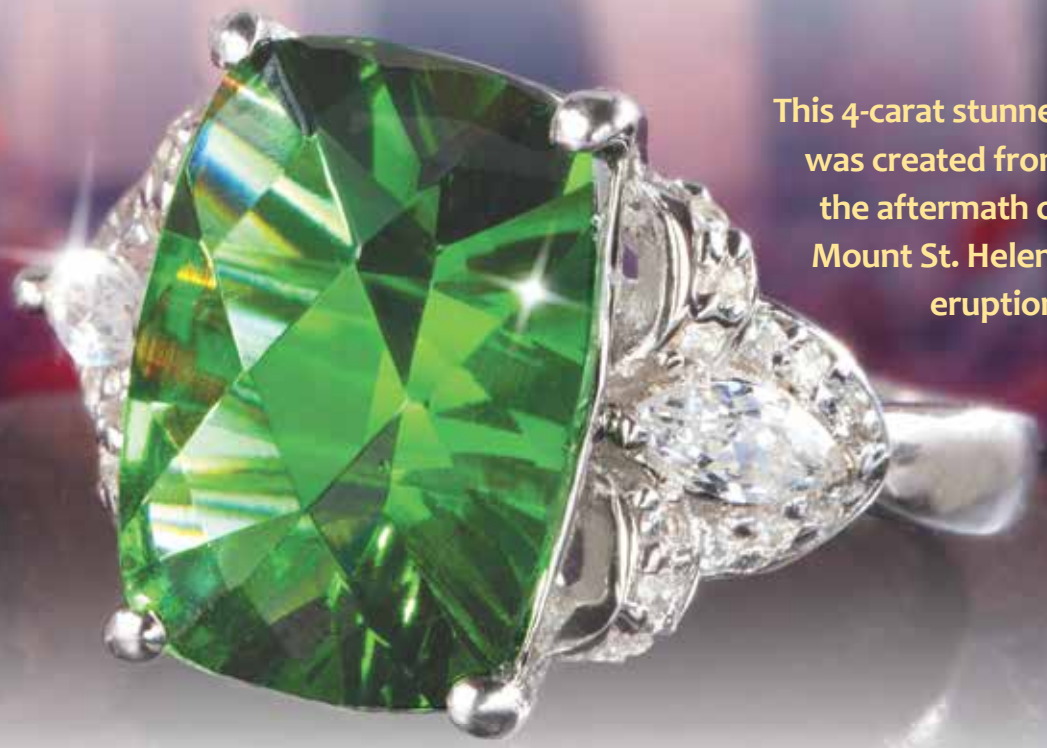

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PHYSICS

Storms boil pots of gamma rays

The emissions may be key to atmospheric electricity

BY EMILY CONOVER

Above the cloud tops, thunderstorms throb with a complex, frenetic light show of high-energy radiation.

A view from a retrofitted spy plane soaring at an altitude of 20 kilometers revealed storms glowing and flickering in gamma rays, high-energy light invisible to the eye. Ten flights with the plane, NASA's ER-2 aircraft, captured the shimmer of gamma-ray outbursts over a variety of timescales and intensities, suggesting that the emissions are more complex and more common than previously thought. And the study unveiled a brand-new type of gamma-ray blast that the researchers named a flickering gamma-ray flash.

"I'm absolutely awestruck," says David Smith, a physicist at the University of California, Santa Cruz who was not involved with the research. It's the most important new data about thunderstorm gamma rays in over a decade, he says.

Scientists knew of two main types of thunderstorm gamma-ray emissions. Short, intense blasts called terrestrial gamma-ray flashes are so luminous they can be seen from space and last for mere fractions of a millisecond (SN: 2/11/23, p. 5). Then there are longer, dimmer emissions called gamma-ray glows. Scientists spotted both on the flights.

Glows were unexpectedly persistent and prevalent, physicist Nikolai Østgaard of the University of Bergen in Norway and colleagues found. The glows continued for hours, covered thousands of square kilometers and were seen in nine of the plane's 10 flights, the team reports in the Oct. 3 *Nature*.

That makes gamma-ray emissions much more common than previously thought, says Ningyu Liu, a physicist at the University of New Hampshire in Durham who was not involved with the research. "It's astonishing."

A thunderstorm gives off gamma rays (purple in this illustration) as a plane flies above the clouds.

THE ALOFT TEAM/MOUNT VISUAL (CC BY 4.0)

What's more, the gamma-ray glows weren't static, as previously thought, but constantly simmered, brightening and dimming repeatedly on timescales of seconds. "Large storms are bubbling. It's like a boiling pot," Østgaard says.

Carrying sensors to detect gamma rays, radio waves, visible light and more, the aircraft flew over storms in the Caribbean and Central America. Cruising at an altitude about twice that of commercial flights, the plane had a front-row seat to the fireworks. And because the plane was rigged to send data to the ground in real time, researchers could direct the plane's pilot to return to regions that were hopping with gamma rays.

The flights also detected terrestrial gamma-ray flashes, including many that were too dim to be spotted by satellites in space, the team reported in the Sept. 16 *Geophysical Research Letters*. It's possible that satellite observations have missed many terrestrial gamma-ray flashes, which means the phenomenon might be more common than thought.

Thunderstorms produce gamma rays when the strong electric fields that build up inside storm clouds accelerate electrons (SN: 3/16/19, p. 10). These electrons produce more electrons, and so on. When electrons in this avalanche collide with air molecules, gamma rays result. Although this process is well understood, scientists don't understand the details behind the different types of gamma-ray outbursts, or how they are related.

The newfound flickering gamma-ray flashes could be a missing link between terrestrial flashes and glows, as the brightness and duration of the newbies fell in between those of the other two classes. Like high-energy strobe lights, these outbursts consist of short pulses of gamma rays that repeat over tens to hundreds of milliseconds, the team reports in a second paper in the Oct. 3 *Nature*.

Many of the flickering gamma-ray flashes were followed by lightning, which could mean that they help initiate it. Scientists still don't understand how exactly lightning gets started (SN: 11/5/11, p. 16).

Gamma rays might also be involved in limiting how strong electric fields can get in thunderclouds, says study coauthor Steven Cummer, an electrical engineer at Duke University. That would mean that "this whole gamma ray–generating process that was interesting and uncommon before, now actually appears to be quite central in all of atmospheric electricity." ■

CLIMATE

An old log bolsters a climate solution

Burying wood can keep carbon out of the atmosphere

BY JONATHAN LAMBERT

In 2013, Ning Zeng came across a very old, and ultimately very important, log.

He and colleagues were digging a trench in Quebec, Canada, that they planned to fill with 35 metric tons of wood, cover with clay soil and let sit for nine years. The team hoped to show that the wood wouldn't decompose, a proof of concept that burying biomass could be a cheap way to store climate-warming carbon. But during excavation, the researchers unearthed a pristine, twisted log that was older than anything they could have possibly produced in an experiment.

"I remember standing there just staring at it," says Zeng, a climate scientist at the University of Maryland in College Park. He recalls thinking, "Wow, do we really need to continue our experiment? The evidence is already here, and better than we could do."

That log was once an eastern red cedar that drew carbon dioxide from the air and transformed the carbon into wood some 3,775 years ago, the researchers report in the Sept. 27 *Science*. Buried beneath as little as two meters of clay soil for millennia, the log retained at least 95 percent of that carbon, the study estimates.

"Scientists and entrepreneurs have long contemplated burying wood as a climate solution. This new work shows that it is possible," says Daniel Sanchez, an environmental scientist at the University of California, Berkeley who wasn't involved in the study. "High-durability, low-cost climate solutions like these hold immense promise for fighting climate change."

New solutions are sorely needed. Curbing greenhouse gas emissions isn't enough to meet global climate targets, according to the Intergovernmental Panel on Climate Change. In addition, about 10 billion tons of atmospheric CO_2 need to be captured and stored annually by 2050. Plants store about 220 billion tons of CO_2 each year just by growing, but much of this gets released back to the atmosphere through decomposition. Preventing just a fraction of that decomposition by burying wood could help meet the carbon-capture goal. But that potential rests on finding conditions that would prevent air, water and microbes from breaking down that carbon for long enough to make a difference.

The ancient log gives researchers a clue. Zeng suspects the largely impermeable clay soil blanketing the region helped prevent oxygen from reaching the log, even at relatively shallow depths. "This kind of soil is relatively widespread. You just have to dig a hole a few meters down, bury wood, and it can be preserved," he says.

Burying wood could cost as little as $30 to $100 per ton of CO_2, the researchers estimate. That simplicity and cost, Zeng says, makes wood vaults more practical than developing direct air capture technology, which runs $100 to $300 per ton of CO_2.

If the conditions that preserved the Canadian log can be replicated — which is still unclear — buried biomass from discarded wood and sustainable harvesting could sequester up to 10 billion tons of carbon annually, the researchers estimate.

Despite finding the ancient log, Zeng's team carried out their planned experiment in part to figure out best practices. But the log itself exemplifies wood vaulting's promise, he says. "We now have the evidence to say, 'Yes, it's ready to be implemented.'" ■

CHANDAN KHANNA/AFP/GETTY IMAGES

HEALTH & MEDICINE

A hurricane's aftermath may be a silent killer

A hurricane's lethal aftermath could last a decade or more (Hurricane Helene's damage, shown). Whirling storms boost local death rates for up to 15 years after hitting U.S. coastlines, researchers report October 2 in *Nature*. Two economists analyzed the impact of all 501 tropical cyclones that hit the contiguous United States from 1930 to 2015, measuring changes in mortality in the areas where the storms came ashore for up to 20 years after each storm. A single storm may indirectly cause between 7,000 and 11,000 deaths on average. Altogether, the tempests might have spurred 5 percent of all deaths in areas hit by tropical cyclones over that time period. Post-storm stress or pollution, less money for health care and other factors may contribute to mortality, the team says. — *Meghan Rosen*

SCIENCE & SOCIETY

2024 Nobel Prize winners announced

Laureates studied microRNA, proteins and neural networks

This year's Nobel Prizes, announced in October, celebrates research in the realms of biology and artificial intelligence. Honorees discovered a key player in gene regulation, pioneered neural networks and developed AI tools to predict the shapes of proteins and build new ones.

MicroRNA makes waves

Biologists Victor Ambros and Gary Ruvkun won the prize in physiology or medicine for discovering microRNAs. These tiny snippets of RNA play an outsize role by helping to control the production of proteins throughout the body.

Instructions for making proteins are encoded in DNA, which get copied, or transcribed, into RNA versions that cells then use to make the proteins. A molecule called messenger RNA, or mRNA, ferries copies of the DNA instructions to be transcribed. This is where microRNA comes in: When this tiny RNA latches on to mRNA, the mRNA gets degraded and the instructions for making proteins don't get delivered, Ambros and Ruvkun found. In effect, microRNA works like a dimmer switch to dampen production of proteins.

The researchers studied the worm *Caenorhabditis elegans*. Worms with a mutation in the gene *lin-4* repeated certain developmental steps and failed to make some adult parts. In 1993, Ambros, now of the University of Massachusetts Chan Medical School in Worcester, reported that *lin-4* makes a microRNA rather than a protein.

Ruvkun, now of Harvard Medical School, found that the *lin-4* microRNA latches onto mRNA for the gene *lin-14* and turns down production of its protein, which regulates other developmental genes. He went on to find that another microRNA is present throughout the animal kingdom, including in humans.

More than 1,000 microRNAs are now known to regulate genes in people. Some microRNAs regulate processes that are fundamental to all plant and animal cells.

A nod to neural networks

John Hopfield of Princeton University and Geoffrey Hinton of the University of Toronto share the prize in physics for their work on artificial neural networks.

These computational tools underlie many AI techniques and have helped physicists grapple with large amounts of complex data, allowing them to make images of black holes and devise new battery materials. The technology also enabled the protein-folding work honored with this year's chemistry prize.

Neural networks find patterns in data rather than making explicitly programmed calculations. They're based on a web of individual elements called nodes that are inspired by the brain's neurons. Training a neural network by feeding it data optimizes the connections between nodes, honing its ability to make accurate conclusions.

In 1982, Hopfield built an early neural network that reconstructs patterns in data. The network, which holds a value of 0 or 1 at each node, is similar to magnetic materials in physics, in which atoms have magnetic fields that can point up or down. Scientists can calculate the energy of any given configuration of those fields. Hopfield's network minimizes an analogous energy to reveal patterns from its training data that are hidden in the input data.

Hinton devised the Boltzmann machine, a neural network with nodes that process data but do not directly receive input. Different states of the model have different probabilities of occurring. The probabilities are set by the Boltzmann distribution, which describes collections of many particles, such as molecules in a gas.

The power of protein folding

Efforts to unlock the mysteries of life's building blocks earned three scientists the prize in chemistry.

How a protein functions depends on it's shape. In 1998, David Baker, a biochemist at the University of Washington in Seattle, and colleagues debuted Rosetta, a computer program that predicts a protein's 3-D structure from a given amino acid sequence. In 2003, his team asked Rosetta to do the opposite: predict an amino acid sequence from a given 3-D structure for a protein that doesn't exist in nature. When the scientists synthesized the sequence, it folded into the shape. Baker has since created designer proteins, including one that blocks the coronavirus from entering cells.

Demis Hassabis and John Jumper of Google DeepMind in London debuted AlphaFold2 in 2020. This AI uses a neural network to predict protein structures from amino acid sequences with 90 percent accuracy. The team has predicted structures for over 200 million known proteins.

—Tina Hesman Saey, Sophie Hartley, Emily Conover, Lisa Grossman, Meghan Rosen and Andrea Tamayo

An AI predicted this shape for a plant protein. Colors indicate the AI's confidence in its prediction, from dark blue (very high) to orange (very low).

EMBL-EBI, GOOGLE DEEPMIND

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ANIMALS

Fungus-laced bird nests repel ants

Aggressive insects behave oddly after touching toxic fibers

BY RICHARD KEMENY

For birds that build nests in ant territory, the best defense could be an offensive fungus.

Multiple species of ants aggressively defend swollen-thorn acacia trees. Yet, several species of birds across Central America and Africa nest in these trees. Building nests with fungal fibers seems to deter the ants and alter their behavior, making them apparently alarmed and intoxicated, researchers report in the October *Animal Behaviour*.

Birds such as the yellow-olive flycatcher (*Tolmomyias sulphurescens*) build nests in swollen-thorn acacia trees. Nests often include fungi that repel ants that guard the trees.

"It seemed very strange to me that the ants did not harm the chicks," says Rhayza Cortés-Romay, an ecologist at the Universidad Mayor de San Andrés in La Paz, Bolivia. "So I started to think from the bird's perspective: How does it achieve this?"

The relationship between swollen-thorn acacia trees (*Vachellia collinsii*) and ants is a symbiotic one. The ants collect nectar from the acacia and shelter in its thorns while patrolling the trees like possessive bouncers, biting and stinging invaders and even trimming back or killing encroaching plants. The ants may provide protection from predators for birds that nest in the trees, but it was unclear to researchers how the birds kept the ants away from their young.

Throughout the tropics and subtropics, many birds use fungal organs known as rhizomorphs to build nests. These cord-like structures consist of densely woven filaments that fungi use to search for nutrients.

In tropical forests, rhizomorphs grow in the canopy, forming complex networks that catch falling litter. Previous research has suggested that birds may use rhizomorphs for the structures' strong support, antimicrobial features and water repellency.

In Costa Rica's Palo Verde National Park, two bird species that live on swollen-thorn acacias build their nests almost entirely using rhizomorphs of horsehair fungus (*Marasmius*)—and appear to successfully keep out ants. So Cortés-Romay and behavioral ecologist Sabrina Amador-Vargas of the Smithsonian Tropical Research Institute in Balboa, Panama, placed strands of horsehair fungus onto the branches of 30 acacia trees inhabited by a species of symbiotic ant, *Pseudomyrmex spinicola*. The team also left out plant fibers of a similar thickness and type that birds also often use to build nests.

Recordings revealed that ants that touched the fungus groomed themselves and moved faster more often than ants that touched only the plant fibers. Those actions indicate repellence and alarm, the researchers say.

Some ants exhibited extreme behaviors almost exclusively after coming into contact with the fungus, including biting other ants, spinning and wandering

ANIMALS

Some comb jellies can fuse together

Merged sea walnuts have synchronized bodily functions

BY JUDE COLEMAN

In a Frankenstein-y feat, a small, gelatinous sea creature can merge its body with a neighbor's. The animals—a type of comb jelly called a sea walnut—then sync up their bodily functions, scientists report in the Oct. 7 *Current Biology*.

Biologist Kei Jokura first discovered the mash-up when he found an unusually large sea walnut (*Mnemiopsis leidyi*) floating in a collection tank. Turned out, it was actually two jellies joined together.

Jokura, who made this discovery while at the Marine Biological Laboratory in Woods Hole, Mass., and his colleagues suspected the jellies had become injured in the collection process and, due to tight quarters, fused their bodies while healing. Comb jellies are known for their ability to regenerate body parts, but the sight of two attached sparked Jokura's curiosity.

"At first, I was very surprised," says Jokura, now at the National Institutes of Natural Sciences in Okazaki, Japan. Then he thought, "Let's try to reproduce this under the microscope."

Jokura and colleagues took pairs of comb jellies, trimmed off a piece from each and then pinned the two jellies to dissection dishes with their cut ends abutting. In nine out of 10 pairings, the injury sites fused overnight, creating a continuous stretch of tissue.

They didn't just look like a single organism—they also acted like one. When scientists prodded one side of the dual jelly, both bodies responded by contracting. That suggests the jellies' nervous systems also fused, the team says (SN: 6/3/23, p. 12). And both bodies circulated food between them, despite the team feeding only one mouth of the duo.

Because comb jellies are spread out in open waters, fusion probably happens only in a lab setting, says Steven Haddock, a marine biologist at the Monterey Bay Aquarium Research Institute in Moss Landing, Calif. In his own work with

around aimlessly and unpredictably. This "drunkard's walk" is reminiscent of ant workers infected by the zombifying fungus *Ophiocordyceps* and suggests the ants may have been disoriented or ingested toxins.

"The first time we saw the behaviors, we were amazed," Cortés-Romay says. "These ants are very aggressive. To see something that affected them really was a discovery."

Some of the results offer compelling support to the idea that these fungi are noxious to the ants, says Fran Bonier, a behavioral ecologist at Queen's University in Kingston, Canada. But birds use the same rhizomorphs on trees that are free of ants as well, she says. That suggests the rhizomorphs benefit nests in other ways.

At least 176 bird species use fungal rhizomorphs in their nests. Given that frequency, it's not surprising the researchers found evidence that the rhizomorphs may provide some chemical defenses, says biologist Todd Elliott of the University of New England in Armidale, Australia.

The finding "raises many questions about the chemistry of what is being released," Elliott says, "and if it is unique to this ant and this fungus or whether analogous situations are playing out in other ecosystems around the world." ■

comb jellies, he's seen another species, the sea gooseberry (*Pleurobrachia pileus*), fuse after collection but not in a synchronized way. "Nothing like this, where they're coordinating their reactions," he says. "It's pretty remarkable."

Their fusion prowess suggests that sea walnuts don't distinguish between their body and another body, an ability called allorecognition. In humans, allorecognition can cause the body to reject organ transplants. Comb jellies are one of the oldest lineages of animals, which means this absence of allorecognition might hold clues for when the trait evolved (SN: 1/25/14, *p.* 16). But to understand that, Jokura says, more research needs to be done on the animals' neurobiology and genetics. ■

ANIK GREARSON

The northern sea robin's legs are sensory organs that help the fish seek out prey buried in sand.

ANIMALS

Sea robins use their legs to taste prey

Sensory cells that stud the limbs help the fish find food

BY ERIN GARCIA DE JESÚS

It's a bird! It's a crab! No, it's a fish that can taste with its legs.

Some sea robins, a group of fishes with two winglike fins and six crablike legs, dig their legs into the sand and find buried prey using a tastelike sense, developmental biologist David Kingsley and colleagues report in the Oct. 7 *Current Biology*. An ancient gene important for limb formation in humans and other animals, as well as a gene involved in building taste buds, helped a few sea robin species develop legs that taste.

"New things came from old parts," says Kingsley, of Stanford University. A walking fish with taste organs on its limbs may look "new and cool and different, but … the new things have come by taking a toolkit of preexisting genes and deploying them in new ways."

The northern sea robin (*Prionotus carolinus*) is skilled at finding buried crabs or shrimp to eat. Previous studies suggested that this sea robin's legs could pick up chemical cues, but it was unclear if the limbs could sense anything as they dug into the seafloor.

Fish have taste buds in their mouths, and some fish even have taste buds on the outside of their bodies, says Peihua Jiang, a neurobiologist at the Monell Chemical Senses Center in Philadelphia who was not involved in the work. The findings indicate that northern sea robin legs are sensory organs, which is "actually quite amazing," he says. "That's completely a new feature [for fish], not what we typically see for how you detect or process taste information."

The scientists used an array of experiments to explore how northern sea robins dig up food. Fish in lab tanks zero in on extract from mussels while using their legs to sift through sand, behavioral tests showed.

Closeup images of the legs revealed they are covered in small sensory mounds called papillae, like the papillae that feature taste buds on the tongue. These papillae have many of the same receptors that taste buds in the fish's mouth do, but the receptors are repurposed and arranged in a different way.

The papillae also have touch-sensitive nerve cells and taste sensors that help sea robins figure out where to dig, genetic and physiological tests found. At the tip of each leg, the team detected high levels of activity from *t1r3*, a gene that provides instructions for making a receptor found in mammalian sweet-detecting taste buds. What's more, the ancient gene *tbx3a*, which drives limb development in people, chickens and other animals, was crucial for sea robin limb and papillae formation as well as driving the digging behavior.

Most sea robin species have smooth legs that probably can't taste, the team found. That difference suggests that the northern sea robin and another digging relative, the leopard sea robin (*P. scitulus*), are among a few species benefiting from an "evolutionary innovation," says Stanford developmental biologist Amy Herbert.

Jiang wonders whether the papillae can sense bitter tastes that indicate something should be avoided. He also wants to know if the taste buds in sea robin mouths detect the same tastes that the legs do. Once the fish find food, "what's the next step?" ■

ARCHAEOLOGY

The origin of Scythian 'spectral riders'

Horse-riding Scythians, who inhabited Central Asia and Eastern Europe around 2,500 years ago, may have had cultural roots thousands of kilometers to the east in Siberia. Remains of one person and 18 horses (mandible shown) found atop a 2,800-year-old royal tomb in Siberia evoke a Scythian-style ceremony, archaeologists report October 8 in *Antiquity*. Artifacts at the burial mound include belt fittings decorated with stylized animals like those in later Scythian art and remnants of birch stakes. An ancient written account indicates Scythian kings' tombs were guarded by "spectral riders" — 50 sacrificed servants mounted on 50 sacrificed horses and held in place atop the burial mound by stakes driven through their bodies. — *Bruce Bower*

ASTRONOMY

Barnard's star has a planetary pal

A red dwarf star known as Barnard's star, which lies six light-years from our solar system, has at least one small rocky planet orbiting it, a new study suggests.

Due to its proximity to Earth, Barnard's star has long been a target of astronomers looking for exoplanets. Now, after several false starts over the decades, researchers may finally have hit pay dirt.

Astrophysicist Jonay González Hernández and colleagues scrutinized more than 150 observations made by a telescope in South America over the course of four years. Specifically, the team looked for tiny wobbles that would betray the presence of planets gravitationally yanking the star to and fro as they orbited.

The largest wobble takes place every 3.15 days, the team reports in the October *Astronomy & Astrophysics*. It's probably caused by the orbit of a small rocky planet about three times the mass of Mars, says González Hernández, of the Instituto de Astrofísica de Canarias in Tenerife, Spain.

The team also noted smaller oscillations that are superimposed on the large wobble, which probably represent the presence of three small orbs circling the star every 2.34 days, 4.12 days and 6.74 days. All four of the purported planets are too close to the star to support life, the researchers suggest. — *Sid Perkins*

HEALTH & MEDICINE

An mRNA vaccine protects mice from deadly C. diff bacteria

The technology that enabled the first COVID-19 vaccines shows promise against an intestinal pathogen that kills about 30,000 people in the United States every year.

An mRNA vaccine designed to target *Clostridioides difficile* protected mice from severe disease and death after exposure to lethal levels of the bacterium, researchers report in the Oct. 4 *Science*.

C. difficile can wreak intestinal havoc after a course of antibiotics clears healthy gut bacteria, secreting toxins that can cause diarrhea, sepsis or death. Infections can be hard to kick because antibiotic-resistant spores can lurk in the body for years. Researchers have developed several vaccines to prime the immune system to recognize *C. difficile*'s toxins, but none have been shown to be very effective.

Biomedical engineer Mohamad-Gabriel Alameh of the University of Pennsylvania and colleagues took a new approach, designing an mRNA vaccine that targets several proteins that underlie *C. difficile*'s ability to cause disease. In lab mice and hamsters, the vaccine elicited a more robust uptick in a variety of immune cells than traditional vaccines.

All vaccinated mice survived a highly lethal dose of *C. difficile*, while all unvaccinated mice died after a few days. Vaccinated mice still got infected, but experienced mild symptoms and bounced back quickly. The immune protection proved durable, as vaccinated mice challenged with a second *C. difficile* infection after six months fared about as well as they did in the first round.

The mRNA vaccine also spurred an immune response in a rhesus macaque. Still, the researchers acknowledge that the vaccine needs further testing before it is ready for trials in people. — *Jonathan Lambert*

HEALTH & MEDICINE

Arm position matters for accurate blood pressure readings

When the arm is on the lap or the side, a blood pressure reading can be erroneously high. But when the arm is supported and at heart height, a blood pressure reading is more likely to be right.

In a clinical trial, scientists investigated the effect that arm position had on blood

TREVOR WALLACE

pressure readings, which consist of two numbers. The first, the systolic, represents the blood's pressure against the artery walls when the heart beats. The second, the diastolic, is the pressure between beats, when the heart rests.

For participants with their arm in their lap, systolic and diastolic readings skewed about 4 millimeters of mercury higher, on average, compared with the readings of participants with the recommended arm position: at heart level and supported by a desk or table.

For participants whose arm hung at their side, the systolic reading was close to 7 millimeters of mercury higher and the diastolic reading was about 4 millimeters of mercury higher, the scientists report October 7 in *JAMA Internal Medicine*.

An estimated 120 million adults in the United States have high blood pressure (defined as a reading equal to or greater than 130/80 millimeters of mercury) or take drugs that lower blood pressure. High blood pressure increases the risk of cardiovascular disease and stroke.

To get the most accurate blood pressure reading, medical guidelines recommend people have their legs uncrossed and feet flat on the floor, their back supported, their arm positioned correctly and a properly fitting blood pressure cuff. But how closely medical offices follow these guidelines varies, the researchers note. That could mean inaccurate readings for some people, which might lead to unwarranted diagnoses of high blood pressure.

Using data from a national survey on health and nutrition, the scientists calculated that 54 million adults might be misclassified as having high blood pressure due to improper arm positioning.

— Aimee Cunningham

ANIMALS

How some tree frog tadpoles cope with small nurseries

Eiffinger's tree frogs don't poop in the first weeks of life, biologists Bun Ito and Yasukazu Okada of Nagoya University in Japan report September 22 in *Ecology*. Instead, the tadpoles store their poop in an intestinal pouch until they metamorphize into full-fledged frogs.

This self-induced constipation may help the tadpoles cope with their small nurseries — puddles in plant stems, tree hollows and bamboo stumps that don't have enough water to dilute ammonia in the animals' waste. "The behavior likely serves to prevent contamination," Ito says.

In lab tests, tadpoles representing four frog species were reared in makeshift nurseries and moved to smaller cribs with less water over time. Ito and Okada measured both how much ammonia each species excreted and how much each stored in their guts. On average, Eiffinger's tree frog (*Kurixalus eiffingeri*) tadpoles released less than half as much ammonia and kept more ammonia in their guts than the other species. The tadpoles can also survive in high-ammonia environments, which may help them share cribs with other animals that don't hold in waste, such as mosquito larvae.

— Andrea Tamayo

The whale whisperer

By discovering a unique population of blue whales, Asha de Vos popularized marine biology in Sri Lanka

By Sandy Ong

Pooping whales changed the course of Asha de Vos' career.

The Sri Lankan marine biologist was aboard a research vessel near her home island in 2003 when she spotted six blue whales congregating. A bright red plume of whale waste was spreading across the water's surface.

De Vos, then a master's student, recalls being "super excited." What she witnessed went against prevailing dogma: Her textbooks and professors had taught that blue whales, like other large whales, embark on long-distance migrations between colder feeding areas and warmer breeding and calving areas. But seeing whales pooping in tropical waters meant the behemoths must be feasting locally.

Intrigued, de Vos spent the next few years documenting how blue whales near Sri Lanka differ from those elsewhere in the world. For one, the population feeds on shrimp rather than krill. The whales also have unique songs. But the key difference, she realized, is that they remain year-round in the waters between Sri Lanka, Oman and the Maldives — making them the only nonmigratory blue whales in the world. Abundant upwellings of nutrient-rich water from the ocean depths support a steady food supply for the whales.

Eventually, the International Whaling Commission, the intergovernmental body dedicated to protecting whales, recognized Sri Lanka's blue whales as a distinct subspecies called *Balaenoptera musculus indica*.

This distinction is crucial for conservation management, explains retired whale biologist Phillip Clapham, formerly of the U.S. National Oceanic and Atmospheric Administration's National Marine Fisheries Service. Small, localized populations — like the one in Sri Lanka — face higher risks of being wiped out in the face of environmental or human threats, such as deep-sea mining.

More than two decades on, de Vos is now one of Sri Lanka's most renowned scientists — famed for nurturing the country's nascent marine biology scene. She is also an ardent champion for greater diversity among researchers in ocean conservation.

De Vos has garnered numerous accolades, including being named a National Geographic Explorer, a TED Senior Fellow and one of the BBC's 100 most inspiring and influential women of 2018. But such recognitions don't spur her on.

"I'm driven by trying to make a change," especially around the negative narrative many Sri Lankans

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

By studying the blue whales around Sri Lanka (one shown), marine biologist Asha de Vos discovered they are the only nonmigratory blue whales in the world.

OPPOSITE PAGE: SPENCER LOWELL, *WIRED* © CONDÉ NAST; THIS PAGE: FRANCO BANFI/NATURE PICTURE LIBRARY/ALAMY STOCK PHOTO

hold for the ocean, she says. "I want people to fall in love with the ocean … to recognize the ocean as this incredible space that is life-giving in so many ways."

Setting her own course

For all her love of the deep, de Vos' early memories of the ocean — a mere mile from where she grew up in Sri Lanka's capital, Colombo — are, surprisingly, tinged with fear. Like her compatriots, she was raised with repeated warnings that the ocean was "a big beast" to avoid, unless you were fisherfolk with little choice but to venture into such unforgiving territory.

"There were often stories of drownings that came with people who went to sea," she says. Most people in Sri Lanka never learn how to swim, despite living on an isle so picturesque it's often called the "pearl of the Indian Ocean."

"People have this disconnect with the sea" de Vos says. "Life always ended at the shoreline."

The few people who do learn how to swim usually stick to swimming pools. The ocean is "not recreational space," de Vos says. "I'd say it's a common problem, particularly in poorer nations where you don't have time to waste and there's no frolicking on the beach." But her forward-thinking mother sent her for swim classes. The young girl took to the water so well that she soon began competing in freestyle sprint events.

Her love for the ocean, however, stemmed from another source: secondhand *National Geographic* magazines her father would bring home from the local bookshop. "It was just the pictures that really drew me in," de Vos says.

By the time she turned 17, de Vos had narrowed her career path to marine biology. No local universities offered such a course, and she hadn't heard of anyone from Sri Lanka who had ever ventured abroad to pursue the subject, but that didn't deter de Vos. Nor did just missing the required grades for her dream school, the University of St. Andrews in Scotland, which has a strong marine biology program. "I called [the university] and said, 'Look, I really want to come to your school. I know I'm capable,'" she recalls with a laugh.

Her powers of persuasion worked, kick-starting an academic journey that would take her through three continents — including a Ph.D. in Australia and a postdoc in the United States that she completed in 2015.

The journey hasn't always been smooth sailing. The naysaying began when she applied for university. "There's no scope in this country for a marine biologist," people would say. "They couldn't understand that there could be work, there could be jobs out at sea," de Vos says. "I always joke now that maybe people thought I was going to go to university and then become a fisherwoman."

As de Vos progressed in her career, the criticism continued, both from within and outside her country. In a personal essay she penned for the *New York Times*, de Vos recounts a handful of fellow scientists from wealthier nations who questioned her authority as a researcher from an impoverished country, assuming that she would "lack the knowledge, know-how and interest to participate in marine conservation."

Meanwhile, fellow Sri Lankans criticized de Vos for not staying within the boundaries of a "respectable" woman, engaging in relatively risky, labor-intensive outdoor tasks. A fisherman piloting a boat she was on demanded to know what her

Seeing whale poop (below), colored red thanks to the whale's diet, was the first clue that Sri Lanka's blue whales don't migrate between feeding and breeding areas. Asha de Vos (shown in 2015) made this observation while a master's student.

FROM LEFT: A. DE VOS; STEVE DE NEEF

husband thought of her being out on the water and "getting black in the sun." De Vos replied that she wasn't married. The man retorted, "I thought as much."

Such critics served only as fire starters. "I was like, 'OK, whatever. I'll show you,'" she says. "In many ways, I'm grateful for the challenges — they really made me who I am. They made me have to think outside the box. They made me have to work superhard and really grind at what I do."

For Clapham, who was one of her Ph.D. examiners, it is this steely, determined de Vos he knows and loves. "She's just a force of nature" and is simply relentless, he says.

Creating a lasting legacy

Today, de Vos continues to study cetaceans through the Sri Lankan Blue Whale Project, which she launched in 2008. "We have the longest running dataset of blue whales in this part of the world," she says, including a photo catalog of hundreds of individuals in the population.

But much about the creatures remains unknown, including their precise numbers and what drives long-term fluctuations in their abundance. During the project's first five years, de Vos and her team observed numerous sightings of the giants, sometimes between 10 and 12 creatures at a go "just blowing everywhere," she recalls. "But now on the southern coast, we don't see as many blue whales." She and her team are trying to figure out why and whether it's cause for concern.

But the researchers are limited by their vessels, which can only support day trips rather than longer journeys farther out to sea. "We are searching such a tiny sliver of ocean," de Vos says.

In addition to the whales, de Vos also surveys the biodiversity of their deep-sea environment. She conducted, as far as she knows, the first such audit of the northern Indian Ocean in 2022. "I do these things from a conservation perspective.... People are getting more and more bold about what can be done in these deep-sea environments," she says, citing underwater mining as a potential threat. "I work with whales and that's my primary love. But the whales need a perfectly healthy ecosystem because they don't just live in a bubble where everything around them doesn't bother them."

A key aim of de Vos' work is to protect blue whales from ship strikes. Sri Lanka lies along one of the world's busiest shipping routes, and in a survey of 14 stranded whales that had died from ship strikes in 2010–2014, a total of nine, or more than 60 percent, were blue whales.

De Vos brought the danger of shipping to light in 2012. It "started a whole cycle of conversations" with the Sri Lankan government, International Whaling Commission, World Shipping Council and other bodies. These talks culminated in victory in 2022, when the world's largest container shipping firm, the Mediterranean Shipping Company, announced it would reduce the speed of its ships when traveling around the island and adopt a more southerly route that avoided the whales.

Another aim is to get more Sri Lankans to appreciate the ocean and the importance of protecting it. "My whole goal is to create love for the ocean and remove the fear," says de Vos, who wants to inspire custodians, or "ocean heroes." To this end, she gives her time to numerous outreach events, including public talks and monthly science journal clubs. In 2017, she founded the nonprofit Oceanswell, Sri Lanka's first marine conservation research and education organization. "For me," she says, "the education component is as important as the research component."

"She's a tremendously engaging and eloquent speaker," Clapham says. "She's a lot of fun when she's doing educational stuff." He recalls how de Vos once created animation to explain what blue whales typically eat, snubbing more traditional presentation formats. "It was very entertaining," he says.

To help grow Sri Lanka's nascent marine biology scene, de Vos advises universities on how to teach the subject.

Lasuni Gule Godage is among the first students to pursue a master's degree in marine science and fisheries at the Ocean University of Sri Lanka, created in 2014 by the Sri Lankan government to promote oceanic education. De Vos was instrumental in establishing and obtaining funding for the university's pioneering program.

De Vos is also a mentor. Gule Godage notes how de Vos advised her on how to conduct fieldwork. "I faced many challenges because there was no postgraduate program [at my school]," Gule Godage says. "But Dr. Asha supported me so much."

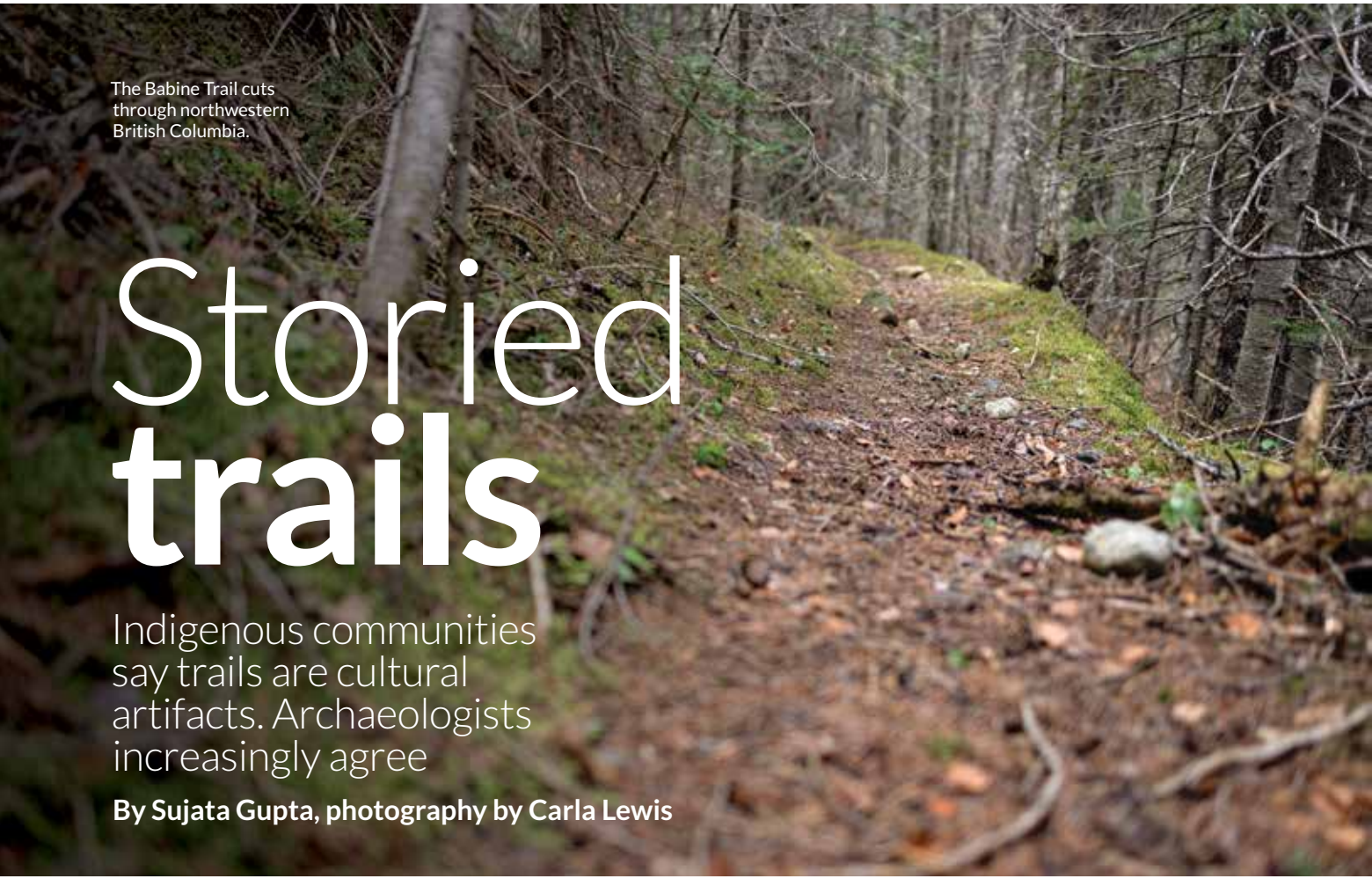
De Vos doesn't want others to go through what she did. "My goal is to give away everything, whether it's my knowledge or tips on how to do something better," she says. "I always tell people when I die, I don't want everything [I've done] to end." ■

> "My whole goal is to create love for the ocean and remove the fear."
>
> ASHA DE VOS

Explore more

- Learn more about the Sri Lankan Blue Whale Project at oceanswell.org

Sandy Ong is a science journalist based in Singapore.



The Babine Trail cuts through northwestern British Columbia.

Storied trails

Indigenous communities say trails are cultural artifacts. Archaeologists increasingly agree

By Sujata Gupta, photography by Carla Lewis

Wind jostles the helicopter as we skim over dense forest and the snow-covered peaks of the Coast Mountains. We are flying over northwestern British Columbia, and from this aerial vantage point, it's easy to see how mid-19th century European fur traders called this land wild. But then, as now, that image is a mirage.

Snaking somewhere below us is the old Babine Trail network, a "grease trail" likely used for millennia by the Gitxsan people to carry goods such as eulachon, a type of smelt rich in oil, from the coast to inland communities. The crew I'm traveling with — which includes archaeologists, locals versed in this region's ecology and culture, graduate students carrying soil-sampling equipment and bear spray, and members of the Indigenous house group, or wilp, whose ancestral lands we're on — has come to mark part of that ancient path.

Beneath the chopper, a small patch of brown grass appears, and the pilot begins a steep descent. Once on the ground, boots squelch on mossy floor or sink into snow as we search for the overgrown Babine. Fierce brambles obscure the terrain. But we know the trail must be nearby.

That's in part because the team is following hints in maps made with lidar. Short for light detection and ranging, this remote sensing method can map the Earth's topography with aircraft or satellites that send pulses of laser light toward the ground and then measure the returning light. But not all snippets of trail show up clearly. Our crew is going in on foot to connect trail fragments visible in those lidar maps.

Eventually Brett Vidler, an archaeological field assistant, calls out, "I think we're on it guys." He's pointing to a tree with a divot and sharp cuts in its trunk — a blaze. From a thick spool of pink ribbon, Vidler rips off a bit that reads "culturally modified tree" and hands it to a group member to tie around the trunk. Periodically, as we fight our way through the brush, someone also stops to tie trees with blue ribbon reading "cultural heritage resource" to signify the trail.

This trail network has become overgrown as Indigenous people's connection to their land and culture has frayed. In the late 1800s, Canada established a federal residential school system that tore Indigenous children from their families, including those living here, and forbade students from speaking their native language.

Marking trails helps local communities reconnect with their heritage. The blue and pink ribbons also symbolize how Indigenous people here — and in many other parts of the world — are turning to the tools and language of Western

science to fight ongoing threats to their communities. One big threat around here is oil and gas development. British Columbia's Indigenous trails are now a test case for how, or if, cultural resource management practices can evolve as archaeological and Indigenous understandings of the landscape coalesce. Developers already bulldozed through one ancient trail in the region a few years back. Now people here worry that the Babine Trail is next.

Western science hegemony

We are in Madii Lii, a 354-square-kilometer tract of land in Gitxsan territory that both the government of British Columbia and the Gitxsan people claim as their own.

"The pipeline is going right underneath here," says Aspin'm nax'nox Ira Good. Good is a member of the Gitxsan Nation's Flying Frog Clan. He's referring to the Prince Rupert Gas Transmission pipeline, which is slated to run along or over this Madii Lii trail segment.

This sliver of earth could soon be buried under access roads, temporary encampments and construction of the pipeline itself, which if completed would carry natural gas up to 780 kilometers from northeastern British Columbia to the coast, almost 300 kilometers west of here by car. Provincial authorities issued certificates for the project to proceed in 2014. After years of delays, developers broke ground on a portion of the pipeline near the coast in late August. They must make substantial headway on that construction by late November or those certificates will expire.

Good and others hope that marking the trail will put pressure on the government to block pipeline development or at least force a reroute. It's a long shot. Generally speaking, Indigenous people see landscapes as interconnected and indivisible while Western people see the reverse. But the Western mind-set governs preservation practices on lands slated for development. Cultural resource management policies typically focus on discrete sites, not on landscapes. By extension, preservation most often centers on the tangible stuff found at excavated sites — old foundations for houses and buildings, pottery shards, arrowheads and the like — rather than the intangible memories and stories woven into the land.

For development projects in Canada and elsewhere, only land within the footprint of the project is subject to archaeological (and environmental) review. Vast or linear cultural features, such as trails, that intersect with that footprint might appear in these assessments but rarely as contiguous wholes.

Historically, Western archaeologists have not questioned this site-based approach, especially as mapping had to be done on foot, a time-consuming and laborious process that could only cover so much ground. But now, some archaeologists have begun using lidar and other remote sensing tools to probe how past peoples connected across gardens, courtyards, cities and even continents. As these archaeologists' spatial lens has widened, they are increasingly seeing landscapes as interconnected places of movement.

The linkages between places, or sites, are just as important as the materials left in a given place, says Kisha Supernant, a Métis archaeologist at the University of Alberta in Edmonton. "People don't just live on a point.... I don't just live in my house."

But most of archaeology — and notably cultural resource management — hasn't kept up. "We are stuck with this mind-set that the past is all about the hearth and the home," says Jim Leary, an archaeologist at the University of York in England. "In reality, real life happens out in paths."

When commercial archaeologists hired by the developers of the Prince Rupert pipeline mapped the proposed pipeline, the Babine Trail made only a scant appearance in their notes. The archaeologists stated that the pipeline would overlap some 200 meters, or about 3 percent, of the nearly 12-kilometer trail. In reality, the trail is roughly 80 kilometers long, and the pipeline will destroy half of it, says Chelsey Geralda Armstrong, an archaeologist at Simon Fraser University in Burnaby in British Columbia and a project lead on the effort to mark the Babine. "The archaeologist who went in for the company recorded a trail but as a point ... not a line."

Here in this dense patch of brush, where the stories of Gitxsan ancestors live on, the archaeology report noted there was little likelihood of finding anything of cultural significance.

The site problem

Culturally modified trees don many guises. Deep slashes on a trunk denote blazes cut with an adze. Bent and plaited branches signal a trail or the intentional clearing of a path. Pines with missing rectangular patches of bark are "noodle" trees, where hungry passersby unfurled the bark and ate sweet ribbons of sap.

I am now in the Wet'suwet'en Nation, south of Gitxsan territory. Armstrong is leading a training session to help students learning about their heritage identify such trees. The students, many Indigenous, include middle-aged community members living elsewhere who've brought children ranging in age from tots to teens and a handful of twentysomethings who've been living off-grid in this area.

Surviving out here has never been easy. Even now in mid-May, temperatures often drop near freezing at night, and black bears, hungry from a long winter preceded by drought, frequently lumber out onto the gravel roads. Identifying modified trees is one way to understand how the ancestors navigated these harsh environs, Armstrong says. She belongs to the small but growing group of archaeologists trying to move past the Western concept of sites, frequently referred to as polygons.

"In the digital age, geospatial technologies give us the capacity to detect, record, index and analyze sites at scales impossible in the analog age when the notion of a site entered our lexicon," archaeologist Mark D. McCoy of Florida State University in Tallahassee wrote in 2020 in the *Journal of Field Archaeology*.

Armstrong and colleagues outlined what a non-site-based approach to archaeology could look like in 2023 in *American Anthropologist*. Her team sought to map both the Babine Trail in Gitxsan territory and the Kweese War Trail in the Wet'suwet'en Nation. The researchers combed through troves of documents dating back to 1980, including earlier land-use studies, cultural

Mike Ridsdale, a member of the Wet'suwet'en Nation's Tsayu Clan, spent years marking the Kweese War Trail. The construction of a natural gas pipeline, he says, destroyed the sacred pathway.

heritage reports, notes from interviews with elders and legal documents. Whenever possible, Armstrong and colleagues wrote down the geographic coordinates for references to trails.

The team used that info to decide what linear features to home in on in visual data, including historical aerial photos, helicopter surveys conducted in 2019 and 2020, and lidar images. The researchers also noted previously recorded archaeological sites located within 200 meters of those likely trail sections. With those clues in hand, the team began schlepping out on foot to mark the Babine and Kweese trails. Whenever a trail's signature disappeared in the images, the team followed the most likely route on the ground until again spotting telltale signs of movement, such as packed earth and culturally modified trees.

Similar research is playing out in other parts of the world. In the Netherlands, archaeologist Wouter Verschoof-van der Vaart of Leiden University has turned his lens on so-called hollow roads. They form when travelers, in this case people bearing carts laden with goods, trample the same route across long stretches of time. The earliest confirmed routes where Verschoof-van der Vaart was looking — the 2,200-square-kilometer Veluwe region in the central Netherlands — date back to the Middle Ages, from 1250 to 1500, though some researchers suspect people began using those paths thousands of years earlier.

Nobody had mapped that extensive road network, in part because those channels are now almost invisible to the naked eye. After beginning to stitch together the networks revealed in lidar maps, Verschoof-van der Vaart realized the tracks harbor secrets about how people once navigated the terrain.

Archaeologists interested in mapping movement must shift their attention from tangible artifacts to subtler alterations of the land. It's rare to find an important artifact along hollow roads, Verschoof-van der Vaart says. "Maybe in some lucky case you find something that was lost along the road, maybe a coin or a belt buckle or … part of a wagon. But it's not like excavating a settlement where you find lots of stuff. So these roads themselves are not that interesting, but the story they tell … is very interesting."

And for Indigenous people who trace their roots to northwestern British Columbia, the routes and journeys are as valuable as any artifact. Twice during my visit, I listen to Mike Ridsdale, a member of the Wet'suwet'en Tsayu, or Beaver, Clan, tell a story about his ancestors' journey along the Kweese War Trail.

Kweese was a hereditary chief when the Kitimat people killed his family centuries ago, says Ridsdale, who is also a retired biologist for the Wet'suwet'en Nation. So Kweese hosted a large feast, where he invited members across the Wet'suwet'en's five clans to help fight the Kitimat. The warriors prepared for a year before heading out to the Kitimat people's coastal village. They traveled along what would become the Kweese War Trail but was then a grease trail like the Babine.

The battle was fierce, but the Wet'suwet'en people prevailed and took the Kitimat people's crests, including a killer whale, as spoils of war. On the return journey along the trail, though, many injured Wet'suwet'en soldiers died. With no way to carry them home, those soldiers were left where they fell. The old grease trail became sacred ground.

"This is why the Trail is so important to the Wet'suwet'en, the ancestors who fought for our freedom, the very Crests that we wear on our backs, the story's linkage through the actual trail that you can see. This is what it means to be Wet'suwet'en," Ridsdale recounts in the 2023 paper in *American Anthropologist*, which he coauthored. "If you destroy the trail, you will destroy our history."

Legal weight

Thanks to a landmark Canadian Supreme Court decision known as Delgamuukw v. British Columbia, those stories should, in theory, hold as much weight as artifacts and colonial maps in the country's judicial system. That legal battle began in 1984 when the plaintiffs, the hereditary chiefs of the Gitxsan and Wet'suwet'en nations, claimed sovereignty over 58,000 square kilometers of land in British Columbia based on their oral histories.

Indigenous land rights have long been a point of contention in Canada. Since the 1600s, colonial and then national leaders sought to claim Indigenous lands through treaties and promises of payment. Such negotiations rarely occurred in British Columbia, and most First Nations have not ceded their land there. That makes the province the focal point for contemporary land-claim battles.

Oral stories passed down through generations often trace the people's presence on the land back to time immemorial. The hereditary chiefs in the Delgamuukw case argued that those stories, coupled with the relative dearth of government treaties, proved their people's sovereignty over the disputed lands.

But the courts repeatedly questioned that territorial claim, arguing instead that Indigenous stories constituted hearsay or myth. In 1997, the case wound up before Canada's Supreme Court, where justices unanimously ruled that oral stories were, in fact, history. "Oral histories," the judges ruled, "can be accommodated and placed on an equal footing with the other types of historical evidence that the courts are familiar with."

But the judges stopped short of granting the Gitxsan and

Wet'suwet'en nations title to that 58,000-square-kilometer expanse. Representatives for those nations walked away from settlement conversations when provincial authorities offered the title to a tiny percentage of the disputed land. With that process stalled, the British Columbia government can still claim ownership.

Since then, economic development has tended to trump Indigenous land claims. Such development began accelerating in Canada in the mid-2000s with the rise of hydraulic fracturing, or fracking, in which liquids are injected underground at high pressure to crack the rock and extract otherwise inaccessible oil and natural gas (SN: 9/8/12, *p.* 20). With the government's backing, developers soon began exploring northwestern British Columbia.

The courts still do not give Indigenous stories equal footing with other forms of evidence, Armstrong and others say. So Indigenous people have turned to lidar and landscape-level mapping to prove to a Western audience that their stories are true and the lands they reference merit saving.

Armstrong's training session in the Wet'suwet'en Nation teaches students not just how to recognize modified trees, but also how to speak the language of the courts. Document everything with geographic coordinates, she frequently notes. "Take a point, take a picture."

Among the equipment Armstrong shows the students is a minimally invasive corer that can be inserted into a tree trunk and carefully removed to measure tree rings. On culturally modified trees, the trunk grows around old adze wounds like a pair of protuberant earlobes. The age of the cultural modification can thus be calculated by coring the entire trunk and an earlobe. "Courts can handle dates. They love them," Armstrong explains. "The idea of validating is powerful in Western courts."

But unless the provincial government changes cultural resource management policies, such landscape-level analyses are unlikely to become the norm, says Rick Budhwa, an applied anthropologist and founder of Crossroads Cultural Resource Management in Smithers, British Columbia. "Someone has to pay these archaeologists. Why would that developer … ever pay to go and do all of this work?"

Boots on the ground

On my second day in Wet'suwet'en territory, I meet Ridsdale and the students from the training session at Gidimt'en Checkpoint, an assemblage of log cabins, a fire pit and a makeshift kitchen that, when I arrive, is warm from a fire burning in a woodstove. Though quiet now, Gidimt'en served as the headquarters for protests against the Coastal GasLink pipeline, a $14.5 billion project that has been on the books since 2012. When operational, the pipeline will carry natural gas 670 kilometers from northeastern British Columbia to a liquefaction facility in Kitimat.

On paper, it can appear as though Indigenous leaders in the area largely support fossil fuel development. Housed within Wet'suwet'en ancestral lands are six small parcels of land that the government reserved for Indigenous people with the Indian Act of 1876. British Columbia officials established band leaders to head each reserve, a leadership system that remains in place today. Five of the six band leaders OK'd the Coastal GasLink project.

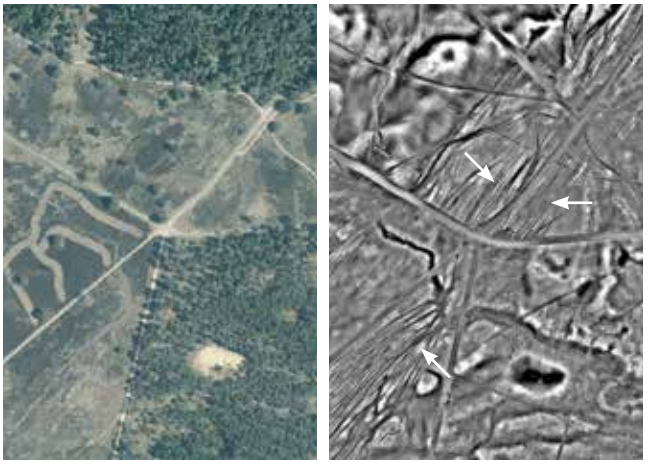
But the Indian Act is a legacy of colonialism, and many Wet'suwet'en people still view hereditary chiefs, not band leaders, as the legitimate leaders of the land and its people, Ridsdale says. Coastal GasLink developers did not garner support from most chiefs, who argued that the pipeline and its construction would wreak havoc on the area's waterways, thereby threatening salmon and steelhead populations, as well as displace land animals, including endangered caribou. The pipeline would also slice up the sacred Kweese War Trail.

Ridsdale had been informally mapping the Kweese trail for years. But as the threat of natural gas pipelines ramped up, he knew he needed to communicate his findings more broadly and began collaborating with Armstrong. "We realized that we have got to document a lot of trails, especially the Kweese War Trail," he tells me. But Ridsdale, Armstrong and the rest of the team abandoned their efforts to mark the Kweese after pipeline construction began in 2019.

Coastal GasLink developers maintain that their assessment found "no evidence of this trail," but, according to their website, they "nonetheless worked diligently to protect the areas identified on the maps provided, including the careful and planned avoidance of the specific areas of concern." Coastal GasLink representatives did not respond to requests for comment.

Protests against the pipeline began shortly before Coastal GasLink broke ground. In February 2020, protestors blockaded the tracks of a major transcontinental Canadian National Railway line, forcing its temporary closure. The fight against Coastal GasLink morphed into a battle for cultural and climate justice, with protestors questioning more oil and gas development in the face of catastrophic global warming. Some people here say protestors might have succeeded in halting the pipeline were it not for the onset of the pandemic, which prevented people from

In the Netherlands, sunken "hollow" roads from the Middle Ages are difficult to see in the landscape (left). But a lidar map (right) reveals faint lines that are old hollow roads (arrows point to some examples). Lidar is also helping researchers map the Babine Trail.



W. VERSCHOOF-VAN DER VAART

gathering in protest while construction proceeded.

From Gidimt'en, Ridsdale is leading the students to the Kweese trail — a pilgrimage to bear witness to what once was and what has now been lost. On the long drive to the trail's access point, neon yellow Coastal GasLink signs caution that we are in the area of a "high pressure natural gas pipeline." Logs left behind as the old logging road was widened and then extended to accommodate an influx of construction flank the roadside, along with culverts, water pooling where they have backed up. As we near a section of the trail, a sign warns against traveling in convoys greater than three vehicles. Our convoy is seven SUVs and pickups long.

"They can't tell us what to do on our own territory," Ridsdale mutters. After an hour or so, we leave the vehicles behind and continue on foot, scrambling over wide trenches dug into the now shuttered road. Ridsdale wanders around where he knows the trail ought to be. "When they built all of this, I lost my bearings," he says. He finally locates the trail. The road has cleaved the Kweese in two.

Speaking the language of Western science

In his second century book *Geography*, Greek cartographer Claudius Ptolemaeus, better known today as Ptolemy, used latitude and longitude lines to partition the world into a grid. Ptolemy's idea of gridded space might well have languished in obscurity were it not for a 15th century translation of the book from Greek to Latin.

That translation paved the way for the Western world's separation of space from place, ethnobiologist Leslie Main Johnson wrote in her 2010 book, *Trail of Story, Traveller's Path*. Land became an abstraction, a canvas that European rulers could carve up for exploration, development and settlement, and on which they could fight wars over arbitrary boundaries.

Today's grid-based maps bear little resemblance to maps drawn by Indigenous people. For instance, in their maps, Northern Ontario's Cree people marked rapids and portages, as well as secondary streams that allowed travelers to circumvent dangerous waters. Cree mappers omitted prominent landscape features that had no bearing on the designated travel route.

The Babine Trail runs through the Gitxsan people's ancestral lands. Charlie Wright (left), a hereditary chief, and Aspin'm nax'nox Ira Good stand in front of a culturally modified tree on the trail.

Yet Ptolemy's grids underpin the field of archaeology. "Archaeology itself as a discipline is a Western concept," says Aviva Rathbone, an archaeological consultant in Vancouver.

And that mind-set extends to the geospatial tools that commercial archaeologists use to estimate cultural value, says Supernant, the Métis archaeologist at the University of Alberta. The initial analysis is typically done using a Geographic Information System, or GIS, a computer system that captures, stores and displays data about a given geographic location. GIS software can help cultural resource managers identify various landforms and resources that correlate with past human activity to estimate a site's archaeological potential.

When that software flags an area as moderate to high in potential value, archaeologists often investigate on foot to determine if mitigation is required. Where models predict low potential, development can typically proceed without boots on the ground — even when Indigenous community members challenge those findings.

In their computer assessment, archaeologists hired by the developers of the Prince Rupert pipeline labeled more than 85 percent of Gitxsan territory — including most of Madii Lii — as low in archaeological potential. Given that designation, it's not clear if anyone representing the developers will walk the Babine to ground-truth those findings, Armstrong says. But she disputes that assessment, arguing that another appraisal of the region from the 1990s revealed rich potential. Stantec, the cultural resource management company hired by Prince Rupert developers, did not respond to requests for comment.

Johnson, now retired, notes that lidar maps' more expansive view better reflects Indigenous world views and can empower Indigenous communities to dispute archaeological assessments conducted on their lands.

But such tools can also disempower Indigenous people by forcing them to converse in a foreign spatial language. "The widespread adoption of GIS and Western mapping conventions by Canadian Indigenous people can be seen as the result of a power imbalance and the people's need to present their knowledges in a language and form that can be understood and accommodated by governments and industry," Johnson wrote in her book.

Some of that imbalance might be playing out back in Madii Lii. After a kilometer or so of fighting through the brush, the crew marking the Babine Trail reaches the confluence of two streams, which run fast and cold this time of year. Soil samples taken from a depression in the earth come out deep and dark. Good suspects we might have found the site of an old cabin his grandmother, Tillie Sampare, used to talk about.

Sampare figures large in Good family lore. Family members recall how Sampare would reminisce about walking this trail as a little girl with her grandparents, her *na'a* and *ba'a*. Sampare knew

where to find the best berries and how to hide them for later. She once walked the trail for seven days, stopping frequently so that her grandparents could wrap her aching feet in deer or moose leather. When government agents started sending kids to residential schools, Sampare's family hid her at Madii Lii. That enabled the family to hold onto their connection to the land, language and culture a little bit longer.

Like many Indigenous people, Good now struggles to speak the language. And he must travel here from Prince George, some five hours away, where he works as a trucker. But he's still bonded with this land. He has spent the last few years driving his all-terrain vehicle, chainsaw in hand, clearing the Babine. By this point, he figures he's cleared about 10 kilometers. Good scrolls through pictures on his cell phone before pausing on one shot. A moose carcass lays across his lap, his shirt crimson with blood from the recent kill.

Volunteers mark trees along the Babine Trail that have telltale signs of human modification, such as gouge marks or missing patches of bark.

Connecting the trail where the chopper has deposited us to the part he's cleared, a distance of some 15 kilometers, would take another three years, Good speculates, likely more. He almost certainly doesn't have that much time; the Prince Rupert Gas pipeline would overlap roughly half of the 80-kilometer trail, including the part Good has been trying to clear.

The fight is not as simple as Indigenous people versus the province. Earlier this year, TC Energy, the umbrella company for both Coastal GasLink and the Prince Rupert pipeline, sold rights to the latter pipeline and its export gas facility, now known as Ksi Lisims LNG, to Western LNG and the Nisga'a Nation. "You've got an Indigenous group essentially pushing pipelines through other Indigenous groups' territories," says Budhwa, who is Indigenous and a formally adopted member of the Wet'suwet'en people's Gitdumden, or Wolf/Bear, Clan.

Though Western LNG and Nisga'a Nation representatives could not be reached for comment, a joint August press release notes that construction on the portion of the project located on Nisga'a land has begun. To prevent the permits from expiring, the developers' imminent construction plans include clearing land for roads and a right-of-way, installing bridges and building a facility to house several hundred workers.

Scorched earth

On my last day in British Columbia, I hike up an access road to a waterfall located between Wet'suwet'en and Gitxsan nations, armed with a can of bear spray and a 130-decibel horn that purportedly can scare a bear almost a kilometer away. Per locals' recommendations, I dutifully clap my hands around blind turns to announce my presence.

A sign up the road, where a nearby tree displays the gouge of an adze, cautions: "Mountain goats can be adversely affected by humans (e.g. hikers, loud noises, vehicles, etc.)… When mountain goats are present, please… move slowly and quietly."

In this rugged landscape, it can be hard to ignore a sense of foreboding. As efforts ramp up to save the Babine Trail, the existing landscape is facing interconnected challenges. Last year, wildfires scorched a record-high area of land in British Columbia, nearly 3 million hectares. Climate change is the main culprit behind an uptick in wildfires here since 2005, research shows. But clearing land for mining and other extractive activities is also increasing the fire risk.

Curtailing global greenhouse gas emissions by ending our reliance on fossil fuels is one solution to curbing climate change's threats, here and elsewhere. Current global energy needs can be met through existing pipelines, argued the authors of a policy paper published in May in *Science*. Committed groups of people can help block new projects by facilitating "mass social movements that pressure governments to ban them," the authors wrote.

An outpouring of support, however slim the possibility, would buoy those working to save Madii Lii. Protesters failed to protect the Kweese trail, but they came closer to halting the pipeline than anyone expected. What if things play out differently for the Babine?

With construction in this area seemingly near, Good has come into the brush with a last-ditch plan. He has brought the modern and very Western tools of public relations: a drone equipped with a video camera. He's also radioed members of his family to join us. By the time they chopper in and find our crew in the thicket, the small entourage is exhausted from hauling garbage bags bulging with drums and heavy regalia — cloaks embroidered with the clan crest, a flying frog. Three-year-old Ax K'ets Gianna Starr, whose dad carried her atop his shoulders, is in tears from her bevy of scratches.

Using the potential site of Sampare's old cabin as a backdrop, Good gets everyone in position and launches the drone, which zooms in as a family member sings and drums. Good's careful vision doesn't quite materialize. The drone is too loud and drowns out the ceremony. But Good remains optimistic the video can convince people this land is worth saving: "It will be pretty powerful to have this right here, right now." ■

Explore more

- Chelsey Geralda Armstrong *et al*. "Liberating trails and travel routes in Gitxsan and Wet'suwet'en territories from the tyrannies of heritage resource management regimes." *American Anthropologist*. June 2023.

Uncovering Dinosaur Behavior
David Hone
PRINCETON UNIV., $29.95

BOOKSHELF

Unearthing biases in dinosaur research

In 1971, paleontologists stumbled upon the remains of an 80-million-year-old battle in the sandstones of Mongolia's Gobi Desert. Dubbed the "Fighting Dinosaurs," the fossilized scene shows a carnivorous *Velociraptor* locked in a deadly embrace with an herbivorous *Protoceratops*. The turkey-sized predator had embedded its famed foot claw into its combatant's neck. The downed plant eater had chomped onto and broken its attacker's arm.

For some researchers, the remains all but confirmed that *Protoceratops* served as regular prey for *Velociraptor*. Paleontologist David Hone, though, isn't entirely convinced. The preserved clash may reflect an abnormal situation rather than the typical dining habits of *Velociraptor*.

In his latest book, *Uncovering Dinosaur Behavior: What They Did and How We Know*, Hone warns against using individual fossils to make overarching claims about how dinosaurs behaved. "Specimens are, of course, single data points," he writes, and should not be used to infer too much about a species.

The book starts strong with a straightforward and cautious introduction to dinosaur biology and behavior, and how biases affect our understanding of them. Hone forgoes the touches of personal narrative that make other dino digests by contemporaries Steve Brusatte and Michael J. Benton so accessible. Instead, Hone thrusts readers into a rigorous overview of the latest research, most of which he tempers with disclaimers. Such reality checks would sour most reads. But Hone's frankness is welcome in a post-*Jurassic Park* world, where misconceptions continue to capture the public's imagination.

> A fossil "ultimately represents the moment that an animal was buried, and not usually when it died."
> **DAVID HONE**

Some of the biases that shape our perception of dinosaurs come from paleontologists themselves. "New or rare species are more likely to be collected and described than well-known ones," Hone writes. Paleontologists also tend to collect and publish more on specimens related to the rise of birds or those with unique features, leaving other dinosaur groups understudied.

But some misconceptions are born long before a fossil even forms. Floods and rivers can carry carcasses miles away from where an animal died, misrepresenting where that species lived. Scavengers might take their meal to go, displacing, damaging or preventing an animal's body from being buried. Acids and bacteria in rainforest soil often decompose corpses before they can be preserved, leading to gaps in the fossil record. "A [body] fossil only represents a moment in time," Hone writes. "It ultimately represents the moment that an animal was buried, and not usually when it died."

Certain behaviors are also better preserved than others. Take foraging. Teeth marks on the intact arm bone of a duck-billed dinosaur suggest that *Tyrannosaurus rex* probably stripped meat from the bone rather than chomping straight through. Tooth wear can help reveal whether sauropods such as *Diplodocus* preferred snacking on tall trees or low-lying foliage.

But the chances of a dinosaur being buried and, in turn, fossilized during a brief act such as mating are slim to none. This is where scientists can turn to creative tactics, such as inferring behavior from the last surviving dinosaurs—birds—and their closest relatives, crocodilians. For example, in 2021, scientists used an exceptionally preserved specimen of the herbivore *Psittacosaurus* to three-dimensionally reconstruct the dinosaur's cloaca. Like today's birds and reptiles, dinos used this all-purpose orifice to urinate, defecate and reproduce. The study revealed the cloaca had swellings that may have been similar to the musk glands of today's crocs, suggesting scent may have been one way *Psittacosaurus* communicated.

Hone ends most chapters with case studies on some of the most misrepresented dinosaurs to date. Enter the predator *Deinonychus*, the inspiration for the cunning *Velociraptor* dinos of Michael Crichton's book *Jurassic Park* (though *Deinonychus* itself is not a *Velociraptor*). In the 1960s, scientists unearthed four partial *Deinonychus* skeletons surrounding a single unlucky herbivore known as *Tenontosaurus*.

Researchers used this finding to propose that *Deinonychus* and most of its dromaeosaur relatives hunted cooperatively. This idea "has sunk into public consciousness," becoming a common trope in popular media, Hone writes. But evidence for such pack hunting in *Deinonychus* is "extremely limited," he notes. For one, it's possible the *Tenontosaurus* had been scavenged rather than killed. What's more, most *Tenontosaurus* skeletons found near *Deinonychus* at other sites were half-grown, a more manageable snack for a lone predator. And some research suggests that this famous crime scene depicts multiple *Deinonychus* fighting over the carcass, not a coordinated attack.

Though *Uncovering Dinosaur Behavior* succeeds in presenting the latest research, many relevant findings never make it through Hone's fine-tooth comb. Hone's diligence and caution risk leaving readers with surprisingly little insight into how these iconic beasts actually lived. That, of course, is the point. This book offers an expert's thoughts on staying the course against biases, a feat many readers will find rewarding.

Vigilant and authoritative, Hone sounds the alarm on the at times impulsive and rash nature of paleontology. "Much of the scientific literature tends toward a confidence in interpreting dinosaurian behaviors that probably should not be there," he writes. "A failure to recognize alternate possibilities and the inherent uncertainty of interpreting ancient behaviors is a detriment to the field." —*Aaron Tremper*

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Stephen Beall is a science teacher at City High School in Tucson, Ariz. He participates in Society for Science's Advocate Program, which provides educators in the United States with resources for teaching scientific research and guiding students to enter science competitions. Advocates receive a $3,000 stipend and an all-expenses-paid trip to attend the Advocate Training Institute in Washington, D.C.

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Icy moves

Stonehenge's central stone, known as the Altar Stone, may have had Scottish and not Welsh origins, researchers say. The finding suggests that Late Neolithic groups had long-distance connections, ***Bruce Bower*** *reported in "Stonehenge's roots extend to Scotland" (*SN: 9/7/24 & 9/21/24, p. 10*).*

Reader **Ralph Bradburd** wondered if a glacier, not humans, could have at least partly transported the Altar Stone from Scotland to southern England, where Stonehenge is located.

That scenario is worth considering but is unlikely, says geoscientist **Anthony Clarke** of Curtin University in Perth, Australia. Ice sheet reconstructions show that glaciers moved northward from the Grampian Mountains in central Scotland toward the Orcadian Basin in the northeast, where the Altar Stone is thought to have come from, he says. So glacial movement up there would not have brought the Altar Stone south to Stonehenge.

What's more, there is little evidence of rocks deposited by glaciers, known as glacial erratics, in central southern Britain, **Clarke** says. And specifically, erratics from Scotland have not been found near Stonehenge.

Up in the air

Cloud-forming aerosols may be forged during stratospheric air intrusion events, in which Earth's jet streams cause stratospheric air to dip into the underlying troposphere, ***Carolyn Gramling*** *reported in "Earth's jet streams sow cloud seeds" (*SN: 9/7/24 & 9/21/24, p. 12*).*

Reader **James W. Benefiel** asked whether it's more likely for clouds to form when water vapor in the upper troposphere condenses on particles.

This is actually a known mechanism for the formation of cloud condensation nuclei, the tiny particles that water droplets condense onto and which are the genesis of clouds, **Gramling** says. Such particles can form where convective clouds, such as thunderstorm clouds, carry gases or tiny particles from Earth's surface high into the atmosphere, where water vapor can condense onto them.

What this new study suggests is an entirely different chemical process for cloud formation, which involves ozone from the stratosphere, **Gramling** says. Stratospheric air intrusion events were already a known phenomenon. Now researchers have linked such events to a bump in the formation of cloud condensation nuclei. The scientists propose that the mixing of stratospheric ozone with tropospheric moisture, catalyzed by sunlight, may increase the production of free hydroxyl radicals, which can react with other molecules to create the cloud-forming particles.

Given the frequency of stratospheric air intrusion events, this mechanism may be a significant source of cloud nuclei, **Gramling** says. But just how much is still unknown.

Friend or foe?

A chemical analysis suggests that the asteroid that killed the dinosaurs came from beyond Jupiter, ***Carolyn Gramling*** *reported in "Dinosaur killer's origin revealed" (*SN: 9/7/24 & 9/21/24, p. 7*).*

The story sparked a lively discussion on Reddit about whether Jupiter shields Earth from asteroid and comet collisions.

Reddit user **DonManuel** wrote that Jupiter's failure to protect Earth from the dino-killer shows "how important the protection of Jupiter really is for life on Earth." But user **Astromike23** wrote that the idea that Jupiter shields Earth from impacts is a myth.

Indeed, Jupiter's role as a planetary protector is not so clear-cut. The planet's immense gravitational pull can influence the orbits of nearby objects, which could be a double-edged sword for Earth.

Some studies suggest Jupiter may defend Earth and neighboring planets from impacts by pulling passing asteroids and comets toward itself or flinging them out of the solar system entirely. But other research suggests Jupiter can also slingshot asteroids and comets into the inner solar system and set up a collision course with Earth or its neighbors. Jupiter may even attract objects that wouldn't normally pass Earth, increasing the likelihood for collision.

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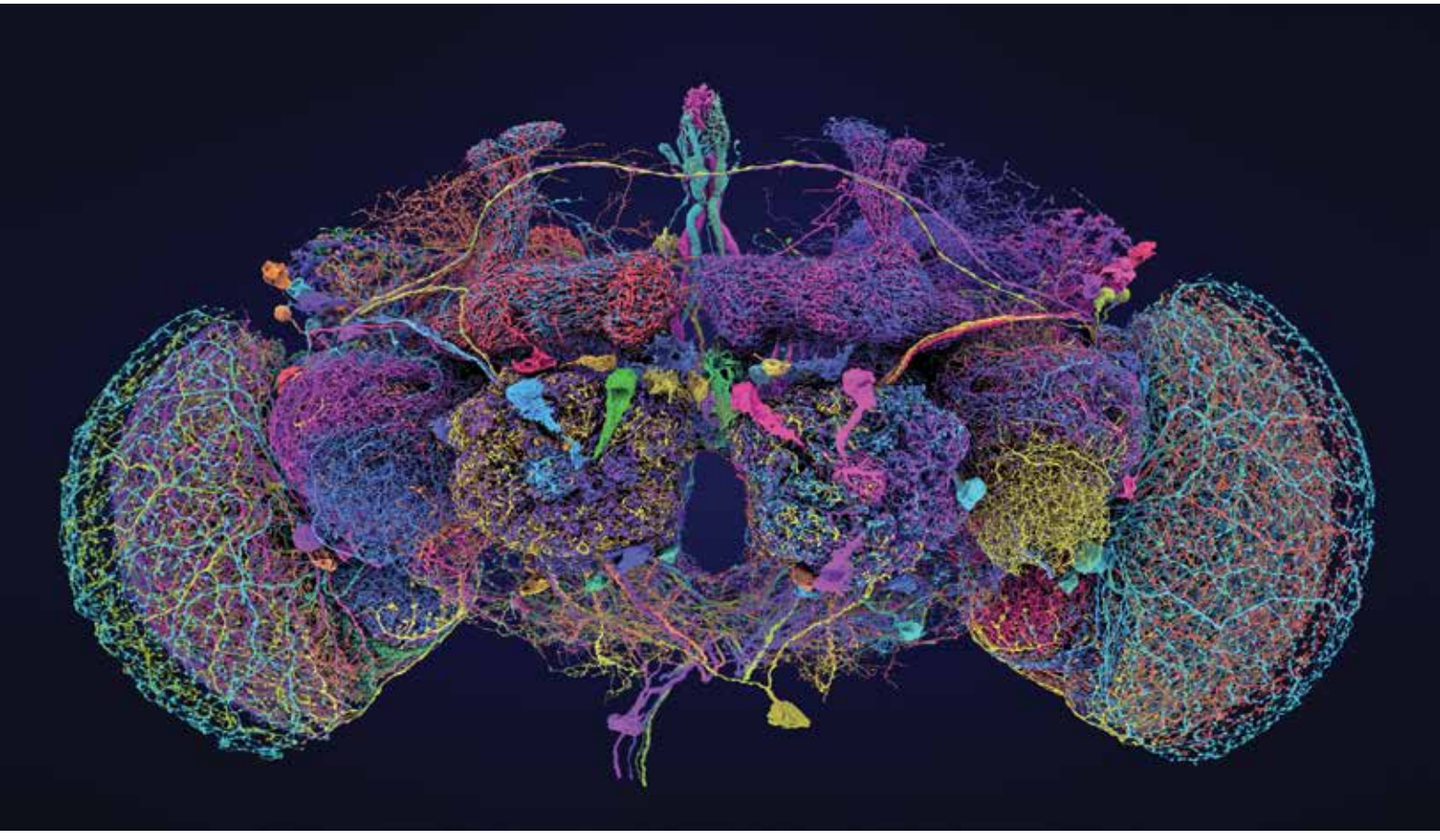

A fruit fly's brain, unveiled

In the brain of a single fruit fly, nerve cells weave together, enabling flying, mating, eating, sleeping and every other activity of its life. In nine papers published in the Oct. 3 *Nature*, scientists report the first complete map of the nerve cells in its brain — all 139,255 of them — and their 54.5 million connections.

This whole-brain map, traced over years with painstaking precision, is tiny but exquisite: It holds nearly 150 meters of neural wiring, all packed into a brain about the size of a poppy seed. The map shows how neural information might flow among cells in *Drosophila melanogaster*, an animal that's simpler than a human but complex enough to remain mysterious to people trying to understand its brain.

"This work is absolutely fascinating," says neuroscientist Olaf Sporns of Indiana University Bloomington. In 2005, he and colleagues coined the term "connectome," an accounting of the connections between neurons. Scientists have since mapped several connectomes, including those of a larval fruit fly's brain, a small bit of a human brain and part of an adult fruit fly's brain (SN: 4/22/23, *p.* 32; SN: 6/15/24, *p.* 32).

This latest connectome is the biggest of its sort. The project involved electron microscopy images of more than 7,000 slices of a female fruit fly's brain and machine learning that aligned the complex tendrils of neurons, tracing cells through different slices. Hundreds of people from more than 50 labs proofread the map. The visualization above shows the 50 largest neurons in the fly's brain, differentiated by color.

Already the data are revealing juicy hints about how brains work. For instance, there are two neurons involved with sensing changes in light and motion. Each one stretches across an entire eye and makes more than 148,000 cellular contacts, the map shows. The massive connectivity gives hints about how brains gather and respond to visual information.

Another analysis sorted some neurons into "integrators," which receive many messages from other cells, or "broadcasters," which send signals to a large audience. These megaphone cells might help signals spread, but in selective ways.

With the connectome mapped, scientists have already begun to build computer models of how information flows in the fruit fly brain. One of the new studies, for instance, shows how taste neurons can activate other downstream cells.

"Connectome maps will become even more comprehensive and detailed, soon to include brains of vertebrates like mouse and human," Sporns says. Those maps, he says, will help answer big questions about the brain — whether connectomes are variable among individuals, if they change over time and whether they can help predict behavior. — *Laura Sanders*

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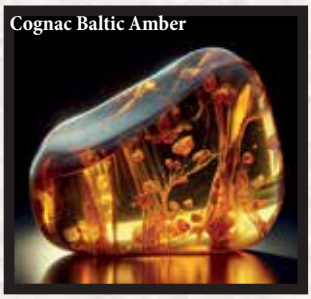

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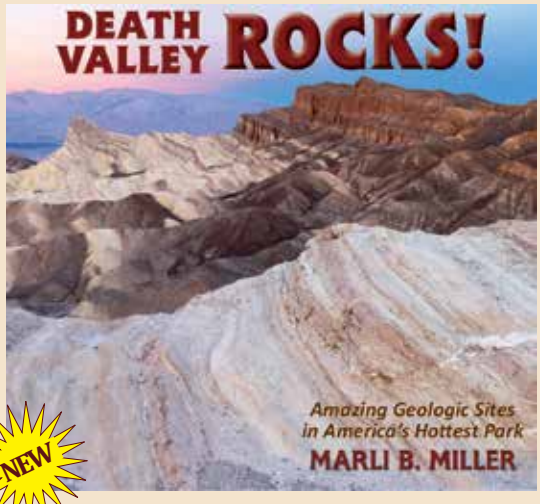

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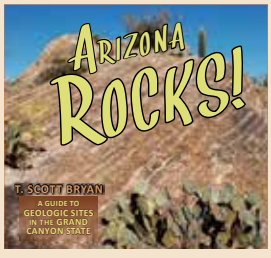

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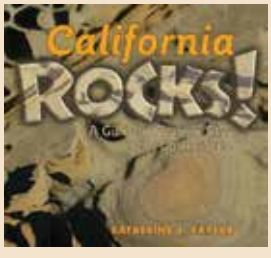

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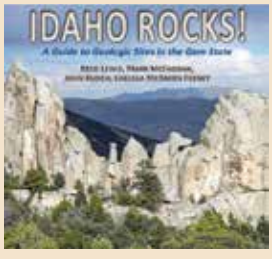

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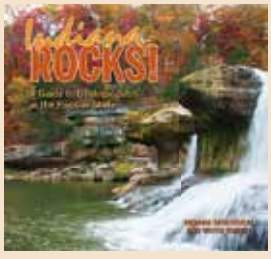

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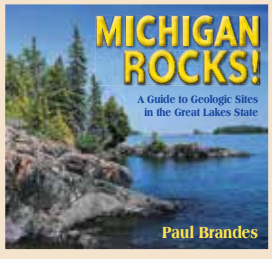

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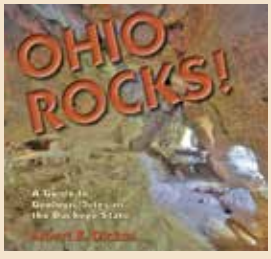

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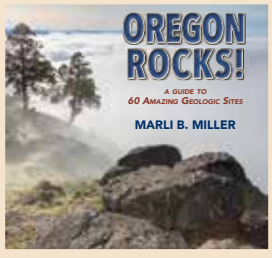

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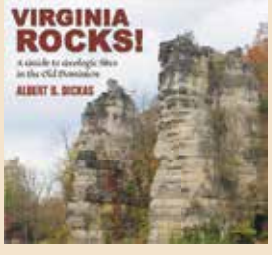

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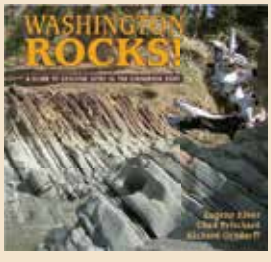

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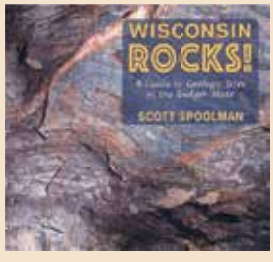

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