SPECIAL ISSUE The SN 10: Scientists to Watch

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ OCTOBER 8, 2022 & OCTOBER 22, 2022

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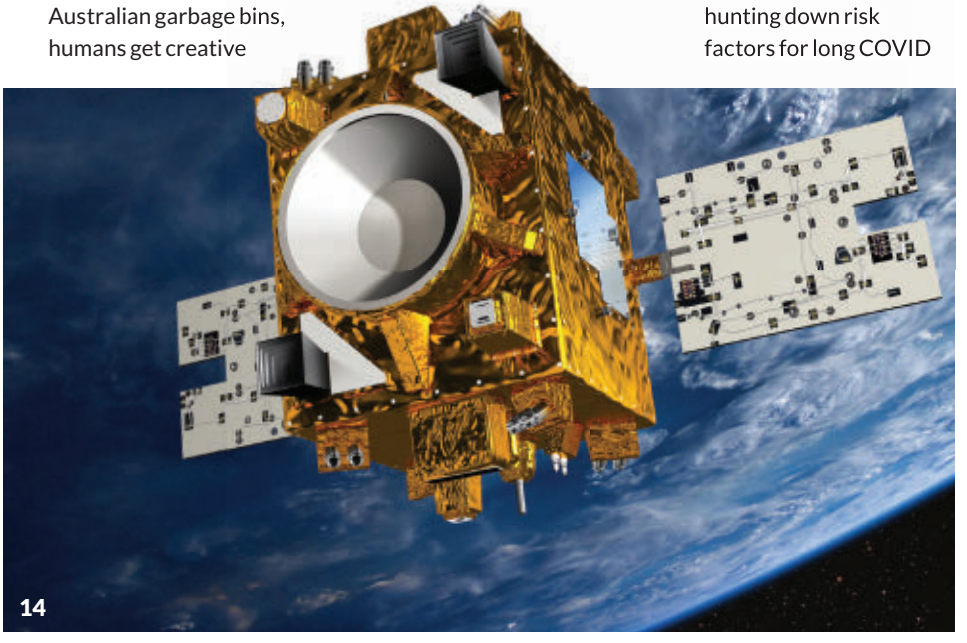
Features

News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Departments

COVER Fishers may look cute, but they can take down a quill-covered porcupine. These predators are part of a balanced ecosystem. *Emily Brouwer/NPS (CC BY 2.0)*

SN 10, CLOCKWISE FROM TOP LEFT: STANFORD UNIV.; BILL MENKE; M. SIMÕES-COSTA; ARIELLE DONESON; PETER GWIAZDA FOR MPI FÜR KOHLENFORSCHUNG; ELIZA GRINNELL/HARVARD SEAS; DENNIS WISE/UNIV. OF WASHINGTON; JUSTIN SHAIFER; BRYCE VICKMARK; COURTESY OF S. KARTHIKEYAN; NEWS: © CNES 2015; DEPARTMENTS: Y. LIU *ET AL/NATURE* 2022

Next-gen science as told by next-gen journalists

If you feel like you could use a boost of hope for the future, don't miss the "SN 10: Scientists to Watch" profiles in this issue (Page 26). For the seventh year, we're featuring early- and mid-career researchers who are racing to solve big problems and answer big questions. In doing so, they're creating a dazzling future for science.

Each year, I enjoy learning about the 10 scientists, marveling at how much they have already achieved and also how far they aim to go. And in a stroke of serendipity—and the good planning by our special projects editor Elizabeth Quill—the authors of this year's profiles are all early- to mid-career science journalists.

"Scientists are usually excited to share their work," said associate editor Cassie Martin, who wrote three of the profiles, when I asked about the experience of writing for SN 10. "What makes SN 10 so special is that we get to know these people on a deeper level. They pull back the curtain, letting us see what makes them tick."

Staff writer Nikk Ogasa had a similar reaction. "It's inspiring and fascinating to hear about someone following their passions for so many years." In the case of Robin Wordsworth, the planetary scientist at Harvard University who Ogasa profiled, his love of science fiction and dream of someday standing on another world has driven him to use supercomputers to replicate the climate of early Mars.

"I'm grateful for the trust the scientists give us to tell their stories," said Aina Abell, *Science News*' editorial assistant, who wrote three profiles. "That's why I feel an enormous sense of responsibility not only to represent their science accurately, but also give our readers a sense of their heart and their humanity: who they are, what drives them, how they perceive the world. It makes for really electric and inspiring conversations."

That comes through in her profile of biological anthropologist Tina Lasisi of the University of Southern California, who is applying scientific methodology to better understand human variation—including why some people, like herself, have curly hair.

Former *Science News* intern Anna Gibbs wrote a profile, as did Asa Stahl, a Ph.D. student in astrophysics at Rice University who was our AAAS Mass Media Fellow in the summer.

Ogasa was also an intern; in fact, many of our staff writers began their careers as interns at *Science News*. Each year, we host three interns and one Mass Media Fellow. We provide extensive mentoring to help these promising writers build skills, explore potential career paths and, of course, produce top-quality journalism. They bring us their energy, new ideas, curiosity and excitement about covering science, and we're lucky to have them with us.

Over the years, many of our interns and early-career journalists have gone on to be leaders in science journalism and science communications. I'm proud that we've been able to help these amazing young people on the way to achieving their career goals and know that the future of science journalism is in good hands. —*Nancy Shute, Editor in Chief*

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Excerpt from the October 14, 1972 issue of *Science News*

50 YEARS AGO

Oil on the waters

[In the late 1960s], about the best means of cleaning up oil was to put straw on it, then scoop up the oily straw by hand or with pitchforks. Now industry … has devised an arsenal of oil cleanup chemicals. Thin-layer chemicals can be used to herd oil together and to thicken it.... Chemicals are available as absorbents too. Still other chemicals … disperse oil throughout the water. Other chemicals show promise as oil-burning agents.

UPDATE: Chemicals are the norm today, but the future of oil-cleanup technology may well be microbial. In recent years, researchers have shown that soil microbes broke down some of the oil from the 2010 Deepwater Horizon spill in the Gulf of Mexico (*SN Online: 6/26/15*). And electrical bacteria, which channel electricity through their threadlike bodies, could help by turning oil munchers' waste into fuel for the microbes, scientists reported (*SN: 7/16/22 & 7/30/22, p. 24*). Microbial mops aren't yet ready for prime time, so chemical dispersants, fire and spongelike sorbents remain key tools in cleanup kits.

In Roman mythology, Hercules captures Cerberus, the three-headed dog that guards the underworld (shown in this 16th century German engraving). Such myths might shed light on dog domestication.

THE SCIENCE LIFE

How mythology could demystify dog domestication

In "Tom Edison's Shaggy Dog," a short story by Kurt Vonnegut, dogs are intellectually superior beings who found that endearing themselves to humans was the easiest way to survive. When Thomas Edison confronts his own dog about this revelation, the dog says, "Look, Mr. Edison. Why not keep quiet about this? It's been working out to everybody's satisfaction for hundreds of thousands of years. Let sleeping dogs lie."

It's true that humankind's close relationship with canines spans millennia. This long-term interspecies friendship is a topic of intense scientific study, though where, when and even why it began remains murky (*SN: 7/8/17 & 7/22/17, p. 20*). Short a talking dog, scientists have had to rely on archaeological and genetic clues. But the similarities between wolves and early domesticated dogs can make it challenging for researchers to tell them apart in the fossil record. In the earliest days, before wolves were fully domesticated, perhaps the most notable difference was simply the animals' involvement with people.

That's where storytelling can help, says historian Julien d'Huy of the Collège de France in Paris. Our penchant for mythologizing canines may be just as ancient as our relationship with them, so d'Huy is turning to these stories to help demystify dog domestication. "With mythology, we can have explanations of archaeology, we can have reasons for domestication, we can test hypotheses," he says.

D'Huy found three core story lines for the earliest known myths related to dogs: The first links dogs with the afterlife, the second relates to the union of humans and dogs and the third associates a dog with the star Sirius. Versions of these stories are found around the world. He then used statistical tools from biology to create family trees of myths, showing how the stories evolved as they followed humans across the globe.

Folktales about dogs stemmed from Central and East Asia and spread to Europe, the Americas, Australia and Africa, d'Huy reports in the June *Anthropozoologica*. The mythological travel route parallels a proposed path of dog domestication borne out by genetic and fossil evidence (*SN: 3/27/21, p. 12*).

"This was a surprise," d'Huy says. He wasn't sure if dogs and our mythologies about them would migrate together.

The prevalence of myths identifying dogs as guides to the afterlife hints that our ancestors domesticated wolves for spiritual or symbolic reasons, d'Huy argues. The hypothesis fits with archaeological finds, he says, such as a Stone Age grave in Germany containing a woman whose hand rested on a dog's head.

D'Huy is now tracing lore about other domesticated animals such as sheep. In the world of science, mythology has "something very precious to say," he says.

—Elyse DeFranco

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SCIENCE STATS

Earth's plants are power hungry

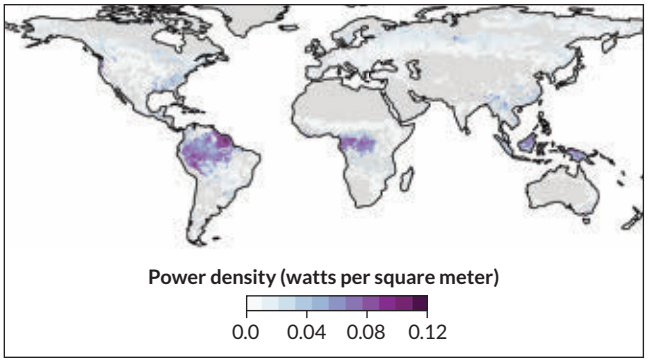
When it comes to hoisting sap, plants are real power lifters.

For a tall tree, slurping hundreds of liters of mineral-infused water each day up to its leaves or needles, where photosynthesis takes place, can be quite a haul. Even for grasses and shrubs, rising sap must somehow overcome gravity and resistance from plant tissues. Now, a first-of-its-kind study has estimated the power and energy needed to lift sap to plants' foliage globally.

Evaporation of water from foliage drives the sappy suction, says climatologist Gregory Quetin of the University of California, Santa Barbara. To estimate the total annual suction power for all plants on Earth (see map, right), he and colleagues divided up the world's land area into cells that span 0.5° of latitude by 0.5° of longitude and analyzed data for the mix of plants in each cell that were actively pumping sap each month.

Over the course of a year, the world's plants harness about 0.03 watts per square meter of sap-pumping power on average, the team reports August 17 in the *Journal of Geophysical Research: Biogeosciences*. Forests use the most power on average, 0.6 watts per square meter. That's about 9.4 quadrillion watt-hours of energy, or roughly 90 percent of the hydroelectric energy produced worldwide in 2019. —*Sid Perkins*

Annual power used by plants to suck up sap, by location



Plant power The world's plants use an average of 0.03 watts per square meter sucking up sap each year. Plants in tropical and temperate forests use the most power (purple regions on the map).

MYSTERY SOLVED

Why some hair can't be tamed

The flurry of frizzy-hair e-mails began in 2016. Researchers had just linked three genes to a rare disorder with eye-catching symptoms: silvery, spangly, spun glass hair that just will not lie flat. People with this uncombable hair syndrome can have dry, shiny strands that stand away from the scalp like a cloud of dandelion fluff. Only about 100 cases of the disorder, which often improves with age and isn't typically tied to health problems, had ever been reported.

After the study, which looked at 18 cases, people from all over reached out. "They said, 'Oh, I have a child like this' or 'Oh, I looked exactly like that as a child,'" says geneticist Buket Basmanav of University Hospital Bonn in Germany. The scientists asked these people to send blood and saliva samples.

Now, the team has analyzed the DNA of 107 people with uncombable hair syndrome. Variants of one gene accounted for 71 percent of cases, the researchers report August 31 in *JAMA Dermatology*. Mutations in this gene, called *PADI3*, can lead to grooved rather than the typical smooth hair shafts. The team also linked nearly 4 percent of cases to variants of the two other hair shaft genes ID'd in 2016. About a quarter of the new cases remain unexplained.

The work could help doctors diagnose the disorder, which might ease the minds of worried parents. —*Meghan Rosen*

Children with uncombable hair syndrome have dry, shiny hair that stands on end.

A skeleton (shown from the waist down) excavated on Borneo displays evidence of the oldest known surgical amputation, a lower left leg removal performed roughly 31,000 years ago.

THE -EST

Amputation dates to the Stone Age

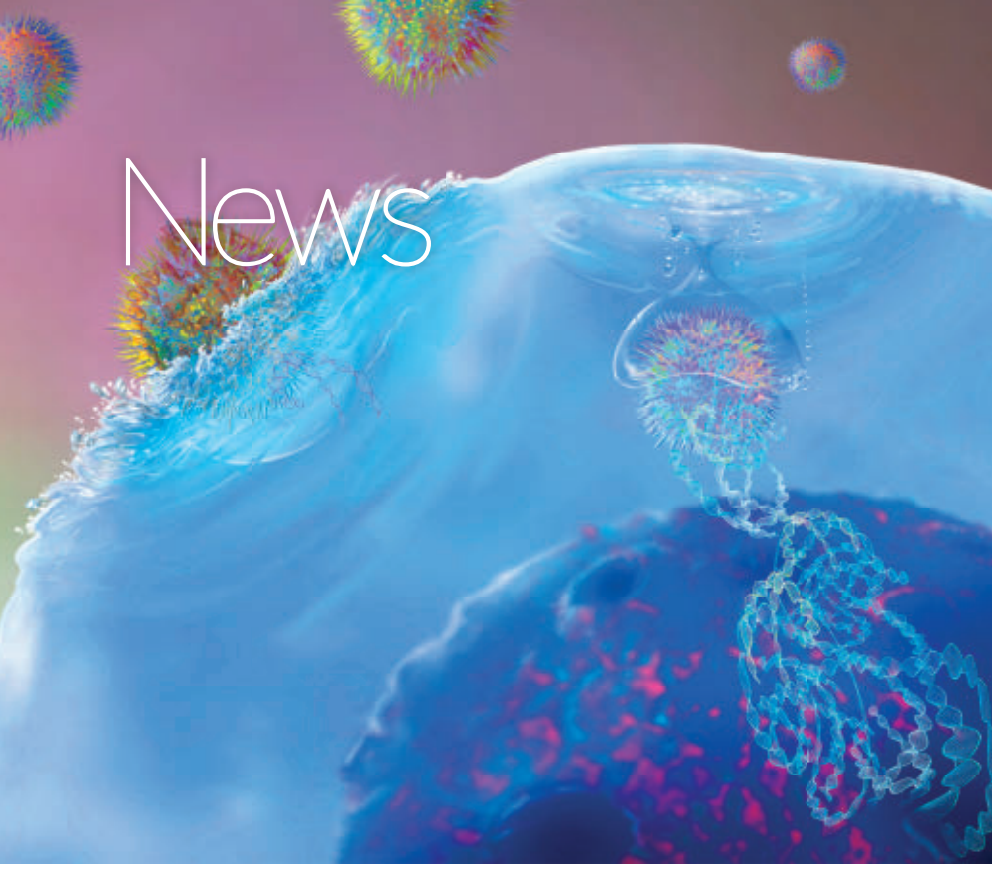
A child who lived on the Indonesian island of Borneo around 31,000 years ago underwent the oldest known surgical operation, an amputation of the lower left leg, scientists say.

One or more hunter-gatherers who performed the operation possessed detailed knowledge of human anatomy and technical skill. That enabled the youngster to avoid fatal blood loss and infection, say archaeologist Tim Maloney of Griffith University in Southport, Australia, and colleagues.

Healed bone at the amputation site indicates that the youth survived for at least six to nine years after surgery before dying at age 19 or 20, the team reports September 7 in *Nature*. The absence of bone crushing, which would have resulted from an accident or an animal's bite, suggests that a medical problem led to the limb's removal. It's unknown what tool was used in the Stone Age operation.

Maloney's team excavated the remains from a cave in 2020. Dating of a tooth as well as charcoal from under the grave let the team estimate when the surgery took place. The previous oldest known amputation, of a farmer's left forearm, occurred nearly 7,000 years ago in France. —*Bruce Bower*

FROM TOP: G.R. QUETIN *ET AL/JGR: BIOGEOSCIENCES* 2022; T.R. MALONEY *ET AL/NATURE* 2022; F.B. BASMANAV *ET AL/AM. J. OF HUMAN GENETICS* 2016



In CAR-T cell therapy, a patient's T cells (one illustrated in blue) are removed and genetically modified using viruses (spiky spheres). After the cells multiply in the lab, they are put back into the patient's body.

BODY & BRAIN

CAR-T cells send lupus into remission

Immune therapy helped 5 people with the autoimmune disease

BY ERIN GARCIA DE JESÚS

After receiving an experimental treatment to stop the body from attacking itself, five people no longer have any symptoms of lupus.

That treatment, called CAR-T cell therapy, seems to have reset the patients' immune systems, sending their autoimmune disease into remission without the need for any additional drugs, researchers report September 15 in *Nature Medicine*.

It's not yet clear how long the relief will last or whether the therapy, which involves genetically engineering a person's immune cells, will work for all patients.

Even so, the results could be "revolutionary," says immunologist Linrong Lu of the Shanghai Immune Therapy Institute at the Shanghai Jiao Tong University School of Medicine, who was not involved in the study. CAR-T cell therapy has been approved for some types of cancer, but it's still in testing for autoimmune diseases (SN: 2/26/22, p. 15).

It's unknown how many people globally have lupus, a painful disease in which some immune proteins called antibodies attack healthy tissue and organs. An estimated 161,000 to 322,000 people in the United States live with the most common form, called systemic lupus erythematosus. While there are effective therapies, those treatments don't work for everyone.

The five people in the study had this most common form with symptoms resistant to multiple commonly used lupus drugs, such as hydroxychloroquine. Laboratory studies in mice hinted that CAR-T cells might help.

So immunologist Georg Schett and colleagues took T cells from each patient and genetically modified the cells to track down and kill all antibody-producing cells. All five participants—four female and one male ages 18 to 24—were in remission three months after being treated with the altered cells.

The antibody-producing cells, called B cells, disappeared from blood samples as the CAR-T cells killed them off. But B cells are an important defense against infectious diseases, such as measles or mumps. Luckily, the immune cells weren't gone permanently, says Schett, of Friedrich-Alexander-Universität Erlangen-Nürnberg in Germany. A few months later, the patients' bone marrow had made more. The B cells were back; the lupus was not.

"Which means, in a way, that we have a reset of the immune system in these young individuals," Schett says.

> "We have a reset of the immune system in these young individuals."
>
> GEORG SCHETT

Typically, the immune system has checkpoints that eliminate cells that attack the body instead of a foreign invader. Autoimmune diseases such as lupus occur when these cells escape scrutiny. For lupus to come back, Schett says, the same mistake may need to happen twice. "So far we think the disease is gone."

To know for sure, the team needs more time to follow the participants. In August 2021, the researchers reported in the *New England Journal of Medicine* that the first treated participant, a 20-year-old woman, was in remission three months after receiving the drug. Now, she has been healthy for a year and a half, Schett says. The other four participants have been healthy for six months to a year. Time will tell how long these people will stay free of lupus.

Which lupus patients might benefit most from CAR-T cell therapy is not yet clear either. Lupus symptoms and severity vary from person to person. The treatment could, for instance, be most useful for patients who are in earlier stages of the disease before it becomes too severe, Lu says.

Still, if future clinical trials prove effective, CAR-T cell therapy could be another option for patients with the disease. ■

KEITH CHAMBERS/SCIENCE PHOTO LIBRARY/GETTY IMAGES PLUS

COVID-19 boosters take on omicron

Regulators are treating the updated shots more like flu vaccines

BY TINA HESMAN SAEY

Revamped COVID-19 vaccines have been unleashed on the super-contagious omicron variants. On September 1, U.S. health officials green-lighted the first major update of the mRNA-based shots, reformulated to recognize both the original version of SARS-CoV-2 and the recently circulating versions of omicron.

"They can help restore protection that has waned since previous vaccination and were designed to provide broader protection against newer variants," Rochelle Walensky, director of the U.S. Centers for Disease Control and Prevention, said in a statement after endorsing a vaccine advisory committee's approval of the shots.

Both Moderna and Pfizer and its German partner BioNTech created bivalent boosters, ones that contain instructions for making the BA.4 and BA.5 omicron subvariants' spike protein, which the virus uses to grab onto human cells, as well as the original virus' spike protein. Here's what you need to know about these new shots:

Who should get boosted and why?

The CDC recommends that all fully vaccinated people 12 and older get a bivalent booster shot — Pfizer's shot is approved for those over 12; Moderna's, for those over 18 — as long as it has been at least two months since the last vaccine dose.

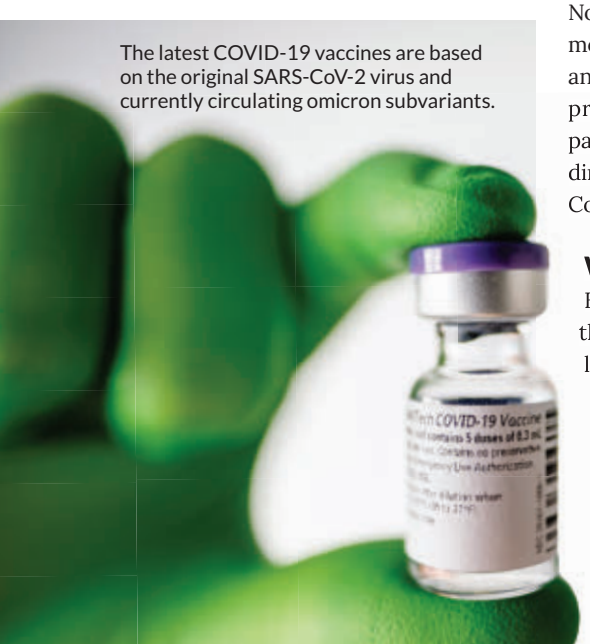
That recommendation comes regardless of how many boosters a person has already had. "We want to emphasize we're no longer looking at total number of doses," Evelyn Twentyman, who leads the CDC's vaccine policy unit, said when the vaccine advisory committee met September 1. The CDC hopes to transition to a more regular schedule for COVID-19 vaccines, such as annual shots.

The decision to move forward with boosters was made without data from human trials. Such trials are under way, but results won't be known until the end of the year. In authorizing the boosters without clinical trial data, officials are treating COVID-19 vaccines more like flu vaccines.

Evidence of the boosters' likely safety and effectiveness came from data collected from people immunized with a booster based on the original omicron BA.1 subvariant and data from studies of mice inoculated with the BA.4/5 vaccine.

Some CDC advisers said they would have been more comfortable having the clinical trial data before recommending the shots, but computer projections suggested a delay could be costly. The COVID-19 scenario modeling hub, a consortium of COVID-19 forecasters, considered what would happen if the boosters were given to adults in September versus not until November. Waiting would lead to 137,000 more hospitalizations in the United States and 9,700 more deaths, the researchers projected. An early fall booster campaign could save more than $62 billion in direct medical costs, an analysis from the Commonwealth Fund projects.

BIONTECH



The latest COVID-19 vaccines are based on the original SARS-CoV-2 virus and currently circulating omicron subvariants.

Why target BA.4 and BA.5?

BA.1, the omicron subvariant that caused the massive surge earlier this year, is no longer circulating in the United States. As of the week of September 11–17, BA.5 was estimated to cause about 85 percent of U.S. COVID-19 cases, with BA.4 responsible for 12 percent.

Omicron subvariants share common mutations. But the shape of BA.4/5's spike protein looks much different to the immune system, CDC immunologist Natalie Thornburg said at the meeting. Those differences may train immune cells to build a wider variety of antibodies that can target a broad array of variants.

Mice inoculated with a BA.4/5 booster had fewer viruses in their lungs than mice given a BA.1 booster, Jacqueline Miller of Moderna said. These engineered mice make a human version of ACE2, the protein on the surface of cells that the coronavirus uses to gain entry. And bivalent vaccines perform better — raising antibody levels higher in people and in lab animals — than ones that have just the original spike protein or only a variant spike protein, Miller said. The spike protein is a three-pronged claw. With the bivalent vaccine, each prong could be either an original or an omicron version. The mixed claw may expose parts of the spike to the immune system that are normally hidden, Miller suggested.

Are the boosters safe?

In studies of a BA.1 bivalent booster, the shot produced similar side effects as those of the original shots. Some data indicate that the chance of serious side effects, like heart inflammation, called myocarditis, with boosters is similar to or lower than with the second doses of the original mRNA vaccines. Myocarditis is also rare; the CDC has verified 131 cases out of over 123 million booster doses given, reported Tom Shimabukuro of the CDC COVID-19 Immunization Safety Unit. The rate of myocarditis is 1.8 to 5.6 times higher after a COVID-19 infection than after vaccination for 12- to 17-year-old males — the group at highest risk for the condition.

"We don't usually have too much clinical information … when we are thinking about changing influenza vaccines," said Sarah Long, an infectious diseases pediatrician at Drexel University College of Medicine in Philadelphia. Much like how the flu shot remodels last season's version, the updated COVID-19 booster is built on the same scaffolding as the original. "It's part of the same roof. We're just putting in some dormers and windows." ■

EARTH & ENVIRONMENT

Deadly eruption gave no warning

Volcano's magma was too close to the surface for usual signs

BY CAROLYN GRAMLING

Congo's Mount Nyiragongo suddenly burst into life on May 22, 2021, without the usual seismic warnings. The volcano spewed lava and smoke that threatened the nearby city of Goma.

ALEX MILES/AFP/GETTY IMAGES PLUS

On May 22, 2021, Congo's Mount Nyiragongo, one of the world's most dangerous volcanoes, burst to life without warning. Lava erupted from fissures and flowed down the mountain toward cities below, leaving hundreds of people dead or missing and hundreds more injured.

Using data from monitoring stations near the volcano, researchers have pieced together how that eruption happened so suddenly. The data suggest that the event could have been even deadlier. And importantly, they highlight the urgent need to better understand this volcano's particular hazards before the next eruption, volcanologist Delphine Smittarello and colleagues report in the Sept. 1 *Nature*.

"Nyiragongo is unique in that 1 million people are living just at the foot of the volcano," says Smittarello, of the European Center for Geodynamics and Seismology in Luxembourg. The mountain sits near the eastern border of Congo, looming over both the Congolese city of Goma and the Rwandan city of Gisenyi (SN: 12/13/14, *p.* 26). "There are so many people so close to a very dangerous place," she says.

Nyiragongo's last two eruptions, in 1977 and 2002, were both presaged by days of distinct seismic rumblings strong enough to be felt by people living nearby. But before the 2021 eruption, even the sensitive monitoring stations near the volcano seemed to detect no clear warning signs of magma on the move underground.

Smittarello and colleagues took another look at the monitoring stations' seismic and acoustic data. This time, the analysis identified a rumbling of small quakes that commenced just 40 minutes before the eruption. About 10 minutes before the eruption, acoustic signals—low-frequency "infrasound" waves—began to increase, a hint that the volcano was about to erupt.

The likely trigger for the eruption was a tiny rupture that formed in the volcanic cone due to the buildup of stress over time from the pressure and heat of the magma within, the researchers say. That would have been enough to allow the magma to push through.

The short lag time between the signals and the eruption was probably because that magma was already close to the surface, the researchers suggest. "What we monitor is the magma moving, not the presence or absence of magma," says Smittarello. Because the magma had very little distance to travel, there was very little warning.

The eruption lasted about six hours, but the seismic activity lasted another 10 days. Those data, monitored in real time, indicated something troubling—the magma was moving underground, away from the summit, snaking beneath the city of Goma and nearby Lake Kivu.

As the magma migrated, scientists and local citizens worked together to trace the formation of cracks in the ground, which can indicate propagating dikes, lateral pathways through which magma is moving beneath the surface. Similar lateral pathways formed during the 2018 eruption of Kilauea in Hawaii, Smittarello says. In that case, the magma migrated to a neighborhood along the volcano's lower east rift zone before erupting.

Based on the possible path of the magma, Goma city officials issued evacuation orders for tens of thousands of people who were potentially in the magma's path. Scientists anxiously watched for signs of a potential limnic eruption at Lake Kivu—a rare type of disaster in which a noxious cloud of dissolved gases suddenly erupts from deep lakes, suffocating living creatures nearby. Gas-rich magma seeping into the lake's bottom could have triggered such an eruption. In either case, "if [the magma] finds a path to the surface, it's a catastrophe," Smittarello says.

Neither catastrophe occurred. "It was a lucky situation," Smittarello says. "But we don't know why." It was especially lucky given that the magma was closer to the surface than thought at the time.

By reanalyzing posteruptive seismic data, the team determined the position of the underground dikes. One dike beneath Goma was as shallow as 450 meters deep. Such a shallow magma channel would be expected to emit a telltale cocktail of volcanic gases from the ground cracks.

It's not unheard-of for volcanic dikes to give no gassy indicators of their presence, says geophysicist Michael Poland of the U.S. Geological Survey, who is based in Vancouver, Wash., and leads the Yellowstone Volcano Observatory. The magma may have lost gases as it circulated up into the large lake of lava in the volcano's summit crater. By the time the magma pushed into underground channels, it was potentially already degassed.

That scenario is worrisome because then there's one fewer warning signal to the communities above, Poland says. It also raises questions—such as how gas-poor magma might interact with Lake Kivu if it does flow into the lake.

What the 2021 eruption makes clear is the need to better understand Nyiragongo and to tailor monitoring and hazard warnings accordingly, Poland says. ■

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LIFE & EVOLUTION

Stopping cockatoo bandits is tricky

The birds and humans may be in a battle of wits over trash

BY ERIN GARCIA DE JESÚS

Human trash can be a cockatoo's treasure. In Sydney, the birds have learned how to open garbage bins and for the last few years have been tossing trash around in the streets as they hunt for food scraps. People are now fighting back.

Bricks, pool noodles, spikes, shoes and sticks are just some of the tools that Sydney residents use to keep sulphur-crested cockatoos (*Cacatua galerita*) from opening trash bins, scientists report in the Sept. 12 *Current Biology*. The goal is to stop the birds from lifting the lid while the container is upright but still allow the lid to flop open when a trash bin is tilted to empty its contents.

This interspecies battle could be an innovation arms race, says behavioral ecologist Barbara Klump of the Max Planck Institute of Animal Behavior in Radolfzell, Germany. When cockatoos learn how to flip trash bin lids, people change their behavior, using things like bricks to weigh down lids, to protect their trash from being flung about. "That's usually a low-level protection and then the cockatoos figure out how to defeat that," Klump says. People then beef up their efforts and the cycle continues.

Researchers are closely watching this escalation to see what the birds — and humans — do next. With the right method, the cockatoos might fly by trash bins and hunt for a different target. Or the birds might learn how to get around the MacGyvered solution.

Some people in Sydney are waging a war with birds over trash. Residents are wedging water bottles in the handles of trash bins to stop cockatoos (one shown) from breaking in.

B. KLUMP/MAX PLANCK INSTITUTE OF ANIMAL BEHAVIOR

Klump and colleagues inspected more than 3,000 bins across four Sydney suburbs where cockatoos invade trash, noting whether and how people protected their garbage. Observations and online surveys showed that people living on the same street are more likely to use similar deterrents, and those efforts escalate over time.

Tricks such as trying to scare off the parrots with rubber snakes don't work well, Klump says. Nor does blocking access with heavy objects such as bricks; cockatoos push them off with brute force. Hanging weights from the lid or wedging items such as water bottles and sticks through a bin's handles work better. The team didn't observe any parrots ransack wedged bins or those with hanging weights. But how the birds will respond to new lid-securing methods is an open question, Klump says.

Some survey responses suggest parrots are learning. "Bricks seemed to work for a while, but cockies got too clever," one participant wrote. "Neighbors on other side of highway suggested sticks. They work."

Next, scientists could explore the costs and benefits of various tactics for humans and birds, says behavioral ecologist Anne Clark of Binghamton University in New York. "I'm curious the degree of effort that people put into this and whether sometimes that effort limited their use of one solution versus another," Clark says.

For instance, some people might not have time to attach a weight to the bin or might depend on children, who can't lift heavy bricks, to put out trash. In the same vein, cockatoos may ignore secured bins that take too long to open. Bricks can be quickly pushed off a lid; breaking sticks wedged in the handle may take more time. Perhaps if a neighborhood adopts a highly effective method, Clark says, the cockatoos may not find it worth it to stop by. ■

LIFE & EVOLUTION

Not all camouflage is equally effective

Some disguises work better to evade predators than others

BY JAKE BUEHLER

From crabs to caterpillars, a wide range of animals successfully use camouflage to hamper detection by hungry predators. But some concealment strategies are more effective than others, a new study suggests.

The analysis compiles and synthesizes data from scores of studies on animal camouflage. Comparisons between different camouflaging methods show that masquerading as specific objects in the environment is the best way to go unseen, scientists report in the Sept. 14 *Proceedings of the Royal Society B*.

Behavioral and sensory ecologist João Vitor de Alcantara Viana had been studying animal camouflage for his doctoral research when he realized a comprehensive comparison of different camouflage strategies had never been done.

"There was a big gap in the literature on this topic," says de Alcantara Viana, of the State University of Campinas in São Paulo.

So, de Alcantara Viana and colleagues searched scientific publication databases for studies on animal camouflage dated from 1900 to July 2022. The team zeroed in on 84 studies that experimentally tested at least one camouflage strategy and reported either how long predators took to find camouflaged prey or how often predators attacked. The team also limited the analysis to studies that compared camouflaged prey with non-camouflaged, often artificial, versions.

The team grouped the data from these studies by the types of predators and prey analyzed and the variety of camouflage strategies examined. Camouflage tactics included "background matching," where the animal matches the color and patterning of the environment, and "masquerading," where the prey mimics a particular object uninteresting to predators, such as a twig, leaf, bird

Watch a video of a cockatoo breaking into a bin at **bit.ly/SN_BirdBandit**

dropping or even shed tarantula skin.

Camouflage is generally effective at making the hunt difficult for predators, increasing their search time by more than 62 percent and dropping their attack rate by more than 27 percent, the team found.

But the type of prey mattered. For example, caterpillars benefited from camouflage more than their winged adult counterparts. Moths and butterflies can fly and have other antipredator adaptations, de Alcantara Viana notes.

The masquerade strategy was especially effective at helping prey elude predators, increasing search time by nearly 300 percent. One of the most striking examples of this, de Alcantara Viana says, are caterpillars that disguise themselves as twigs. A study on brimstone moth caterpillars (*Opisthograptis luteolata*) and chickens showed that the birds take longer to attack masquerading caterpillars after being recently exposed to twigs.

Masquerading as the most effective camouflage strategy is intriguing, says Anna Hughes, a sensory ecologist at the University of Essex in England who was not involved with the research. "If this is indeed the case, it will be interesting to further investigate the constraints—size, movement requirements—that mean that not all animals evolve this strategy," she says.

Caterpillars that masquerade as twigs, like this brimstone moth caterpillar, may be better at evading predators than caterpillars that just blend into the environment.

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Masquerading is probably more likely to evolve if the animal is a similar size as the object it's mimicking, de Alcantara Viana and colleagues note. This could limit what species can benefit from this supercamo.

The team thinks masquerading is so effective because it's so specialized. Prey that masquerade benefit from predators mistaking them for real objects, not just failing to detect them in the environment.

The new work is excellent, Hughes says. Still, it's not clear if the noncamouflaged controls, which she says vary widely from study to study, have inherently different effects on predator reactions. This could make the tested camouflage seem more or less effective than it is in nature.

Another notable finding is that most of the analyzed studies occurred in the Northern Hemisphere, Hughes says. "It is clear that our understanding of the evolution of camouflage strategies is going to be ... incomplete unless more studies are carried out in the Southern Hemisphere." ■

LIFE & EVOLUTION

‘ManBearPig’ lived fast, died young

A quick lifestyle may have helped early mammals get big

BY MARIA TEMMING

In the wake of the dinosaurs’ demise, a bizarre beast that some researchers have nicknamed “ManBearPig” lived life in the fast lane. This lamb-sized mammal—which sported five-fingered hands, a bearlike face and the stocky build of a pig—gave birth to highly developed young after long pregnancies. And those young grew up much faster than expected for an animal as big as ManBearPig, fossil analyses show.

That combination of long gestation and quick aging may have led to many rapid generations of bigger and bigger babies, researchers report August 31 in *Nature*. Such an approach to life could help explain how some mammals took over the world after the dinosaur doomsday.

During the age of the dinosaurs, mammals “only got as large as a domestic cat, maybe, or a badger,” says Gregory Funston, a paleontologist at the Royal Ontario Museum in Toronto. But after an asteroid wiped out all nonbird dinosaurs about 66 million years ago, “we see this huge explosion in mammal diversity, where mammals start to get really big,” Funston says.

In particular, placental mammals got really big. Those are mammals whose babies develop mainly in the womb while fed by a placenta—unlike egg-laying platypuses or marsupials, whose tiny newborns do much of their development in their mother’s pouch. Today, placental mammals are the most diverse group of mammals and include some of the world’s largest animals such as whales, elephants and giraffes.

Paleontologists have long wondered how placental mammals rose to dominance. Researchers suspected that the long gestation period of this mammal lineage was an important factor. Modern placental mammals typically have months-long pregnancies compared with the weeks-long gestation seen in marsupials and platypuses. But it was unclear how long ago such a long gestation evolved.

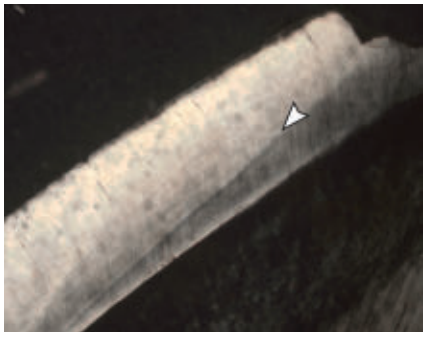
For clues, Funston and colleagues turned to what they call ManBearPig, or *Pantolambda bathmodon*. This ancient herbivore, which lived about 62 million years ago, was one of the first large mammals to appear after the dinosaur apocalypse. The team examined fossils from the San Juan Basin in New Mexico, including two partial skeletons and scattered teeth from several other individuals.

Daily and annual growth lines in the teeth sketched out a timeline of each animal’s life. On that timeline, chemical signatures recorded when the creature underwent major life changes. The physical stress of being born left a deposit of zinc on the tooth enamel. Barium in the enamel spiked while an animal was nursing. Other details of the teeth and bones revealed how fast *P. bathmodon* grew throughout life and each animal’s age at death.

P. bathmodon stayed in the womb for about seven months, nursed for just a month or two, reached adulthood within a year and lived at most about 11 years, the team found.

“It was reproducing like the most extreme placentals do today,” Funston says, such as giraffes and wildebeests, which are on their feet within minutes of birth. *P. bathmodon* gave birth to “probably just one baby in each litter, and that baby had a full set of teeth already in the mouth when it was born, and that means it was probably born with fur in place and with open eyes,” Funston says.

A close-up of this *P. bathmodon* tooth shows a line of zinc (arrow) caused by changes in body chemistry linked to birth. The mark helped reveal the species’s gestation time.



The ancient mammal *Pantolambda bathmodon* (illustrated) was about as big as a lamb and looked something like a jumbo red panda.

The rest of *P. bathmodon*’s life trajectory, however, was markedly different from modern mammals. This species weaned and reached adulthood faster than expected for an animal of its size. Most individuals died between the ages of 2 and 5 years old, with the oldest one studied dead at age 11—only about half of the 20-year life span expected for an animal as big as ManBearPig.

Such a “live fast, die young” lifestyle may have helped placental mammals fill giant dinosaurs’ empty shoes, says Graham Slater, a paleobiologist at the University of Chicago who was not involved in the study. “These things are going to be kicking out new generations every year and a half,” he says, “and because they’re having that rapid generation time … evolution can just act faster.”

Longer gestation could have led to bigger babies, which grew into bigger adults that had bigger babies themselves. With many such generations passing in quick succession, Slater says, “you’re going to get bigger and bigger animals very, very quickly.”

But no single species can tell the story of how mammals became so successful (SN: 6/18/22, p. 28). Future studies should investigate whether other mammals that lived around this time had a similar life cycle, Slater says. ■

FROM TOP: H. SHARPE; G. FUNSTON

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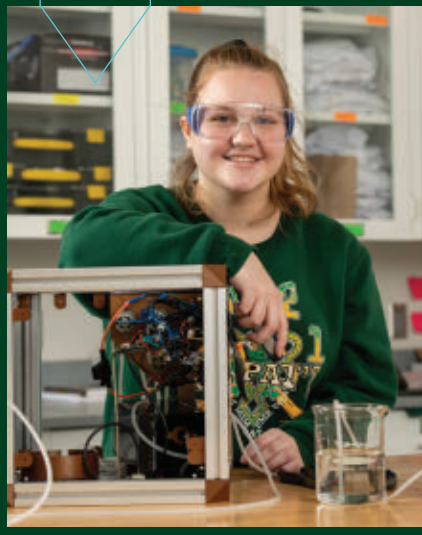

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Saturn's rings, shown in this composite image from NASA's Cassini spacecraft, and tilted orbit are mysteries. A single missing moon could explain both.

ATOM & COSMOS

A moon made Saturn's iconic look

The hypothesis would explain the planet's famous rings

BY LISA GROSSMAN

A single doomed moon could clear up a couple of mysteries about Saturn.

Gravitational tugs from this hypothetical moon, dubbed Chrysalis, could have helped tilt Saturn, researchers suggest in the Sept. 16 *Science*. The ensuing orbital chaos might then have led to the moon's demise, shredding it to form the iconic rings that encircle the planet today.

"We like it because it's a scenario that explains two or three different things that were previously not thought to be related," says planetary scientist Jack Wisdom of MIT. "The rings are related to the tilt," he says. "Who would ever have guessed that?"

Saturn's rings appear young, roughly 150 million years old (SN: 1/20/18, p. 7). If the dinosaurs had telescopes, they might have seen a ringless Saturn. Another mysterious feature of the gas giant is its nearly 27-degree tilt relative to its orbit around the sun. That tilt is too large to have formed when Saturn did or to have resulted from collisions with other objects.

Planetary scientists have long suspected that the tilt is related to Neptune, because of a coincidence in timing between the way the two planets move. Saturn's axis wobbles, or precesses, like a spinning top. Neptune's entire orbit around the sun also wobbles, like a struggling Hula-Hoop.

The periods of both precessions are almost the same, a phenomenon known as resonance. Scientists theorized that gravity from Saturn's moons — especially the largest one, Titan — helped the precessions line up. But some features of Saturn's internal structure were not known well enough to prove the timings are related.

Wisdom and colleagues used precise measurements of Saturn's gravitational field taken by NASA's Cassini spacecraft to figure out details of the planet's internal structure. Specifically, the scientists worked out Saturn's moment of inertia, a measure related to how much force is needed to tip the planet over. Saturn's moment of inertia is close to what it would be if the planet's spin were in perfect resonance with Neptune's orbit, the team found. "It's so close, it couldn't have occurred by chance," Wisdom says. That's where Chrysalis comes in.

This moon could have joined Saturn's dozens of other small moons to gravitationally help Titan bring the planet and Neptune into resonance, the team says. According to that scenario, Titan drifted away from Saturn until its orbit synced up with that of Chrysalis. The gravitational kicks from Titan sent this small moon on a chaotic dance. Eventually, Chrysalis swooped so close to Saturn that it grazed the planet's cloud tops, getting ripped apart and slowly ground into rings.

Calculations and computer simulations show that the scenario is possible. But only 17 of 390 simulations ended with Chrysalis disintegrating to create the rings. Then again, massive rings like Saturn's are rare, too, in the real world.

Planetary scientist Larry Esposito of the University of Colorado Boulder is not entirely convinced. "If Sherlock Holmes is solving a case, even the improbable explanation may be the right one," Esposito says. "But I don't think we're there yet." ■

MATTER & ENERGY

Physics principle remains flawless

Falling objects in orbit show Einstein was right — again

BY JAMES R. RIORDON

Gravity doesn't discriminate. An experiment in orbit around Earth has confirmed, with precision 100 times as great as previous efforts, that everything falls the same way under the influence of gravity.

The finding is the most stringent test yet of the equivalence principle, a key tenet of Einstein's theory of gravity, general relativity. The principle holds to about one part in a thousand trillion, scientists report in the Sept. 16 *Physical Review Letters*.

The idea that gravity affects all things equally might not seem surprising. But the slightest hint otherwise could help explain how general relativity meshes with the standard model of particle physics, the theoretical framework that describes all elementary particles of matter. General relativity is a classical theory that sees the universe as smooth and continuous, whereas the standard model is a quantum theory involving grainy bits of matter and energy. Combining them into a single theory of everything has been an unfulfilled dream of scientists extending back to Einstein (SN: 1/15/22, p. 16).

The equivalence principle is the most important cornerstone of general relativity, says Sabine Hossenfelder, a physicist at the Frankfurt Institute for Advanced Studies in Germany who wasn't involved in the work. "We know [it] eventually has to be altered because it cannot in its present form take into account quantum effects."

To search for potential alterations, the MICROSCOPE experiment tracked the motion of nested metal cylinders — a 301-gram titanium outer cylinder and a 402-gram platinum inner one — as they orbited Earth in near-perfect free fall. Any difference in the effect of gravity on the cylinders would cause them to move relative to each other. Small electrical forces applied to realign the cylinders would have revealed a potential violation.

SPACE SCIENCE INSTITUTE, JPL-CALTECH/NASA

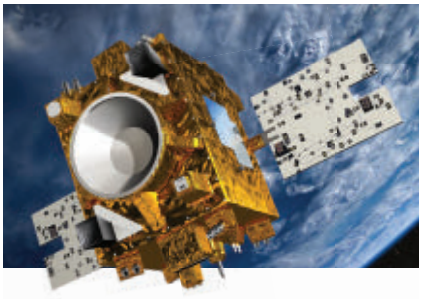
From April 2016 to October 2018, the cylinders were inside a satellite that protected them from the buffeting of solar winds, the minuscule pressure that sunlight exerts and the residual atmosphere at an altitude of about 700 kilometers.

By performing the experiment in orbit, researchers could compare the free fall of two different materials for extended periods without the confounding effects of vibrations or nearby objects, says Manuel Rodrigues, a MICROSCOPE team member and physicist with the aerospace lab ONERA in Palaiseau, France. "Space is the best way to get an important improvement in the accuracy for this kind of test."

Over its two-and-a-half-year mission, MICROSCOPE found no sign of cracks in the equivalence principle, the team says. The finding builds on an interim report that found the same thing, but with less precision (SN: 1/20/18, *p.* 9).

Some physicists suspect that limits to the equivalence principle may never turn up in experiments and that Einstein will perpetually be proved right. Even greater precision from a MICROSCOPE 2 mission, planned for the 2030s, is unlikely to reveal a breakdown, says Clifford Will, a physicist at the University of Florida in Gainesville who is not affiliated with the mission.

Final results from the orbiting MICROSCOPE experiment (illustrated) provide the most precise confirmation yet that all things fall the same way under the influence of gravity.



"It really is still this basic idea that Einstein taught," Will says. The force of gravity is actually the curvature of spacetime. "Any body simply moves along the path in Earth's spacetime," he says, whether that body is made of dense platinum, lighter titanium or another material.

Even if physicists never prove Einstein wrong, experiments like MICROSCOPE are still important because they look for other kinds of deviations that are not part of general relativity, Hossenfelder says.

Now that the mission is complete, the satellite will slowly spiral out of orbit. If you include a reference set of platinum cylinders, there's a couple million dollars' worth of platinum on board, Rodrigues says. Where that precious metal will land is anyone's guess, but the gravity that pulls it down will tug on the titanium just as hard, to one part in a thousand trillion at least. ■

ATOM & COSMOS

Our galaxy strong-armed early Earth

Trips around the Milky Way align with spurts of crust formation

BY KATHERINE KORNEI

Earth's journey around the Milky Way might have helped create the planet's first continents.

Comets may have bombarded Earth every time the early solar system traveled through our galaxy's spiral arms, a new study suggests. Those recurring barrages in turn helped trigger the formation of our planet's continental crust, scientists propose August 23 in *Geology*.

Previous theories have suggested that such impacts might have played a role in forming Earth's landmasses. But there had been little research explaining how those impacts occurred, say geochronologist Chris Kirkland of Curtin University in Perth, Australia, and colleagues.

To peer back in time, the team turned to geologic structures known as cratons, relics of Earth's ancient continental crust that are some of the planet's oldest rocks (SN: 12/18/10, *p.* 22). Using material from cratons in Australia and Greenland that are billions of years old, the team measured the chemistry of over 2,000 bits of rock to determine their exact ages and whether they had formed anew from molten material deep within Earth or from earlier generations of existing crust.

The measurements revealed that new crust formed at roughly regular intervals. "Every 200 million years, we see a pattern of more crust production," Kirkland says.

That timing rang a bell: It's also the frequency at which Earth passes through the spiral arms of the Milky Way (SN: 1/23/16, *p.* 13). Our solar system loops around the center of the galaxy a bit faster than the spiral arms move, periodically passing through and overtaking them.

Perhaps cosmic encounters with more stars, gas and dust within the spiral arms affected young Earth, the team suggests. The higher density of material in the spiral arms would have led to more gravitational tugs on the reservoir of comets at our solar system's periphery (SN: 9/24/22, *p.* 9). Some of those encounters would have sent comets zooming into the inner solar system, a fraction of which could have collided with Earth.

Billions of years ago, Earth's surface was probably mostly ocean. The energy delivered by those comets would have fractured the existing oceanic crust—the relatively dense rock present since even earlier in Earth's history—and excavated a lot of material while launching shock waves into the planet. That mayhem would have paved the way for parts of Earth's mantle to melt, Kirkland says. The resulting magma would have separated by density, with denser material becoming oceanic crust and lighter material turning into continental crust, the team says.

That hypothesis is far from a slam dunk, says geoscientist Jesse Reimink of Penn State. Comet and meteorite impacts are tough to trace, he says, especially that far back in time. And it's not well-known whether such impacts would have resulted in the release of magma.

Kirkland's team hopes to look for similar patterns of crust formation in moon rocks. Our nearest celestial neighbor would have been walloped by about the same amount of stuff that hit Earth, Kirkland says. "You'd predict it'd also be subject to these periodic impact events." ■

HUMANS & SOCIETY

Animal husbandry got an early start

Paleolithic humans may have kept animals for meat and fuel

BY RICHARD KEMENY

Hunter-gatherers in southwestern Asia may have started keeping and caring for animals nearly 13,000 years ago — roughly 2,000 years earlier than once thought.

Ancient plant samples from present-day Syria show hints of charred dung, indicating that people were burning animal droppings by the end of the Paleolithic Period, researchers report September 14 in *PLOS ONE*. The findings suggest humans used the dung as fuel and may have tended animals for meat during or even before the transition to agriculture. But what animals produced the dung and the nature of the animal-human relationship is unclear.

"We know today that dung fuel is a valuable resource, but it hasn't really been documented prior to the Neolithic," says archaeobotanist Alexia Smith of the University of Connecticut in Storrs.

Smith and colleagues examined 43 plant samples collected in the 1970s from a residential settlement at Abu Hureyra, an archaeological site now lost under the Tabqa Dam reservoir. The samples date from roughly 13,300 to 7,800 years ago, spanning the transition from hunter-gatherer societies to farming and herding.

All samples had varying amounts of spherulites, tiny crystals that form in the intestines of animals — most commonly herbivores — and are deposited in dung. There was a noticeable uptick between 12,800 and 12,300 years ago, when darkened spherulites also appeared in a fire pit — evidence they were heated up to 700° Celsius and probably burned.

Comparing the results with previously reported data from Abu Hureyra showed that the dung burning coincided with a shift from circular buildings to linear ones — an indication of a sedentary lifestyle — along with a rise in sheep and a decline in small game. Taken together, the findings suggest humans began tending animals outside their homes and fueling fires with dung, the team argues.

The spherulite evidence "confirms that dung of some sort was used as fuel," says Naomi Miller, an archaeobotanist at the University of Pennsylvania who was not involved with the study.

Figuring out what animal left the dung could reveal whether or not animals were tied up outside. Smith suggests wild sheep, which would have been easily captured. Miller thinks the source might be gazelles, which produce more dung than sheep.

"The whole thing is a classic whodunit," says anthropologist Melinda Zeder of the National Museum of Natural History in Washington, D.C., something DNA analysis could solve (SN: 7/8/17 & 7/22/17, *p.* 20). ■

HUMANS & SOCIETY

Donkeys were domesticated in Africa

The animals became beasts of burden 3,000 years before horses

BY FREDA KREIER

From pulling Mesopotamian war chariots to grinding grain in the Middle Ages, donkeys have carried civilization on their backs for centuries. DNA has now revealed just how ancient humans' relationship with donkeys really is.

The genetic instruction books of over 200 donkeys from countries around the world show that these beasts of burden were domesticated in one fell swoop about 7,000 years ago in East Africa, researchers report in the Sept. 9 *Science*.

"The history of the donkey has puzzled scientists for years," says Ludovic Orlando, a molecular archaeologist at the Centre for Anthropobiology and Genomics of Toulouse in France. This discovery shows that donkeys were domesticated roughly 3,000 years before horses.

In 2021, Orlando and colleagues tracked the domestication of horses to what's now southwestern Russia over 4,200 years ago (SN: 11/20/21, *p.* 15). But the history of donkeys had remained murky.

Today, donkeys are found all over the globe. In Asia and Africa, dwindling numbers of wild asses — the closest wild relatives of donkeys — pointed toward one of those continents as the likely donkey homeland. Archaeological evidence, including a 5,000-year-old Egyptian tablet depicting marching asses, zeroed in on Africa as the most probable contender. But genetic studies have been inconclusive.

This was probably because scientists lacked donkey DNA from many regions of the world, Orlando says. So he and colleagues gathered 207 genomes from donkeys living in 31 countries, ranging from Brazil to China, along with DNA from 31 donkeys that lived between about 4,000 and 100 years ago.

By comparing the genomes with those of wild asses, the team traced the lineage of all donkeys to a single domestication event in East Africa around 5000 B.C. From there, donkeys spread across Africa and into Europe, Asia and elsewhere.

DNA from ancient and living donkeys, such as these in Portugal, has revealed when and where the animals were domesticated.

CLAUDIA COSTA, AEPGA

The findings add clarity to the story of donkey domestication, says livestock geneticist Emily Clark of the University of Edinburgh. Still, it's unclear why people in Africa tamed wild asses in the first place.

The timing of donkeys' spread across eastern Africa coincides with a drying out period in the Sahara, Orlando says. Donkeys could have helped move goods across the increasingly arid terrain, he suggests. ■

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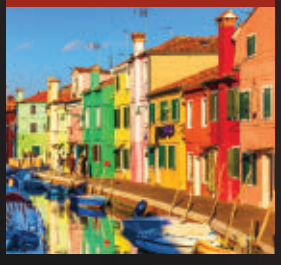

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Researchers are trying to figure out who is at high risk of developing long-term symptoms after an infection with the coronavirus.

BODY & BRAIN

Who is most likely to get long COVID?

Varied symptoms make it difficult to pinpoint risk factors

BY ERIN GARCIA DE JESÚS

For millions of people, COVID-19 doesn't end with a negative test. Weeks or months after traces of the virus disappear from noses and throats, symptoms can persist or come back. New ones might pop up and stick around for months. People suffering from long COVID are unwillingly in it for the long haul — and it's still unclear who's at the highest risk for the condition.

Researchers don't yet have an official definition for long COVID, and its symptoms are wide-ranging. Some people struggle with extreme fatigue that interferes with daily life. Others struggle with memory or can't concentrate amid thick brain fog. Still others have organ damage or a persistent cough and difficulty breathing.

"There are a variety of different kinds of ways that people can have long COVID. It's not just the one thing," says Leora Horwitz, an internal medicine physician at New York University Langone Health. "That's what makes it so hard to study."

This spectrum of symptoms makes pinning down who's at high risk for long-term health problems from the disease especially difficult. Some post-COVID conditions may stem from virus-induced damage or from the stress of being hospitalized with severe disease. In other cases, the body's own immune response to the virus could drive the damage. Or the virus may be hiding somewhere in the body, possibly the gut, helping symptoms to persist. Different causes may have different risk groups, says Hannah Davis, cofounder of the Patient-Led Research Collaborative, a research and advocacy group studying long COVID.

Still, there are some broad hints about who's at risk. Studies suggest that women are more likely than men to have lingering symptoms. COVID-19 patients with more than five symptoms in the first week of infection or preexisting health conditions such as asthma may be more likely to develop long COVID. Age also appears to be a risk factor, though results are mixed regarding whether the burden falls on older people or middle-aged people. Populations that were disproportionally hit by COVID-19 overall — including Black and Hispanic people — may similarly face disparities for long COVID. And while vaccination seems to protect people from developing long COVID, Horwitz says, it's still unclear by how much.

Age, along with more than 30 health problems, including cancer and lung disease, raise the risk for severe COVID-19. "So, many researchers assume that those [risk factors] will be the same for long COVID, and there's no scientific basis for that," Davis says. There are many more risk factors that researchers could be missing.

Using health records and exams, and knowledge of ailments with symptoms similar to long COVID, experts are on the hunt for those risk factors.

Examining health

When it comes to getting a better handle on who's at risk for long COVID — which also goes by the alias post-acute sequelae of SARS-CoV-2 infection — electronic health records may hold important clues.

Horwitz is part of the U.S. National Institutes of Health's RECOVER initiative that aims to understand the long-term impacts of COVID-19. One arm of the study involves mining millions of electronic health records to find potential patterns.

Studying these records should help pinpoint potential risk factors that are rare in the population overall but perhaps more common for people with long COVID, Horwitz says. "That's hard even in a cohort study of thousands."

But health records aren't perfect; they depend on physicians logging that patients are having trouble sleeping or focusing, or that they're exhausted. "The things people are complaining about, we're really bad at writing down those diagnoses on the record," Horwitz says. "So we miss that."

FANATIC STUDIO/GARY WATERS/COLLECTION MIX: SUBJECTS/GETTY IMAGES PLUS

To account for health record deficiencies, Horwitz and colleagues are also reaching out to thousands of people. Participants answer a questionnaire every three months so that the team can identify what kinds of symptoms people have and whether they're getting better or worse.

Then blood, urine, stool and saliva samples can reveal what's happening in the body. Tests on those samples can uncover if the coronavirus is still around and causing trouble, or if the immune system has learned to attack the body itself. Participants with abnormal test results will undergo additional, targeted testing.

"Unlike electronic health records where it's hit or miss, like somebody might have had a CAT scan or might not, here we say, 'OK, you have trouble breathing. We will take a look at your lungs,'" Horwitz says.

The study is looking at a range of people: adults and kids, pregnant people and those currently with COVID-19. The team is also doing autopsies on people who died after having the disease.

Some of the potential risk factors that the team is looking for include other viral infections and autoimmune diseases. The list may grow as more people join the study. "We're trying to balance the fishing versus making sure that we're at least fishing for things that could be in the water," Horwitz says.

In short supply, though, are people who never caught the virus — important controls to highlight what's different about people who got COVID-19.

Overall, more than 8,000 people have signed up so far, and the group plans to recruit around 10,000 more. It's a lot of data, but early results may soon start coming in.

"We'll probably try to do an interim peek at those data this fall," Horwitz says. "It's tricky because we deliberately wanted to enroll 18,000 people so we would have enough power to really look at the things we care about. I don't want to cheat and look too early, but we also know that there's a lot of interest."

> "There are a variety of different kinds of ways that people can have long COVID. It's not just the one thing."
>
> **LEORA HORWITZ**

Striking similarities

Some long COVID symptoms — brain fog, fatigue and trouble sleeping — mirror another illness, called myalgic encephalomyelitis/chronic fatigue syndrome, or ME/CFS. And some long COVID and ME/CFS symptoms, such as rapid heartbeat and dizziness, can fall in the category of nervous system disorders called dysautonomia. Similar symptoms could suggest there are similar risk factors.

Yet potential risk factors for those conditions are largely missing from long COVID research, says Davis, who has had long COVID since March 2020. Among the possibilities that Davis and colleagues are considering are things like Epstein-Barr virus, migraines and some autoimmune diseases.

Epstein-Barr virus could be a big one, Davis says. Infections last a lifetime because the virus can go into hiding in the body and possibly reemerge (SN: 8/13/22, *p.* 14). That virus has been linked to ME/CFS for decades, though its role in the disease remains unclear, Davis says.

Some early hints of a link between Epstein-Barr virus and long COVID already exist. Multiple studies have found evidence in blood samples from some long COVID patients that the immune system recently battled with Epstein-Barr virus, which can cause infectious mononucleosis, a disease characterized by extreme fatigue. Other studies have found signs of the virus itself. And in 2021, Davis and colleagues found that 40 of 580 people with symptoms of long COVID who responded to an online survey reported having a current or recent Epstein-Barr virus infection.

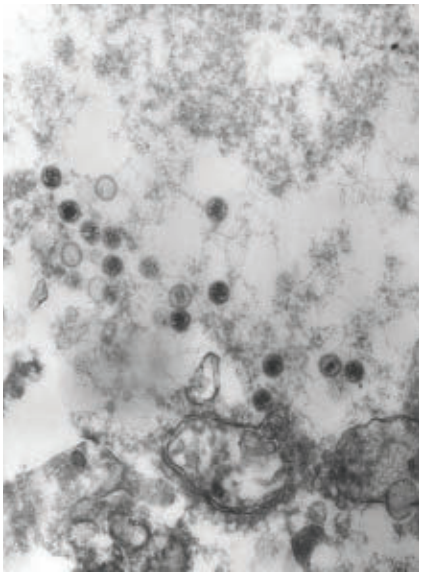
With ME/CFS, it's possible that another illness caused by a different virus coaxes the Epstein-Barr virus out of hibernation to cause the fatigue syndrome. Given the parallels between that condition and long COVID, some scientists are wondering if the two are actually the same disease, with the coronavirus now known as one trigger.

Examining health conditions that raise the chances of long COVID could provide answers for both diseases, says immunologist Nancy Klimas of Nova Southeastern University in Fort Lauderdale, Fla. That's in part because researchers can more easily identify people who developed lingering symptoms after a bout of COVID-19 compared with unknown infections that may precede ME/CFS.

Also, "there's a huge difference in these two fields, and it's money," Klimas says. COVID-19 research has more financial support than studies on ME/CFS. She now has funding from the U.S. Centers for Disease Control and Prevention to compare long COVID patients with people who have ME/CFS. The team hopes that physical exams and specialized tests will reveal whether the two diseases are indeed the same and be a step toward understanding the mechanisms behind the lingering symptoms.

Still, since long COVID as a whole encompasses such a wide range of symptoms, it will take time to uncover who is at risk for what.

If COVID-19 were just one disease impacting the lungs, heart or brain, the research might be easier, Horwitz says. "But we have to test everything." ■



DR. FRED MURPHY/CDC

Scientists are exploring whether infections with Epstein-Barr virus (small circles in this transmission electron microscope image) may be linked to long COVID.

A crowd gathers to watch a fisher released into Washington state's Mount Rainier National Park in December 2016. About 280 of these tree-climbing animals have been translocated from Canada since 2008 to help fisher populations rebound.

KEVIN BACHER/NPS (CC BY 2.0)

Bringing Back the Fishers

The tree-climbing carnivores have returned to Washington state with help from wildlife biologists

By Brianna Randall

Holding an antenna above his head, Jeff Lewis crept through an evergreen forest in the Cascade mountains, southeast of Seattle. As he navigated fallen fir logs and dripping ferns, he heard it: a faint "beep" from a radio transmitter implanted in an animal code-named F023.

F023 is a fisher (*Pekania pennanti*), an elusive member of the weasel family that Lewis fondly describes as a "tree wolverine." Resembling a cross between a cat and an otter, these sleek carnivores hunt in forests in Canada and parts of the northern United States. But fur trapping and habitat loss had wiped out Washington's population by the mid-1900s.

Back in 2017 when Lewis was keeping tabs on F023, he tracked her radio signal from a plane two or three times a month, along with dozens of other recently released fishers. Come spring, he noticed that F023's behavior was different from the others.

Her locations had been clustered close together for a few weeks, a sign that she might be "busy with babies," says Lewis, a conservation biologist with the Washington Department of Fish and Wildlife. He and colleagues trekked into the woods to see if she had indeed given birth. If so, it would be the first wild-born fisher documented in the Cascades in at least half a century.

As the faint beeps grew louder, the biologists found a clump of fur snagged on a branch, scratch marks in the bark and — the best clue of all — fisher scat. The team rigged motion-detecting cameras to surrounding trees. A few days later, after sifting through hundreds of images of squirrels and deer, the team hit the jackpot: a grainy photo of F023 ferrying a kit down from her den high in a hemlock tree. The scientists were ecstatic.

"We're all a bunch of little kids when it comes to getting photos like that," Lewis says.

Chasing babies

This notable birth came during the second phase of a 14-year fisher reintroduction effort. After 90 fishers were released in Olympic National Park from 2008 to 2010, the project turned its focus east of Seattle, relocating 81 fishers in the South Cascades (home to Mount Rainier National Park) from 2015 to 2020, and then 89 fishers in the North Cascades from 2018 to 2020. The animals were brought in from British Columbia and Alberta. The project concluded last year, when researchers let loose the final batch of fishers.

Baby animals are the key measure of success for a wildlife reintroduction project. As part of Washington's Fisher Recovery Plan, biologists set out to document newborn kits as an indicator of how fishers were faring in the three relocation regions.

Three forests
Washington's fisher recovery efforts relocated the animals to three regions of the state: the Olympic Peninsula west of Seattle and the North and South Cascades, a mountain range separated by Interstate 90.

Before F023's kit was caught on camera in May 2017, biologists had already confirmed births by seven relocated females on the Olympic Peninsula, where the whole project began. Two of the seven females had four kits, "the largest litter size ever documented on the West Coast," says Patti Happe, wildlife branch chief at Olympic National Park. Most females have one to three kits.

Lewis is often asked, why put all of this effort into restoring a critter many people have never heard of? His answer: A full array of carnivores makes the ecosystem more resilient.

Happe admits to another motive: "They're freaking adorable — that's partly why we're saving them."

The missing piece

Contrary to their name, fishers don't hunt fish, though they'll happily munch on a dead one if it's handy. They mainly prey on small mammals, but they also eat reptiles, amphibians, insects, fruit and carrion. About a meter long, males weigh up to six kilograms, about twice as much as females. Fun facts: Females raise young high above the forest floor in hollowed-out spaces in tree trunks. Fishers can travel face-first down tree trunks by turning their hind feet 180 degrees. They have wickedly sharp teeth and partially retractable claws. And they're incredibly agile, leaping up to two meters between branches and traveling as much as 30 kilometers in a day.

Fishers' stubby legs and unique climbing skills make them a threat to tree-climbing porcupines. It isn't pretty: A fisher will force the quill-covered animal down a tree and attack its face until it dies from blood loss or shock. Then the fisher neatly skins the prickly prey, eating most everything except the quills and bones.

But these fearsome predators were no match

C. CHANG

for humans. In the 1800s, trappers began targeting fishers for their fur. Soft and luxuriant, the glossy brown-gold pelts were coveted fashion accessories, selling for as much as $345 each in the 1920s. This demand meant fishers disappeared not only from Washington, but from more than a dozen states across the northern United States. Once fisher populations plummeted, porcupines ran rampant across the Great Lakes region and New England. This wreaked havoc on forests because the porcupines gobbled up tree seedlings.

Hoping to keep porcupine populations in check, private timber companies partnered with state agencies to bring fishers back to several states in the 1950s and 1960s. Thanks to these efforts and stricter trapping regulations, fishers are once again abundant in Michigan, Wisconsin, New York and Massachusetts.

But in Washington, like most of the West, fisher numbers were still slim. By the turn of the 21st century, no fisher had been sighted in the state for over three decades.

As in the Midwest and New England, private timber companies in Washington supported bringing back fishers. Although porcupines are uncommon in Washington, mountain beavers — a large, primitive rodent endemic to the Pacific Northwest — fill a similar role in Washington's evergreen forests: They eat tree seedlings. And fishers eat them.

By 2006, the state hatched a plan to bring the animals in from Canada. "It was a big opportunity to restore a species," Lewis says. "We can fix this."

A new home

Like the other Canadian fishers moved to Washington, F023's relocation story began when she walked into a box trap in British Columbia, lured by a tasty morsel of meat. The bait had been set by local trappers hired by Conservation Northwest, a nonprofit that is one of the recovery project's three main partners, along with Washington Fish and Wildlife and the National Park Service. After veterinarians checked her health and administered vaccines and antiparasitics to help her survive in her new home, F023 received a surgically implanted radio transmitter and was driven across the border.

She was met by members of the fisher recovery team, who released her just south of Mount Rainier National Park. The forest's towering Douglas fir, western red cedar and western hemlock trees were full of cubby holes and cavities to hide in, and the undergrowth held plenty of small mammals to eat. At the release, upward of 150 people gathered around F023's box, part of the team's effort to engage the public in championing fisher recovery. Everyone cheered as a child opened the door and the furry female bounded into the snowy woods, out of sight in a flash.

The team monitored each relocated fisher for up to two years to see if the project met key benchmarks of success in each of the three regions: more than 50 percent of the fishers surviving their first year, at least half establishing a home range near the release site, and a confirmed kit born to at least one female.

This agile member of the weasel family may look cute, but it is a fearsome predator. Fishers are one of the few carnivores that can hunt and kill quill-covered porcupines.

EMILY BROUWER/NPS (CC BY 2.0)

"We met those marks," says Dave Werntz, science and conservation director at Conservation Northwest.

The effort may have been aided by a series of bypasses built over and under a roughly 25-kilometer stretch of Interstate 90 east of Seattle. One of these structures is the largest wildlife bridge in North America, an overpass "paved" with forest. In 2020, a remote camera caught an image of what looks like a fisher moving through one of the underpasses.

"Male fishers go on these huge walkabouts to find females," Werntz says. While biologists assumed fishers would cross the freeway to search for mates, having photographic proof "is pretty wonderful," he says.

Happe and others hope to also see wildlife crossings along Interstate 5 one day. The freeway, which runs north-south near the coast, is the main obstacle keeping the Olympic and Cascade populations apart, she says. "We're all working on wildlife travel corridors and connectivity in hopes the two populations hook up."

Learning curve

The majority of the initial 90 fishers relocated to the Olympic Peninsula settled nicely into their new homes, according to radio tracking. In the year following release in that location, the fisher survival rate averaged 73 percent, but varied based on the year and season they were released, as well as sex and age of the fishers.

Males fared better than females: Seventy-four percent of recorded deaths were of females, partly because they are smaller and more vulnerable to predators, such as bobcats and coyotes. Of 24 recovered carcasses where cause of death could be determined, 14 were killed by predators, seven were struck by vehicles, two drowned and one died in a leg-hold trap, Lewis, Happe and colleagues reported in the April 2022 *Journal of Wildlife Management*.

Because the first fishers relocated to the Olympic Peninsula were released in several locations, the animals had trouble finding mates. As a result, only a few parents sired the subsequent generations.

The researchers became concerned when they looked at the genetic diversity of fishers on the Olympic Peninsula six years post-relocation. Happe and colleagues set up 788 remote cameras and hair-snare stations: triangular cubbies open on either end with a chicken leg as bait in the middle and wire brushes protruding from either side to grab strands of fur. DNA analysis of the fur raised red flags about inbreeding, Happe and Lewis say.

These camera trap photos, taken in April 2021, show female fisher F105 carrying one of her four kits down from her tree den near Lake Wenatchee in the North Cascades.

NPS

"Models showed we were going to lose up to 50 percent of genetic diversity, and the population would wink out in something like 100 years," Happe says. To expand the gene pool, the team brought 20 more fishers to the Olympic Peninsula in 2021. These animals came from Alberta whereas the founding population had hailed from British Columbia.

As the reintroduction effort moved into the Cascades, the team adapted, based on lessons learned from the Olympic Peninsula. For instance, to increase the likelihood of fishers finding each other more quickly, the animals were released at fewer sites that were closer together. The team also released the animals before January, giving females ample time to settle into a home range before the spring mating and birthing season.

Finding their food

As the experiment went on, more unanticipated findings popped up. Fishers released in the southern part of the Cascades were more likely to survive the first year (76 percent) than those relocated north of I-90 (40 percent), according to the final project report, released in June. Remote-camera data suggest that's because there are less prey and slightly more predators in the North Cascades, says Tanner Humphries, community wildlife monitoring program lead for Conservation Northwest.

And in both the Cascades and the Olympic Peninsula, fishers are using different types of habitat than biologists had predicted, Happe says. The mammals — once assumed to be old-growth

Speeding vehicles on busy highways pose a threat to fishers and other migrating wildlife. This new bridge east of Seattle is "paved" with trees and plants to let animals safely cross I-90 to find habitat, food or mates on the other side.

WASHINGTON STATE DEPT. OF TRANSPORTATION

specialists — are using a mosaic of young and old forests. Fishers require large, old trees with cavities for denning and resting. But in younger managed forests where trees are thinned or cut, prey may be easier to come by.

Live traps in the South Cascades support that idea. Fishers' preferred prey — snowshoe hares and mountain beavers — were most abundant in young regenerating forests. In older forests, traps detected mainly mice, voles and chipmunks, which are not substantial meals for fishers, Mitchell Parsons, a wildlife ecologist at Utah State University in Logan, reported with Lewis, Werntz and others in 2020 in *Forest Ecology and Management*.

The future is re-wild

After F023's baby was caught on camera five years ago, the mother's tracking chip degraded as designed — the hardware lasts less than two years. Since then, many more fisher kits have been born in Washington.

In fact, these furry carnivores are one of the most successfully translocated mammals in North America. According to Lewis, 41 different translocation efforts across the continent have helped fisher populations blossom. The animals now occupy 68 percent of their historical range, up from 43 percent in the mid-1900s.

With the last batch of fishers delivered to Washington in 2021, the relocation phase of the project has ended. Lewis, Happe and their partners plan to continue monitoring how these sleek tree-climbing carnivores are faring — and how the ecosystem is responding. For instance, fishers are indeed feasting on seedling-eating mountain beavers, according to research reported by Happe, Lewis and others in 2021 in *Northwestern Naturalist*.

Given climate change, species loss and ecosystem degradation, animals worldwide face difficult challenges. The fact that fishers are thriving once again in Washington offers hope, Lewis says.

"It's a hard time, it's a hard world, and this feels like something we're doing right," he says. "Instead of losing something, we're getting it back." ■

Explore more

- Jeffrey C. Lewis *et al*. "Post-release survival of translocated fishers: Implications for translocation success." *Journal of Wildlife Management*. April 2022.

Brianna Randall is a freelance writer based in Missoula, Mont.

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THE SN 10

SCIENTISTS TO WATCH

Inspiration doesn't play by any set rules. It can come from anywhere and strike when it's least expected. A first hint of a big idea can hang on in the recesses of the mind and push people ahead in roundabout ways.

Our SN 10: Scientists to Watch list is a brief study in inspiration. For the seventh year, *Science News* is featuring 10 early- and mid-career scientists driven by their curiosity and sense of wonder, and moved to solve some of the world's biggest problems. Each is making a meaningful mark on their chosen field. Inspired by the beauty he saw in a video of a developing embryo during a middle school science class, Marcos Simões-Costa seeks to understand how cells differentiate during development. It was starry skies in Scotland that pushed planetary scientist Robin Wordsworth to study if and how life might survive elsewhere in the cosmos. And for Jacky Austermann, a love of math and the outdoors led her to physics, then the inner Earth — and ultimately climate change.

Each year we seek SN 10 nominations from Nobel laureates, members of the National Academy of Sciences and past SN 10 scientists. This year's names came from those notable folks, and then some. For the first time, we opened up nominations to other scientists and the wider public, expanding the breadth of our list. It's led to another impressive crew — many of them also set on inspiring others.

Biological anthropologist Tina Lasisi, who studies the evolution of human variation, hosts a PBS Digital Studios show and is a popular voice on TikTok. She wants to inspire people of color to ask questions they care about. "Research is me-search," she says. Neutrino physicist Carlos Argüelles-Delgado is passionate about supporting physics students who don't have role models who look like them. "It's about not giving up, right?" Argüelles says. Environmental engineer Smruthi Karthikeyan pulled elementary school students into her coronavirus tracking efforts by asking them to name wastewater-collecting robots (find out what the students came up with on Page 30).

There are a lot of sparks for new ideas in the pages that follow. We hope the scientist stories will inspire you, too.
— Elizabeth Quill, Special Projects Editor

Want to nominate someone for the next SN 10 list? Send their name, affiliation and a few sentences about them and their work to sn10@sciencenews.org.

A universal coronavirus vaccine is on his agenda

CHRISTOPHER BARNES
Biochemist
Stanford University

STANFORD UNIV.

In January 2020, Caltech biochemist Pamela Bjorkman asked for volunteers to help work out the structures of immune proteins that attack a newly discovered coronavirus. The pathogen had emerged in China and was causing severe pneumonia-like symptoms in the people it infected. Knowing the molecular arrangements of these antibodies would be an important step toward developing drugs to fight the virus.

Christopher Barnes, a postdoc working in Bjorkman's lab on the structure of HIV and antibodies that target it, jumped at the chance to solve a new puzzle. "I was like, 'Oh, I'll do it!'" Barnes says. At the time he wasn't aware how urgent the research would become.

Now, we are all too familiar with SARS-CoV-2, which causes COVID-19 and has killed more than 6 million people globally. Studies of the structure of the virus and the antibodies that target it have helped scientists quickly develop vaccines and treatments that have saved tens of millions of lives. But the virus continues to adapt, making changes to the spike protein that it uses to break into cells. That has left researchers scrambling for new drugs and updated vaccines.

Using high-resolution imaging techniques, Barnes is probing coronavirus spike proteins and the antibodies that attack them. His goal: Find a persistent weak spot and exploit it to create a vaccine that would work against all coronaviruses.

Standout research

Barnes' team used cryo-electron microscopy to reveal the structures of eight antibodies that stop the original version of SARS-CoV-2. The technique catches cells, viruses and proteins going about their business by flash freezing them. In this case, the team isolated coronavirus particles entwined with immune system proteins from people with COVID-19.

The antibodies had attached to four spots on the spike protein's receptor binding domain, or RBD, the team reported in *Nature* in 2020. This fingerlike region anchors the virus to the cell it will infect. When antibodies bind to the RBD, the virus can no longer connect to the cell.

Barnes' team also created an antibody classification system based on the RBD location where the immune system proteins tend to latch on. "That's been really helpful for understanding the types of antibody responses that are elicited by natural infection," says structural biologist Jason McLellan, who wasn't involved in the work, and for identifying prime candidates for drug development.

"A major strength of Chris is that he does not limit himself or his research to one technique," says McLellan, of the University of Texas at Austin. "He quickly adapts and incorporates new technologies to answer important questions in the field."

Since launching his own lab at Stanford, Barnes and colleagues have determined the structures of six antibodies that attack the original SARS-CoV-2 virus and delta and omicron variants. Those variants are skilled at evading antibodies, including lab-made ones given to patients to treat COVID-19.

The newly identified antibodies, described in the June 14 *Immunity*, target the spike protein's N-terminal domain. The structures of the sites where the proteins attach are the same in delta and omicron, hinting that the sites might remain unchanged even in future variants, the team says. Eventually, scientists may be able to mass-produce antibodies that target these sites for use in new therapies.

What's next

Barnes has now turned his attention to antibodies that can fend off all coronaviruses—from ones that cause the common cold to ones found in livestock and other animals that have the potential to spill over into people.

Barnes and immunologist Davide Robbiani of the University of Lugano in Switzerland identified classes of antibodies that target variants from all four coronavirus families, blocking the viruses' ability to fuse with cells.

What's more, the structure of one of the binding sites on the spike protein is the same across the coronavirus family tree, Barnes says. "This is something you wouldn't want to mutate as you diversify your viral family because this is a critical component of how you enter the cell."

Two independent teams have identified similarly broad action in the same antibody classes. Taken together, the findings suggest that a universal coronavirus vaccine is possible, Barnes says.

"We've all kind of discovered this at the same time," he says. The teams are now thinking, "Wow, this exists. So let's try to make a real, true pan-coronavirus vaccine." —*Cassie Martin*

Curly hair starts conversations about human variation

Though humans' nearly hairless bodies stick out like a cowlick among other primates, our nakedness isn't unique in the world of mammals. Dolphins and whales are naked, says biological anthropologist Tina Lasisi of the University of Southern California in Los Angeles. There are naked mole-rats. "Elephants, depending on how you look at them, are kind of naked," she says. "But we're the only weirdos that are naked except for our head."

Our species traded off much of our body hair for more sweat glands, an evolutionary adaptation that helps us regulate body heat more efficiently. But what about another uniquely human feature? We're the only animals known to express tightly curled hair, like that seen in many people of African descent. Lasisi wants to know why and how it came to be.

TINA LASISI
Biological anthropologist
University of Southern California

Backstory

For decades, traits that have been associated with racial categories, such as skin pigmentation and hair texture, have gone understudied or ignored among anthropologists, Lasisi says. Much of the study of human biological variation was deserted after the post–World War II backlash against eugenics, a racist field birthed from the idea that humankind could be improved if only those deemed to have desirable traits were allowed to reproduce. Since then, research on human variation has largely focused instead on traits that are not overtly racialized, such as lactose intolerance and adaptations to high altitudes. But studying all forms of human variation is crucial to understanding our species's evolution, Lasisi says.

Lasisi discovered biological anthropology as an undergraduate student at the University of Cambridge. As a Black person who spent many of her formative years among white people in the Netherlands, she was always aware of skin color. She vividly remembers learning that human skin pigmentation evolved as an adaptation to ultraviolet radiation. "It's like a lightbulb went off in my head," Lasisi says, and it made her wonder, "What else out there can be explained by evolution?"

Her interest in the origins of curly hair grew in part as an effort to understand her own locks. "Research is me-search," Lasisi says. But when she first began, there wasn't much science to comb through, and methodologies for measuring hair texture were either unreliable or inefficient.

Standout research

As part of her Ph.D. research, Lasisi worked with a team of anthropologists, thermal engineers and physiologists to study how curly hair might have given our bipedal ancestors a leg up in the hot and dry African savanna.

The team placed a variety of wigs made of human hair onto heat-sensing models and measured heat transfer in different environments. In dry settings, curly hair, especially tightly curled hair, protected the scalp from solar radiation while releasing more heat from the head than straight hair. Lasisi speculates that the larger amount of air space within curly hair is what does the trick.

To underpin her efforts and support future hair research, Lasisi developed an improved and standardized way of measuring hair curvature and cross-sectional shape. The technique involves segmenting, washing and taking pictures of hair strands and then running the images through an open-source computer program that she created.

Measuring these characteristics on a continuous spectrum (much like we do height, for instance), she argues, is a better way of studying hair texture than the long-standing practice of classifying hair into discrete categories, such as straight, wavy or curly. Such categories are not standardized and can become subjective, she says. They also obscure the immense variation that exists, even on a single person's head, and especially among curly hair.

Lasisi is doing highly technical work that hasn't been part of the conversation, says Robin Nelson, a biological anthropologist at Arizona State University in Tempe. "Before Tina, very few people were working on hair texture in the same way."

Reaching out

Lasisi wants everyone to be included in conversations about what makes humans human. She has appeared on the podcast *Getting Curious with Jonathan Van Ness* (of *Queer Eye* fame). She also hosts a PBS digital show on human evolutionary biology called *Why Am I Like This?*, which she helps conceptualize and write.

What's more, Lasisi has cultivated a community of curious science seekers on social media, where she educates thousands of followers on race, ethnicity and human variation. She hopes that her visibility as a Black anthropologist will encourage other people of color to ask questions that are important to them and that her outreach will help people "see human variation for the beautiful, magnificent, complex thing that it is." —*Aina Abell*

JUSTIN SHAIFER

BRYCE VICKMARK

CARLOS ARGÜELLES-DELGADO

Neutrino physicist
Harvard University

Neutrino physicist seeks undiscovered particles

If you saw Carlos Argüelles-Delgado's childhood bedroom—the whiteboard for working out problems, the math textbooks they asked for as birthday gifts—you'd likely not be surprised that this kid would grow up to push the boundaries of modern physics.

For years, physicists have known that the most successful theory to describe what the universe is made of, called the standard model, is broken (SN: 7/2/22, *p.* 18). By prying at one of the biggest cracks in the framework—neutrinos—Argüelles aims to discover what's next for the field.

Neutrinos are mysterious even for subatomic particles. They're hard to study because they barely interact with matter, and what scientists do know is baffling—like why neutrinos have mass when the standard model predicts they shouldn't. "That's why I like neutrinos," Argüelles says. "They misbehave."

Many scientists think this confusing behavior is a sign that neutrinos are affected by undiscovered particles. In that case, demystifying neutrinos could open a new window on the universe. The question is: Who are these hidden partners, and how can scientists find them?

Standout research

To search for answers, Argüelles often relies on data from the IceCube Neutrino Observatory in Antarctica. IceCube's thousands of buried detectors spot neutrinos from the faint flashes of light they leave after interacting with ice (SN: 12/27/14, *p.* 27).

For their Ph.D., Argüelles combed through these signals to look for "sterile" neutrinos. If this breed of neutrinos exists, they would interact with matter even less than normal neutrinos do. Sterile neutrinos could explain several troubling problems with the standard model, like why neutrinos have mass and why antimatter is rarer than matter. Sterile neutrinos are also a candidate for dark matter, the unidentified substance that outweighs normal matter in the universe.

The search made for a huge project, but Argüelles finished it in about half of the time typical for U.S. Ph.D.s in the physical sciences. And though they found no signs of the would-be particle, Argüelles ruled out some ideas about what it could be like.

"It was an amazing performance," says neutrino physicist Francis Halzen, who advised the Ph.D. work at the University of Wisconsin–Madison and is IceCube's head scientist. "It was a piece of art."

Argüelles also looks for other possible hidden particles. And they aren't afraid to pursue research farther from their specialty. Though no expert in quantum computers, for example, Argüelles was the first to use a quantum computer to simulate how neutrinos can change from one type to another. "I just hate when people tell me I cannot do something," Argüelles says.

Halzen describes Argüelles as fearless, the kind of scientist who is never afraid to ask questions. "I don't think they have any regard for their reputation, ever," he says.

Backstory

Argüelles' attitude toward research is forged in part by past struggles to overcome hardship and discrimination. "There are worse things in life than not being able to solve a problem," they say.

Growing up in Peru meant building a life on shifting ground. The economy was unstable, and at times Argüelles' family struggled to make ends meet.

Though Argüelles' parents were supportive and saw knowledge as a safe investment, they at first rejected Argüelles' desire to study physics. Argüelles, wiping a tear from their eye, recalls their father saying, "You're just going to die of hunger." Soon Argüelles' parents did embrace the career choice.

Argüelles says Peru, when they were growing up, was also an "extremely negative environment" for LGBTQ+ people. "I'm a gay man," they say, "and it was very, very, very difficult."

Same-sex marriages are not recognized in Peru. Hate crimes and discrimination based on sexual orientation were only prohibited in 2017, by a presidential decree that the country's Congress tried but failed to overturn.

When Argüelles left Peru in 2012 to pursue their Ph.D., they found that studying physics in the United States wasn't without obstacles. Almost nobody high up in the field looked like them. They struggled under the weight of expectations and felt that voicing their anxieties would get them branded as weak. But with help from mentors, Argüelles persevered.

Now, as an assistant professor at Harvard, Argüelles sees their students—particularly women and Hispanics—facing the same challenges. Argüelles is passionate about supporting them.

"It's about not giving up, right?" Argüelles says. "I still go through some of these things myself. But I'll survive it."
—*Asa Stahl*

How wastewater got scientists ahead of COVID-19

Environmental engineer Smruthi Karthikeyan had spent just a couple of days working in her new lab at the University of California, San Diego when the state instituted its first coronavirus lockdown in March 2020.

She'd been brought on as a postdoc by biologist Rob Knight to develop new techniques for studying how microbes in complex ecosystems shape human health and vice versa. The COVID-19 pandemic quickly put a new spin on that mission.

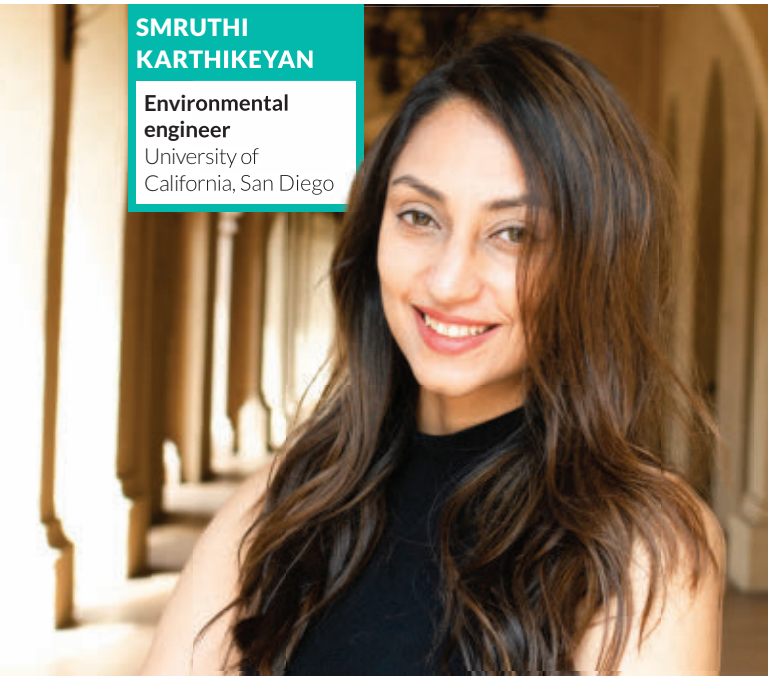
Soon, the lab pivoted to support the coronavirus response. Infections were outpacing testing capacity in San Diego County, Karthikeyan says. Meanwhile, the university wanted to keep the campus open for 10,000 students still living on campus and 25,000 workers. There had to be a way to monitor infections without requiring thousands of people to get tested all the time, Karthikeyan and colleagues thought.

Public health researchers had previously tested wastewater for pathogens as a way to spy on the movements of infectious agents in communities. Viruses, bacteria and parasites can show up in stool before people exhibit symptoms, giving clues to a coming outbreak. But no one had implemented such a system to track a respiratory virus before, and never at a scale of tens of thousands of people.

Karthikeyan was up for the challenge.

Bold idea

The wastewater monitoring system that Karthikeyan and colleagues developed for UC San Diego, reported July 7 in *Nature*, processes upward of 200 samples per day. It has identified newly spreading coronavirus variants up to two weeks earlier than clinical testing and has forecasted the mix of variants infecting students and staff. That has given school officials more time to take action to keep infection rates low.



SMRUTHI KARTHIKEYAN

Environmental engineer
University of California, San Diego

COURTESY OF S. KARTHIKEYAN

Among the key players in the team's monitoring system are 131 robots that collect wastewater samples throughout each day from 360 university buildings. Back at the lab, the samples are screened for viral RNA and results are fed into a publicly available online dashboard created as part of the project.

Karthikeyan's team isn't the only one using human waste to get a jump on COVID-19. But the scale of the monitoring "is a bit unprecedented," says Ameet Pinto, an environmental engineer at Georgia Tech in Atlanta. During a study period that ran from November 2020 to September 2021, the team processed a total of nearly 20,000 samples. "That's amazing," he says.

A positive result triggers a campus-wide notification via smartphone app. For a dormitory, anyone living there is mandated to get tested for COVID-19, while anyone who may have recently been in the building is strongly encouraged to get tested. The team processes the tests and sends results within a day.

Anyone testing positive for the coronavirus is moved to an isolation dorm or, if they live off campus, told to isolate at home. If the coronavirus shows up in the next day's wastewater test, the building's remaining occupants receive a notification to test again.

To figure out which variants are responsible, Karthikeyan's team built a freely available computational tool called Freyja. It uses a library of genetic markers to identify the relative abundances of well-known and emerging variants in the wastewater. Freyja detected the emerging delta variant on campus 14 days before clinical tests did, Karthikeyan and colleagues report.

Growing the effort

Based on success at the university, San Diego County officials asked the researchers to test a modified version of the system at the Point Loma Wastewater Treatment Plant, which serves more than 2.2 million residents, and at 17 public schools. Elementary school students got to name the robots, dubbing the machines Sir-Poops-a-Lot, Harry Botter and the Rancid Water, and other silly monikers, Karthikeyan says with a chuckle.

On the county level, the system detected the emergence of the omicron variant 11 days before clinical testing, the team reports in the same study in *Nature*.

Karthikeyan and colleagues' methods have been adapted by researchers at the state, national and international levels. For instance, the U.S. Centers for Disease Control and Prevention and the Food and Drug Administration use Freyja to track variants in wastewater across the country. The system is now being used to monitor monkeypox too.

Karthikeyan will launch her own lab at Caltech in 2023, where she plans to adapt these tools for monitoring groundwater. Communities of microbes that live there can serve as sentinels, flagging disturbances from pollution, climate change and more, she says. "My whole thing is to look at a much larger system from a very tiny lens." — *Cassie Martin*

Earth's inner workings will shape sea level rise

It's no revelation that sea levels are rising. Rising temperatures brought on by human-caused climate change are melting ice sheets and expanding ocean water. What's happening inside Earth will also shape future shorelines. Jacky Austermann is trying to understand those inner dynamics.

A geophysicist at Columbia University's Lamont-Doherty Earth Observatory, Austermann didn't always know she would end up studying climate. Her fascination with math from a young age coupled with her love of nature and the outdoors—she grew up hiking in the Alps—led her to study physics as an undergraduate, and later geophysics.

As Austermann dug deeper into Earth's geosystems, she learned just how much the movement of hot rock in the mantle influences life on the surface. "I got really interested in this entire interplay of the solid earth and the oceans and the climate," she says.

BILL MENKE

JACKY AUSTERMANN
Geophysicist
Columbia University

Big goal

Much of Austermann's work focuses on how that interplay influences changes in sea level. The global average sea level has risen more than 20 centimeters since 1880, and the yearly rise is increasing. But shifts in local sea level can vary, with those levels rising or falling along different shorelines, Austermann says, and the solid earth plays a role.

"We think about sea level change generally as 'ice is melting, so sea level is rising.' But there's a lot more nuance to it," she says. "A lot of sea level change is driven by land motion."

Understanding that nuance could lead to more accurate climate models for predicting sea level rise in the future. Such work should help inform practical solutions for communities in at-risk coastal areas.

So Austermann is building computer models that reconstruct sea level changes over the last few million years. Her models incorporate data on how the creeping churning of Earth's mantle and other geologic phenomena have altered land and sea elevation, particularly during interglacial periods when Earth's temperatures were a few degrees higher than they are today.

Standout research

Previous studies had suggested that this churning, known as mantle convection, sculpted Earth's surface millions of years ago. "It pushes the surface up where hot material wells up," Austermann says. "And it also drags [the surface] down where cold material sinks back into the mantle."

In 2015, Austermann and colleagues were the first to show that mantle-induced topographic changes influenced the melting of Antarctic ice over the last 3 million years.

What's more, mantle convection is affecting land surfaces even on relatively short timescales. Since the last interglacial period, around 130,000 to 115,000 years ago, mantle convection has warped ancient shorelines by as much as several meters, her team reported in *Science Advances* in 2017.

The growing and melting of ice sheets can deform the solid earth too, Austermann says. As land sinks under the weight of accumulating ice, local sea levels rise. And as land uplifts where the ice melts, water falls. This effect, as well as how the ice sheet tugs on the water around it, is shifting local sea levels around the globe today, she says, making it very relevant to coastal areas planning their defenses in the current climate crisis.

Understanding these geologic processes can help improve models of past sea level rise. Austermann's team is gathering more data from the field, scouring the coasts of Caribbean islands for clues to what areas were once near or below sea level. Such clues include fossilized corals and water ripples etched in stone, as well as tiny chutes in rocks that indicate air bubbles once rose through sand on ancient beaches. The work is "really fun," Austermann says. "It's essentially like a scavenger hunt."

Her efforts put the solid earth at the forefront of the study of sea level changes, says Douglas Wiens, a seismologist at Washington University in St. Louis. Before, "a lot of those factors were kind of ignored." What's most remarkable is her ability "to span what we normally consider to be several different disciplines and bring them together to solve the sea level problem," he says.

Building community

Austermann says the most enjoyable part of her job is working with her students and postdocs. More than writing the next big paper, she wants to cultivate a happy, healthy and motivated research group. "It's really rewarding to see them grow academically, scientifically, come up with their own ideas … and also help each other out."

Roger Creel, a Ph.D. student in Austermann's group and the first to join her lab, treasures Austermann's mentorship. She offers realistic, clear and fluid expectations, gives prompt and thoughtful feedback and meets for regular check-ins, he says. "Sometimes I think of it like water-skiing, and Jacky's the boat."

For Oana Dumitru, a postdoc in the group, one aspect of that valued mentorship came in the form of a gentle push to write and submit a grant proposal on her own. "I thought I was not ready for it, but she was like, you've got to try," Dumitru says.

Creating a sense of inclusion, support and community "is the groundwork for having an environment where great ideas can blossom," Austermann says. —*Aina Abell*

There's beauty and wisdom in a developing embryo

Growing up in Brazil, Marcos Simões-Costa often visited his grandparents' farm in the Amazon. That immersion in nature — squawking toucans and all — sparked his fascination with science and evolution. But a video of a developing embryo, shown in his middle school science class, cemented his desire to become a developmental biologist.

"It's such a beautiful process," he says. "I was always into drawing and art, and it was very visual — the shapes of the embryo changing, the fact that you start with one cell and the complexity is increasing. I just got lost in that video."

Today, Simões-Costa, of Harvard Medical School and Boston Children's Hospital, is honoring his younger self by demystifying how the embryo develops. He studies the embryos and stem cells of birds and mice to learn how networks of genes and the elements that control them influence the identity of cells. The work could lead to new treatments for various diseases, including cancer. "The embryo is our best teacher," he says.

Standout research

Simões-Costa focuses on the embryo's neural crest cells, a population of stem cells that form in the developing central nervous system. The cells migrate to other parts of the embryo and give rise to many different cell types, from the bone cells of the face to muscle cells to brain and nerve cells.

Scientists have wondered for years why neural crest cells in the cranial region of the embryo can form bone and cartilage, while those in the trunk region can't form either. While a postdoc at Caltech, Simões-Costa studied the cascade of molecules that govern how genes are expressed in each cell type. With his adviser, developmental biologist Marianne Bronner, he identified transcription factors — proteins that help turn genes on and off — that were present only in cranial cells. Transplanting the genes for those proteins into trunk cells endowed the cells with the ability to create cartilage and bone.

MARCOS SIMÕES-COSTA

Developmental biologist
Harvard Medical School and Boston Children's Hospital

M. SIMÕES-COSTA

Now in his own lab, he continues to piece together just how this vast regulatory network influences the specialization of cells. His team reconstructed how neural crest cells' full set of genetic instructions, or the genome, folds into a compact, 3-D shape. The researchers identified short DNA sequences, called enhancers, that are located in faraway regions of the genome, but end up close to key genes when the genome folds. These enhancers work with various regulatory elements to control gene activity.

Simões-Costa is also using neural crest cells to elucidate a strange behavior shared by cancer cells and some embryonic cells. These cells produce energy anaerobically, without oxygen, even when oxygen is present. Called the Warburg effect, this metabolic process has been studied extensively in cancer cells, but its function remained unclear.

Through experiments manipulating the metabolism of neural crest cells, Simões-Costa's team found that the Warburg effect is necessary for the cells to move around during early development. The mechanism, which should stay turned off in non-embryonic cells, somehow "gets reactivated in adult cells in the context of cancer, leading those cells to become more migratory and more invasive," Simões-Costa says.

"He's one of the few people who's really looked at [this process in neural crest cells] at a molecular level and done a deep dive into the mechanisms underlying it," says Bronner.

Cleverly combining classic embryological methods with the latest genomic technologies to address fundamental questions in the field is what makes Simões-Costa special, says Kelly Liu, a developmental biologist at Cornell University. He wants to understand not only what individual genes do, but also how they work at a systems level, she says.

What's next

How does the genetic blueprint tell cells where they are in the embryo, and what they should be doing? How do cancer cells hijack the Warburg effect, and could understanding of that process lead to new treatments? These are some of the questions Simões-Costa wants to tackle next. "There's still so much mystery in the genetic code," he says.

Those mysteries, plus a deep passion for lab work, fuel Simões-Costa's research. "Being at the bench is when I'm the happiest," he says. He likes the delicate craft of performing precise surgeries on tissues and cells to meditation. "It does not get old." — *Aina Abell*

HUIJIA LIN
Cryptographer
University of Washington

DENNIS WISE/UNIV. OF WASHINGTON

A master cryptographic tool is now within reach

A long-sought "holy grail" in cryptography is poised to change the way we protect sensitive information.

Today's standard encryption schemes take an all-or-nothing approach. Once scrambled, your data become inaccessible to anyone without the secret key.

This has allowed for secure e-mail communication, the proliferation of online shopping and digital signatures. It allows all kinds of personal information to be passed more safely across the internet. But if you give someone the secret key to access any of the data, all of the data become vulnerable.

What if instead you could assign specific people access to do very specific things with your data? Someone could get the information they need (the info you want them to have) without unlocking all of the original data. Bank details, credit card numbers, account passwords—all would remain hidden. That wholly different approach would allow Google to sort your e-mails without knowing what's in them, for example. Medical researchers could analyze data to identify risk factors for a disease without accessing any individual's health information.

This and other cryptographic wonders now appear possible through a master tool called indistinguishability obfuscation.

"It's a new tool—a very powerful tool," says Huijia (Rachel) Lin, a cryptographer at the University of Washington in Seattle who showed with colleagues in 2020 how to construct the tool. "Once you have this superstrong power, then a lot of the other tasks are either special cases of it, or you can easily use this to realize [those tasks]."

Vinod Vaikuntanathan, a computer scientist at MIT who has worked with Lin in the past, compares indistinguishability obfuscation, or iO, to a grand theory in physics that would unite gravity and quantum mechanics. "iO gives you a way to do a grand unification of cryptography in the sense that you can explain much of what cryptography does in a very simple way."

Standout research

Indistinguishability obfuscation is a form of program obfuscation, an approach that seeks to hide the inner workings of a computer program, not just the message or data itself. Though proposed in the 1970s, program obfuscation proved difficult to achieve. For many years, people thought it might not be possible. And in 2001, researchers showed that the strongest version—called black-box obfuscation—is impossible.

Yet indistinguishability obfuscation, proposed at the same time and shown to be incredibly powerful, doesn't demand that everything about a program remain hidden. It instead deals with two programs that perform the same function. If the inner workings of those two programs can be hidden enough that the two can't be distinguished from each other, indistinguishability obfuscation has been achieved. By hiding the secret key within the program itself, iO enables the delegation of specific data and data tasks to specific people.

Still, proposal after proposal for making iO work proved breakable. Researchers couldn't figure out how to keep it safe from an adversary's attacks. Lin says the approaches being used didn't appeal to her. Researchers were leaning on what appeared to be "good enough" ways of getting at the problem that weren't backed by rigorous mathematical proofs.

Lin instead wanted to break the problem down so she could understand each component and how they worked together. She wanted to approach the problem like a clock, with gears and nuts and bolts, instead of tangled like "a bowl of spaghetti."

Through this strategy, Lin and colleagues demonstrated that iO is achievable. It would be secure based on standard assumptions in the field, the team proved, renewing hope in the tool.

"Of course, [Huijia] is brilliant," Vaikuntanathan says, adding that her persistence is what really sets her apart. "It takes some guts to continue with an approach when essentially all the rest of the world thinks that it is not going to work."

Backstory

Lin says she didn't grow up with computers or fall in love with computer programming at an early age. She started with computer science in college; a class in cryptography as a Ph.D. student "was really mind-opening," she says.

Her introduction to what are known as zero-knowledge proofs stands out in her memory. A zero-knowledge proof says that a person can convince someone else that they know a secret without revealing the secret or any details about it. Say, for example, you know that a number is the product of two prime numbers. Can you convince someone that fact is true without revealing what the primes are?

Cryptography includes a lot of these seeming paradoxes that prove to be possible. Indistinguishability obfuscation is yet another example—and Lin works on others too. "I'm very attracted to these magical concepts," Lin says. "The fun of it is to make this concept come to realization."

Indistinguishability obfuscation is still far from real-world implementation. But Vaikuntanathan says it's not unusual for first constructions of what will become important approaches to be impractical at first. "Wait for a decade," he says.
—*Elizabeth Quill*

JOSEP CORNELLA

Chemist
Max-Planck-Institut für Kohlenforschung

Chemist breaks boundaries to make better catalysts

Josep Cornella doesn't deal in absolutes. While chemists typically draw rigid lines between organic and inorganic chemistry, Cornella, a researcher at Max-Planck-Institut für Kohlenforschung in Mülheim an der Ruhr, Germany, believes in just the opposite.

"You have to be open to cross boundaries," he says, "and learn from it." The fringes are "where the rich new things are."

Cornella is an organic chemist by industry standards; he synthesizes molecules that contain carbon. But he's put together a team from a wide range of backgrounds: inorganic chemists, physical organic chemists, computational chemists. Together, the team brainstorms novel approaches to designing new catalysts, so that chemical reactions essential to pharmaceuticals and agriculture can be made more efficient and friendly for the environment. Along the way, Cornella has unlocked mysteries that stumped chemists for years.

"He has told us about catalysts … that we didn't have before, and which were just pipe dreams," says Hosea Nelson, a chemist at Caltech who has not worked with Cornella.

Bold idea

When Cornella heard a speaker at a 2014 conference say that bismuth was nontoxic, he was sure it was a mistake. Bismuth is a heavy metal that sits between toxic lead and polonium on the periodic table. But it is indeed relatively nontoxic — it's even used in the over-the-counter nausea medicine Pepto-Bismol.

Still, bismuth remains poorly understood. That's one reason it attracted him. "It was a rather forgotten element of the periodic table," Cornella says. But, "it's there for a reason."

Cornella started wondering if an element like bismuth could be trained for use as a catalyst. For the last century, scientists have been using transition metals, like palladium and iron, as the main catalysts in industrial synthesis. "Could we actually train [bismuth] to do what these guys do so well?" he asked. It was a conceptual question that "was completely naïve, or maybe stupid."

Far from stupid: His team successfully used bismuth as a catalyst to make a carbon-fluorine bond. And bismuth didn't just mimic a transition metal's role — it worked better. Only a small amount of bismuth was required, much less than the amount of transition metal needed to complete the same task.

"A lot of people, including myself and other [researchers] around the world, have spent a lot of time thinking about how to make bismuth reactions catalytic," Nelson says. "He's the guy who cracked that nut."

Standout research

While the bismuth research is "weird" and "exciting," Cornella says, it remains a proof of concept. Bismuth is not as abundant as he had hoped, so it's not a very sustainable option for industry.

But other Cornella team findings are already being used in the real world. In 2019, the group figured out how to make an alternative to $Ni(COD)_2$, a finicky catalyst commonly used in the lab. If it's not kept at freezing temperatures and protected from oxygen by a layer of inert gases, the nickel complex falls apart.

The alternative complex, developed by Lukas Nattmann, a Ph.D. student in Cornella's lab at the time, stays stable in oxygen at room temperature. It's a game changer: It saves energy and materials, and it's universal. "You can basically take all those reactions that were developed for 60 years of $Ni(COD)_2$ and basically replace all of them with our catalyst, and it works just fine," Cornella says.

Cornella's lab is also developing new reagents, substances that transform one material into another. The team is looking to transform atoms in functional groups — specific groupings of atoms that behave in specific ways regardless of the molecules they are found in — into other atoms in a single step. Doing these reactions in one step could cut preparation time from two weeks to a day, which would be very useful in the pharmaceutical industry.

Taking risks

It's the success that gets attention, but failure is "our daily basis," Cornella says. "It's a lot of failure." As a student, when he couldn't get a reaction to work, he'd set up a simple reaction called a TBS protection — the kind of reaction that's impossible to get wrong — to remind himself that he wasn't "completely useless."

Today he runs a lab that champions taking risks. He encourages students to learn from one another about areas they know nothing about. For instance, a pure organic chemist could come into Cornella's lab and leave with a good understanding of organometallic chemistry after spending long days working alongside a colleague who is an expert in that area.

"If you tackle a problem from just one unique perspective," he says, "maybe you're missing some stuff."

While Cornella might not like absolutes, Phil Baran, who advised Cornella during his postdoctoral work at Scripps Research in San Diego, sees Cornella as fitting into one of two distinct categories: "There are chemists who do chemistry in order to eat, like it's a job. And there are chemists who eat in order to do chemistry," Baran says. Cornella fits into the latter group. "It's his oxygen." — *Anna Gibbs*

PETER GWIAZDA FOR MPI FÜR KOHLENFORSCHUNG

This neuroscientist is demystifying the female brain

When Emily Jacobs embarked on a career studying the brain in the early 2000s, a technique called functional magnetic resonance imaging, or fMRI, was having a moment. "Just like we have super powerful telescopes that can let us quantify the farthest reaches of the known universe, here we have this tool that could allow us to see the entire human brain and as a pulsing, living organ," says Jacobs, a cognitive neuroscientist at the University of California, Santa Barbara.

By measuring changes in blood flow that serve as a proxy for brain activity, neuroscientists were getting new views of how different situations spur conversations between brain regions, and how the intensity of the conversations changes over time. "I was riding that wave of excitement," Jacobs says.

But she soon realized there were big questions that weren't being asked — questions important to half the world's population. Do the natural hormonal changes that come with menstruation, pregnancy and menopause affect communication across the brain? What about hormonal contraceptives, such as the birth control pill, which are used by hundreds of millions of people globally? And what does it all mean for brain health and behavior?

EMILY JACOBS

Cognitive neuroscientist
University of California, Santa Barbara

Big goal

The rise and fall of hormones is a big reason women have historically been excluded from biomedical research, even though hormones in men fluctuate too. The resulting gap in knowledge of female biology has led to inadequate mental, physical and reproductive health care. "Science, and especially neuroscience, has not served the sexes equally," Jacobs says.

With a range of tools — fMRI, other types of MRI and brain imaging, blood testing, neuropsychological testing, virtual reality and more — Jacobs' lab is trying to fill in gaps in our basic understanding of how hormones act in the human brain. And she is studying the hormones as a lens for bigger questions about brain changes. "What's really special about Emily's work is that she does it at so many different levels. It's so multifaceted," says cognitive neuroscientist Caterina Gratton of Northwestern University in Evanston, Ill. "She has multiple different types of brain measures, from the molecular all the way up to brain systems."

Standout research

In a series of studies dubbed 28 and Me — for the 28 days of a typical menstrual cycle — Jacobs and colleagues closely monitored the brain of one woman for the duration of her natural menstrual cycle. Every 24 hours over 30 days, this 20-something woman's brain was scanned, blood hormone levels checked and mood assessed.

As the woman's estrogen levels peaked during ovulation, regions throughout the brain synced up. And regions in an important hub called the default mode network became tight conversationalists. What's more, one part of this network rearranged itself to create a new and transient communication clique. After ovulation, when estrogen levels dropped and progesterone levels spiked, gray matter temporarily expanded in a brain structure tied to learning and memory.

When the same woman was examined a year later while on the pill, which quells progesterone, the changes weren't observed.

Reported last year in *Current Opinion in Behavioral Sciences*, the findings provide strong evidence that the ebb and flow of sex hormones drives changes in the brain on a day-to-day basis, Jacobs and colleagues say. They also saw links between hormone fluctuations and brain changes in a male participant.

What's next

The observations led cognitive neuroscientist Caitlin Taylor, a postdoc in Jacobs' lab, to wonder how the brain responds to chronic hormone suppression from oral contraceptive use. The team is launching a large-scale study to attempt to find out.

Initially, Jacobs hesitated to greenlight the research. She worried it could be twisted to erode access to contraception. Eventually, she relented, because women "deserve to have science that can serve us," she says.

Another effort, which Jacobs and Taylor are building, will make data for such large-scale studies widely available. Called the University of California Women's Brain Initiative, it aims to funnel records from the university system's eight brain-imaging research centers into an open-access database. When a woman gets her brain scanned at one of the centers, her de-identified brain-imaging data, medical data and information about hormonal contraceptive use will be entered into the database. Once all eight centers are on board, there could be about 10,000 participants annually — way more than a single lab could recruit.

The expected mountain of data should be a boon to researchers asking big and small questions about brain health, Jacobs says. And she hopes it will improve women's health care. — *Cassie Martin*

ARIELLE DONESON

Climate is key to whether alien worlds could host life

Visitors to the village of Drumnadrochit, on the western shore of Scotland's murky Loch Ness, come to see the nearby ruins of Urquhart Castle or to chance a glimpse of the elusive Loch Ness Monster. But growing up in Drumnadrochit, planetary scientist Robin Wordsworth says it was the unobscured view of the cosmos that seized his attention. "There are incredibly clear skies up there," he says.

Today, Wordsworth lives on the other side of the Atlantic. He's a researcher and professor at Harvard University. But his gaze is still set on the solar system and beyond. From studying how rocky planets may occasionally become encased in glaciers to exploring the sizes of alien raindrops (SN: 5/8/21, p. 12) or the details of how humans might one day settle Mars, Wordsworth's scientific explorations vary widely. His research group tends to "do a lot of different things at once," he says. "If I was to summarize it in a sentence, it would be to understand what drives habitability on planets through time."

Standout research

Wordsworth defines a planet's habitability as its ability to support life. The idea that life could survive elsewhere in the cosmos has always fascinated Wordsworth, a science fiction fan. Apart from Earth, astronomers have discovered roughly 20 potentially habitable worlds in the universe. With data collected by ground-based observatories, satellites and rovers, he uses supercomputers to construct simulations of planets and the evolution of their climates. Climate is a big focus because it determines whether a planet's surface can harbor liquid water—a necessity for all known forms of life.

Wordsworth's most notable research reconstructs the climate of early Mars. Martian river valleys and other geologic clues suggest that abundant liquid water once flowed across the Red Planet, and the early Martian climate has thus become a hot topic for scientists seeking signs of alien life. But for decades, the best researchers could do was build one-dimensional models that struggled to replicate key atmospheric components, such as clouds.

In 2013 while at the Laboratory of Dynamic Meteorology in Paris, Wordsworth and colleagues presented a 3-D model of the early Martian climate, with clouds and an atmosphere containing large amounts of carbon dioxide. Those are key components for studying how the early Martian atmosphere may have reflected and trapped heat, says astrobiologist James Kasting of Penn State.

Wordsworth was the one who figured out how to incorporate clouds into the model, thanks to his strong programming skills, handle over mathematics and determination, Kasting says. "He's been publishing the best climate calculations for early Mars. There's really nobody else who is in his lane."

ROBIN WORDSWORTH
Planetary scientist
Harvard University

ELIZA GRINNELL/HARVARD SEAS

What's next

Wordsworth's otherworldly reconstructions may help us better understand whether life might have emerged on Mars or elsewhere. Another strand of his research could help humans one day settle the Red Planet.

Today, most of Mars' surface is too cold to sustain liquid water, and the planet's thin atmosphere offers little protection from the sun's intense ultraviolet radiation. These conditions make it inhospitable to would-be Martian settlers. But in a 2019 study, Wordsworth and colleagues proposed that sheets of insulating silica aerogel deployed over ice-covered areas might make survival possible.

In lab tests, layers of aerogel just centimeters thick filtered out 60 percent of UVA and UVB radiation and almost all of the more dangerous UVC rays, while permitting enough light through for photosynthesis. What's more, the shields warmed the air underneath by more than 50 degrees Celsius, which could make liquid water and growing crops possible.

Looking ahead, Wordsworth plans to investigate how settlers on Mars might use bioplastics or other renewable materials to become self-sustaining.

And far beyond the Red Planet, the exoplanets await. "The James Webb Space Telescope has just begun to collect new exoplanet data," Wordsworth says (SN: 9/24/22, p. 6). Observations of their atmospheres will help researchers test ideas about how these distant planets and their climates evolve, he says. "It's just an incredibly exciting time." —*Nikk Ogasa*

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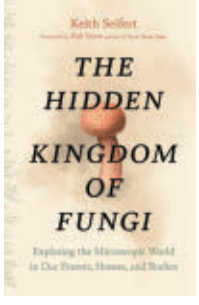
Scientists estimate there are as many as 15 million species of fungi, including the pretty but poisonous fly agaric mushroom (*Amanita muscaria*).



The Hidden Kingdom of Fungi
Keith Seifert
GREYSTONE BOOKS, $27.95

BOOKSHELF

Meet the fungal friends and foes all around us

Take a walk through the woods after it rains and you can catch a glimpse of the incredible diversity of fungi. You might spot the real-life version of the red-and-white "power up" mushroom from the Super Mario Bros. video games or the aptly named dead man's fingers, a blackened fungal growth that resembles a hand emerging from the grave. Perhaps you'll notice a cluster of frilly pink shelves on a log or a striking purple mushroom that's a doppelgänger for underwater coral.

But for all that you can see, you've barely scratched the surface of the fungal world.

Scientists estimate there are between 1.5 million and 15 million species of fungi, but have discovered and named only 140,000 or so. Most of that identification was performed with microscopes. Over the last two decades, DNA sequencing has allowed researchers to zero in on and distinguish large numbers of microfungi. It's these rarely noticed and poorly understood fungi that mycologist Keith Seifert focuses on in his book *The Hidden Kingdom of Fungi*.

Seifert has spent his career "obsessing over Latin names of fungi" but recognizes that taxonomy may not come easily to his readers. So he begins with a note on scientific names, explaining why they're a "necessary evil." He provides a primer on the modern classification system, likening it to "a phone book for looking up the evolutionary address of a fungus."

From there, the book explores fungi's evolutionary journey and the various symbiotic relationships they have with other organisms. These relationships have muddied scientists' picture of ecology and evolution. In the traditional view of evolution proposed by Charles Darwin, competition is seen as the major driving force of natural selection. But Darwin "underplayed the significance of cooperation in nature," Seifert writes. Take the evolutionary success of lichens, a highly diverse group that has spread around the world. These complex organisms consist of an alga and fungus living together in a mutually beneficial relationship.

Throughout the book, Seifert delves deeper into fungi's complicated relationships with other organisms, covering the role fungi play in forest ecology, agriculture, fermentation, the built environment and even the human body. Here, there's something for everyone. Nature lovers will enjoy learning about the "Wood Wide Web" (SN: 8/9/97, p. 87), an underground network of mycorrhizal fungi. They connect to tree roots, enabling trees to exchange water, nutrients and minerals. Gardeners and farmers can gain useful knowledge about the fungi that can help or harm crops. Foodies will find themselves singing fungi's praises after learning about the yeasts and molds that give us the "sacred fungal trilogy" of wine, cheese and chocolate. But many readers might cringe as Seifert takes them on a room-by-room tour of which fungal species lurk in a person's house or shares how fungi can cause illness (SN: 12/4/21, p. 16).

As the book ends, Seifert focuses on how humans and fungi can build a better world together. Humans have already used fungi to create a range of products, including penicillin, stonewashed denim and the meat substitute Quorn. Now, fungi are also helping with environmental cleanup and the development of leatherlike textiles and solid building materials. We've put only a small number of fungal species to work so far, but the possibilities are endless. Seifert paints a picture of what a healthier, more sustainable future could look like, with fungal foam beds and bioluminescent lamps. Such a future isn't some far-off fantasy, he writes, at least from a technological standpoint. But there's more than just technical know-how needed to create a more sustainable and symbiotic world.

We also must reconsider our attitude toward fungi, Seifert says. "If we are going to make peace with fungi, we need to be aware of their biodiversity and embrace their talents for biodegradation, symbiosis and biochemistry that make them such significant players in the environment," he writes. "Only then will we be able to work with them effectively for our own prosperity and health, while they also collaborate with us."
—*Allie Wilkinson*

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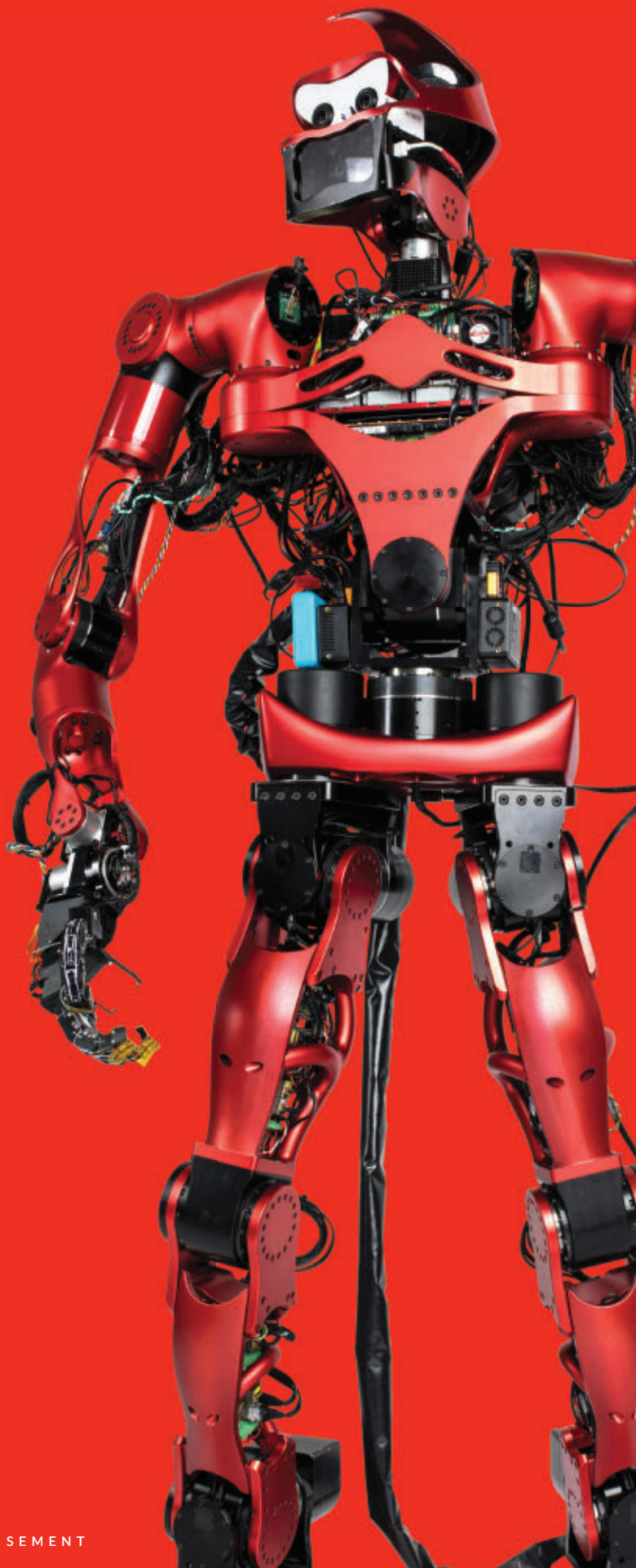

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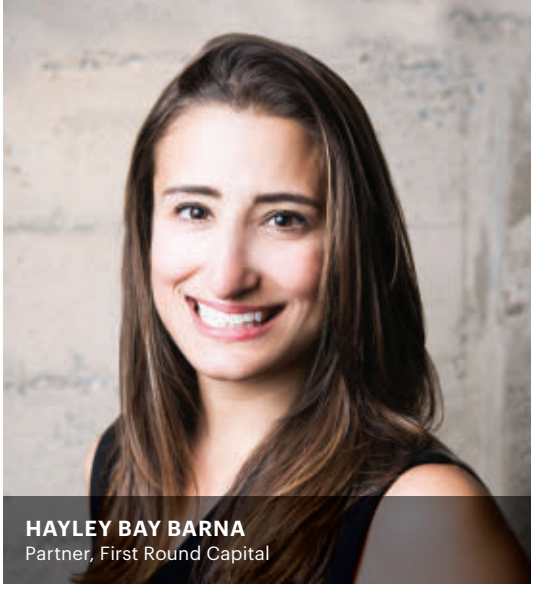


HAYLEY BAY BARNA
Partner, First Round Capital

Maya Ajmera, President & CEO of the Society for Science and Publisher of *Science News*, chatted with Hayley Bay Barna, Partner at First Round Capital, a seed-stage venture capital firm. Before joining First Round, she cofounded and grew Birchbox, a company that helped redefine online shopping for beauty and grooming products through personalized monthly subscriptions. Barna was a finalist in the 2001 Science Talent Search (STS), a competition owned and produced by the Society for Science. She serves on the Society's Board of Trustees.

You are an alumnus of the 2001 STS. How did the competition influence you?

I was lucky. I went to a great public high school that offered a science research class that I chose to take, starting with my sophomore year. The work that I did from sophomore year through senior year—when I became an STS finalist—had a big influence on me. Looking back on my career, there's a lot that I learned in terms of going beyond the "conveyer belt" of an average high school student to chart my own path, like finding a mentor, contacting different labs, getting comfortable with uncertainty and balancing priorities. Learning those skills as a high school student was tough, but they are real life skills that continue to apply to my life today.

I could have easily just been someone who focused on getting A's in my classes and doing extracurriculars, but instead I reached out to scientists whose journal articles I liked, and I found my way into being an employee at IBM's research center in Yorktown, N.Y. I was wearing a clean suit and conducting research as a 16-year-old, fitting my job between school and soccer practice. It was difficult for me to do something that maybe was considered uncool at the time, but I learned a lot.

Being named a finalist was transformational. In the other finalists, I found kids who were proud of being smart and were excited to work hard, which wasn't necessarily the value system at my school. I also think many colleges accepted me thanks to the recognition I received at STS.

You cofounded Birchbox with Katia Beauchamp while you were students at Harvard Business School in 2010 at the height of the Great Recession and before subscription services became part of the mainstream. What motivated you to launch the company?

First and foremost, it was our own experience as consumers. There were things that we loved about shopping online: the convenience, the efficiency and the access. But there was a lot that we thought was missing: the context, the fun and the delight that you get from an in-person or store experience. Online shopping felt cold. So that's really where it started. Katia and I were very different when it came to the beauty category. She's someone who loved beauty products. I was more of a tomboy who was intimidated by the category. But both of us felt that if there was a service like Birchbox that was able to deliver a personalized set of beauty samples that fit our beauty needs and our preferences, it would be an efficient way to discover new products as well as have a fun and delightful experience.

I recall you saying that Birchbox was a technology company with beauty being an element. Can you explain that?

The innovation of Birchbox at its core wasn't how we helped consumers find the right products. In fact, it wasn't about the products. It was about technology and data. We had to ask ourselves: What data do you collect from consumers? How

do you tag the attributes of different products? How do you do that at scale?

I mean, we were sending a million boxes a month. How do you sort the right products into the right boxes and get them to the right people, such that they can discover a new product that they love and end up purchasing, thus creating a good return on investment for our brand partners and delivering great value to the customers?

You were a pioneer in the subscription services movement. What wisdom would you share with your younger self as you were starting out?

First and foremost, I would try to get myself to understand that this is a marathon, not a sprint. Birchbox was like lightning in a bottle from the beginning. It was a very fast ramp. I was consistently staying up late to answer e-mails, not taking vacations, pretending to be in a conversation with friends, but really checking stats under the table on my phone. Over time, I learned that effective CEOs get the right amount of sleep, but I wish that I had learned that a little bit earlier.

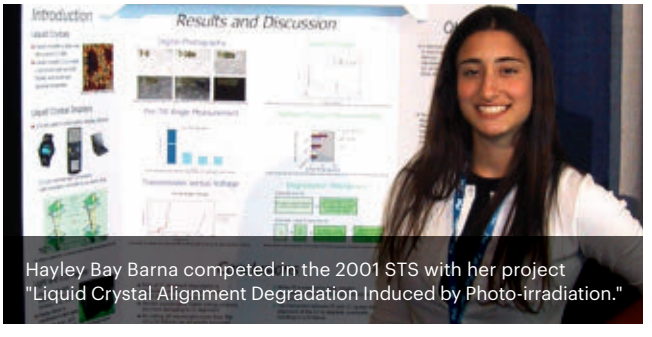
I also learned that vulnerability as a leader is very powerful. Not knowing the answers and asking the team to work together with you to come up with the answer is the most effective way to operate. I would also explain that for start-ups, making mistakes is part of the process. You just have to get more things right than you get wrong. You're not taking enough swings if you're trying to do everything perfectly along the way.

In 2015, you stepped down from your role as CEO of Birchbox and became the first female partner in the history of First Round Capital. Was it difficult to make that transition?

It was a tough transition. I think when you're a founder, it becomes your identity—or at least for me it did. It was difficult to extricate myself from that. But it was the right time.

After five years, it was clear to me that the future of the business was less about business model innovation and big changes, which is the kind of thing that I loved, and more about optimization. The organization structure also needed to change, and it would be better for that to happen if I stepped aside.

Once I made that choice, I was really drawn to being able to take what I learned from my journey and pay it forward. I wanted to help the next wave of founders, especially underrepresented founders. I did that first through angel investing, providing small amounts to founders who I believed in and whose ideas I was inspired by.



Hayley Bay Barna competed in the 2001 STS with her project "Liquid Crystal Alignment Degradation Induced by Photo-irradiation."

Does your experience as a founder inform your role as an investor?

I was an atypical founder at the time that I was funded back in 2010. When we raised our seed rounds, there were very few women being funded, especially women without a classic technical background. I was able to achieve success as a founder despite that. Now, as an investor, I really look for and believe in outsiders, whether it's people who don't fit the mold or people who want to change an industry.

What do you look for in a pitch? Do you primarily evaluate product ideas and business models, or are you investing in the person?

If you forced me to choose one, it would be the person every single time. We invest really early, and it's often just a person and a pitch deck. So, we must bet on the people and the team. A lot of what I do is reading the tea leaves.

You have been an outspoken advocate for promoting diversity and equity across entrepreneurship and venture capital. What are some of the key challenges facing underrepresented groups in venture capital today?

The numbers are dismal. Only 2 percent of venture capital funding goes to female-founded teams. Numbers are much lower for Black and Latinx founders. Why? I don't think there's any good justifiable reason, but a lot of it is because of pattern matching, which investors tend to do. Venture capitalists evaluate start-ups and entrepreneurs based on what has worked before.

It's going to take a lot of sustained effort to get to a place where the group receiving funding is representative of the population, though there has been some progress. One important lever involves diversifying the investor base. If the investor base is more representative of the population, then hopefully money will be distributed in the same way. The funds also should be accountable and sharing what their portfolio looks like, in terms of what percent of their money goes to underrepresented founders. I think all founders are starting to care more about that.

There are many challenges facing the world today. What's keeping you up at night?

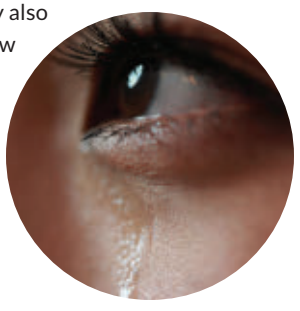
As a parent, making the right choices for my children is keeping me up at night. On a professional capacity, it's maximizing the impact that I'm making in my field. But on a more macro and long-term basis, I'm worried about the climate crisis. I feel a lot of urgency to figure out how to take what I'm doing professionally and figure out what investments we could be making that can help accelerate solutions there, whether it's technology, marketplace or consumer solutions.

AUGUST 27, 2022

SOCIAL MEDIA

Wide-eyed wonder

A new method can analyze tiny sacs of cellular messages, called exosomes, in human teardrops to detect eye disease and potentially other disorders, **Meghan Rosen** reported in "Tears fuel a new diagnostic tool" (*SN: 8/27/22, p. 5*). On Twitter, user **@cooksd** wrote: "They say the eye is a window to your soul. Now it may also be a window to your health."



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Twisted sisters

*Two black holes merged while spinning in nearly opposite directions, suggesting that they were born in different places and found each other late in life, **James R. Riordon** reported in "New type of black hole merger found"* (SN: 8/27/22, p. 13). Reader **Van Snyder** wondered if the reason for the black holes spinning in nearly opposite directions is that some sort of collision flipped the parent star of one of the black holes.

It's possible, though highly unlikely, that one of the black holes was flipped due to an earlier event, **Riordon** says. But even then, that event probably wouldn't have been a collision.

Before a dying star explodes in a supernova to form a black hole, it ejects material. The forces of those ejections could "kick" the dying star, causing it to tilt. That tilt remains even when the star forms a black hole. But the more massive a star, the harder it is to kick. A star that *is* kicked hard enough to develop a severe tilt probably would have been knocked too far away from a partner star to be able to easily merge again as a black hole, **Riordon** says.

Since the black holes in the study were spinning in such drastically different directions—one upside down relative to the other—it's unlikely that the black holes began as a pair and were knocked out of sync by such a kick, **Riordon** says.

What's more, the black holes are incredibly massive. "The lighter of the two was probably around three times the mass of the sun," **Riordon** says. "Flipping it over wouldn't be impossible, but it would be pretty tough to do while leaving the black holes close enough to merge when they did."

Get an earful

*The inner ear canals of mammal ancestors shrank abruptly about 233 million years ago, suggesting that the animals became warm-blooded around that time. The shift in ear structure may have compensated for the thinning of inner ear fluid as body temperatures rose, **Carolyn Gramling** reported in "Warm-bloodedness tracked to Triassic"* (SN: 8/27/22, p. 9).

Reader **Van Snyder** asked when warm-bloodedness, or endothermy, arose in theropods, the ancestors of modern birds. Could a look into birds' ears also provide clues to that evolutionary timeline?

There is a lot of debate among researchers about when birds developed endothermy, says paleontologist **Stephen Brusatte** of the University of Edinburgh.

Some scientists argue that a fast metabolism, which is linked to warm-bloodedness, evolved early in birds' history, **Brusatte** says. "Others argue that even many Mesozoic birds [from around 252 million to 66 million years ago] did not have modern avian-style metabolism," he says, "and that full-on endothermy evolved late in bird history."

Rather than developing small, tightly curved inner ear canals, birds and their ancestors may have gone a different evolutionary route in response to warm-bloodedness, says vertebrate paleontologist **Ricardo Araújo** of the University of Lisbon in Portugal.

Previous studies that looked at pigeons' inner ear fluid, or endolymph, suggest that the endolymph of birds is a lot thicker than that of any other tetrapod, vertebrates that have four limbs or evolved from a four-limbed ancestor, **Araújo** says. "While maintaining a more or less primitive [inner ear] morphology, they changed the chemistry of the endolymph to compensate for the augmented body temperature," he speculates.

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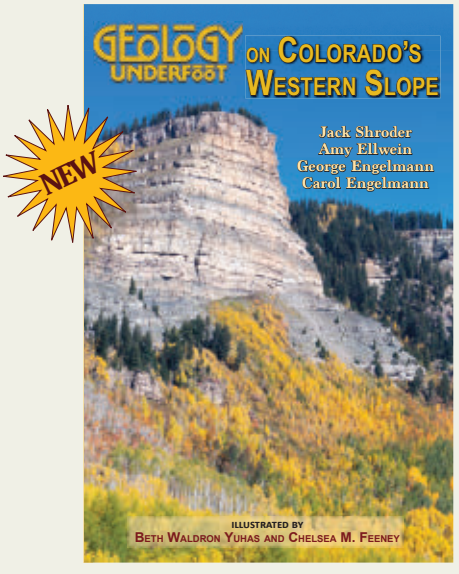

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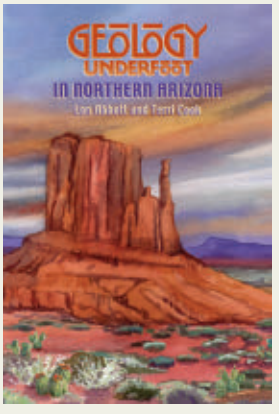

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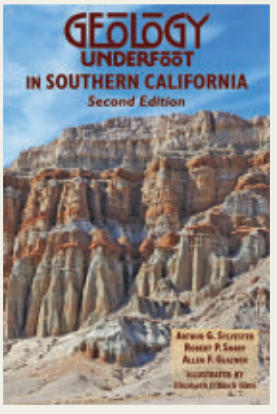

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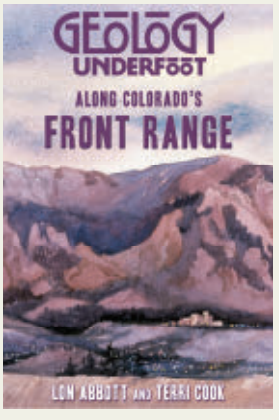

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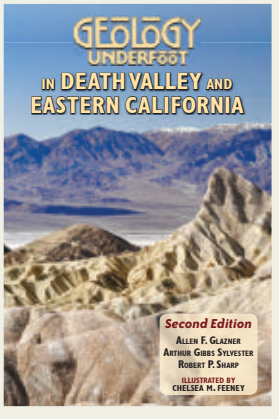

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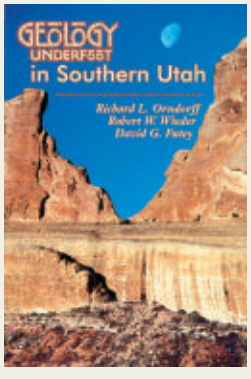

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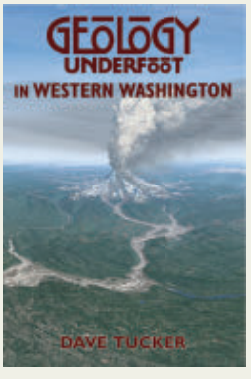

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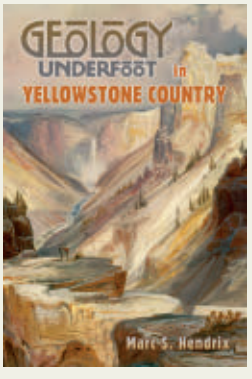

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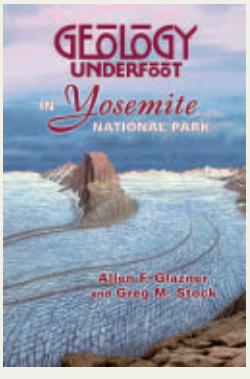

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An ancient critter with a new identity

No ifs, ands or butts about it: A teeny, roughly 530-million-year-old critter that lacked an anus is not, as once thought, the oldest member of a wide-ranging animal group that includes everything from starfish to humans.

Despite the absent anus, *Saccorhytus coronarius* fossils have no shortage of craters on their wrinkly potato-shaped bodies, including a ring of small openings around their mouth. Those holes had previously been identified as an early version of gill slits, typically used for respiration (SN: 3/4/17, p. 5). Since gill slits are found often in an animal group known as deuterostomes, their presence helped nail the critter's spot on life's family tree.

But the craters all over its body are deceiving. Fossil imaging reveals that all those holes are marks left behind by pointy spines, seen poking out of a new reconstruction of the species shown from the front (right) and back (bottom). The presence of spines helps shift the roughly millimeter-long creature into a group with nematodes and arthropods called Ecdysozoa, researchers report August 17 in *Nature*.

After millions of years, fossils often look very different from the original specimens, which makes it hard for researchers to identify biological features (SN: 4/9/22, p. 10). Most fossils of *S. coronarius* have been flattened "like a very sad balloon that's collapsed in on itself," says paleontologist Philip Donoghue of the University of Bristol in England. The new visualization brings *S. coronarius* to life — even if it does look something like an angry minion, he says.

To distinguish biological features from by-products of fossilization, Donoghue and colleagues took X-ray images of many *S. coronarius* fossils representing different stages of the organisms' decay. The images reveal that an inner tissue layer once pushed through pores and extended outward, forming spines. During fossilization, that inner layer was lost, and the holes were left behind.

While the spines pretty much lock *S. coronarius* into its new group, a puzzle remains: the absent anus. It's not inherently weird; many species lack one. Jellyfish, for example, vomit their food waste. But both deuterostomes and ecdysozoans usually have anuses, making *S. coronarius* an uncomfortable fit in either group.

Still, "if you haven't got an anus," Donoghue jokes, "you're not going to be very comfortable anywhere." — *Anna Gibbs*

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