The Search for E.T. Gets New Life | How Malaria Parasites Hide Out

Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ NOVEMBER 21, 2020

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Features

- **18** Sixty Years Into the Search for E.T. With greater observing power than ever before, scientists are intensifying their efforts to find intelligent life beyond Earth. *By Maria Temming*
- 22 A Night With Colugos COVER STORY These mysterious mammals of Southeast Asia don't get a lot of attention, but researchers are filling in the gaps on colugos' social lives and their long-distance glides. By Yao-Hua Law

News

- 6 Environmental disruptions may have made early humans more resourceful
- 7 Major climate changes at the end of the last ice age began in the Pacific Ocean
- 8 Malaria parasites lie low in the dry season

Heat might help an insecticide knock out resistant mosquitoes

9 Scientists still don't know how long immunity to the new coronavirus lasts

- **10** Right now, there's not enough evidence to say supplements can help against COVID-19
- **12** Water molecules are found on sunny parts of the moon

Falling atoms uphold Galileo's famous gravity experiment

13 Gliding was not a stop on the way to birds' powered flight, fossil evidence suggests 14 Endangered gibbons take to a rope bridge to cross a gully

> Simple behavioral nudges help people show up for court and avoid arrests

- **15** Octopus suckers are dotted with specialized cells that "taste" by touch
- **16** New analyses fail to support the recent claim of a possible sign of life in Venus' atmosphere



Departments

- 2 EDITOR'S NOTE
- 4 NOTEBOOK Keeping bats safe from the coronavirus; what makes one hardy beetle nearly unsquishable
- 28 REVIEWS & PREVIEWS Fossil Men relives the drama of discovering the hominid known as Ardi
- 30 FEEDBACK
- **32** SCIENCE VISUALIZED Volcanic ash turned a man's brain to glass

COVER A colugo in Sabah, Malaysia, has a mottled coat that helps the animal hide among the trees. Fletcher & Baylis/ Science Source



www.sciencenews.org | November 21, 2020 **1**



With a pandemic, impatience can be deadly

The question of whether dietary supplements might help combat the coronavirus reveals an essential tension between what people want and what we've got.

What we want is an end to the pandemic. We're tired of high unemployment, being stuck at home, out of school,

fearing for our health and our loved ones' lives, being told that we shouldn't see the grandparents over the holidays. We want a new drug or a vaccine. We want this nightmare to stop. But there is no end in sight.

What we've got, instead, is soaring rates of new infections, up 44 percent in the second half of October in the United States. We've got some treatments that reduce symptoms and some vaccines in the works, but no imminent rescue. And we've got an unrelenting virus that's killed more than 230,000 people in the United States, and more than 1 million worldwide.

Small wonder that people are looking for other options, asking whether dietary supplements such as vitamin D or zinc (both of which President Trump has taken) might help. Science News contributing correspondent Laura Beil examines the data on those and other supplements (Page 10). She finds that while many scientists are conducting studies to see if certain supplements can reduce symptom severity, hospitalizations or deaths, it's still not clear whether there's going to be any benefit. As one scientist told her, the best bet is "wash your hands, wear a mask, stay six feet apart."

In this issue, we also delve into the question of whether people who survive a bout with COVID-19 will be immune from future infection. As staff writer Erin Garcia de Jesus reports, because our experience with the virus is still so new, researchers don't have enough data to know whether surviving an infection will confer lifetime protection, as it does with measles, or be just a short-term deal, as it is with influenza (Page 9). The same goes for a vaccine: Will it work for life, like the measles shot? Or will vaccination have to be an annual affair, as it is for the flu? It's too soon to tell.

Saying "scientists don't yet know" is not what we want to hear. But we do need to accept this uncertainty, especially when some policy makers are arguing that the fastest route to ending the pandemic is to achieve herd immunity by stepping back and letting people get infected. If infections don't confer long-term immunity, that approach won't work. And even if it did, it would condemn many, many more people to illness, suffering and death - tragedies that don't have to happen if we are patient, follow public health guidance and wait for science to find solutions.

Other countries have figured out what to do while giving the scientists time to do their jobs. Nations that have effectively throttled the virus include Japan, Brunei, Finland, China, Thailand, New Zealand, Norway, Taiwan and South Korea. None of those places have fancy technology or miracle cures that we lack. They're relying on long-known public health measures and are trusting in science to drive policy. It's working. People are safely back at work, in school, in restaurants and in shops. If the United States chose to, we could do the same. -Nancy Shute, Editor in Chief

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Editorial/Letters: feedback@sciencenews.org Science News in High Schools: snhs@societyforscience.org Advertising/Sponsor content: ads@societyforscience.org Science News (ISSN 0036-8423) is published 22 times a year with double issues in May, July, October and December by the Society for Science and the Public. 1719 N Street, NW, Washington, DC 20036

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NOTEBOOK



Excerpt from the November 21, 1970 issue of *Science News*

50 YEARS AGO

Effects of Earth's magnetic field

Earth's magnetic field has frequently reversed at intervals of 1 million to 100 million years. A few scientists now suspect that these reversals may have had drastic effects on terrestrial life.... During the past 2.5 million years, eight species of one-cell marine animals called Radiolaria became extinct. Six of these extinctions occurred simultaneously throughout their geographic range immediately following magnetic reversals.

UPDATE: Earth's magnetic field protects the planet from cosmic and solar radiation, but that field can weaken during pole reversals. Such reversals might harm more than select species, perhaps playing a role in some mass extinctions. Direct evidence has eluded researchers, but there are suggestive examples. In 2016, scientists linked a mass extinction of marine life 550 million years ago with reversals that weakened the magnetic field. The resulting increased radiation could have led to the demise of many shallow-water organisms, the team speculated.

North American bats (Indiana bats, shown) don't carry the new coronavirus. Some scientists are socially distancing from the animals to keep it that way.

^{soapbox} **To safeguard bat health, scientists must stay distant**

There's nothing Winifred Frick likes better than crawling through guano-filled caves and coming face-to-face with bats. As chief scientist of Bat Conservation International, she is on a mission to promote understanding of the flying mammals and protect imperiled species from extinction.

For months, though, Frick has avoided research that would put her within spitting distance of bats. Her only projects to persist through the pandemic have been conducted from afar, like using acoustic monitors to eavesdrop on the animals' squeaks and swooshes. In an era of COVID-19, that "hands-off" approach and other precautions are crucial to protect both bats and people, Frick, a biologist at the University of California, Santa Cruz, and over two dozen other scientists argue online September 3 in *PLOS Pathogens*.



A set of fossilized human footprints (top; close-up of one print at bottom) found at White Sands National Park in New Mexico extends some 1.5 kilometers along what was once a lake. The person took the same route out and back.

THE -EST Trail of human footprints hints at a risky Ice Age trek

On a day over 10,000 years ago, a young adult or teen carrying a toddler hustled across a muddy flat. The fossilized human tracks, found in New Mexico's White Sands National Park, stretch for at least 1.5 kilometers — the longest set ever found from the late Ice Age, researchers report in the Dec. 1 *Quaternary Science Reviews*.

Of the 427 human footprints discovered along what was once an ancient lakeshore, researchers analyzed 90. The size and the depth of the footprints suggest that they had been made by a teen or a young woman, the researchers say. Uneven prints hint that the surface was slippery and that on one leg of the round-trip journey, the person at times shifted a child from one hip to the other. Smaller prints from perhaps a child under 3 years old appear next to the larger footprints in several spots.

"It looks like the person was in a hurry," says National Park Service biologist David Bustos. "It was a fast walk and looks like the person was tired ... but kept going." That hurry might have been due to the journey's riskiness, Bustos speculates. Mammoth and ground sloth tracks crisscrossed the human prints. The giant ground sloth appeared to have moved in circles on its hind legs, suggesting it sensed a human presence. — *Aayushi Pratap* Why the call to action? SARS-CoV-2, the virus that causes COVID-19, likely originated in bats in China. The virus has not been detected in any of the more than 40 bat species in North America. Scientists are not worried about catching SARS-CoV-2 *from* these bats. They're afraid of giving it *to* the bats — not an impossibility, the authors say, given that the United States leads the world in infections, with a total of more than 9 million as of early November.

"We can't tell bats to socially distance," Frick says. "We want to reduce the chance that there's any pathogen transfer across animals, full stop." The goal is to prevent viral spillover.

It's unknown if bats are susceptible to SARS-CoV-2 infection, or if the virus would make them sick — bats rarely become ill from the viruses they carry (*SN*: *3/14/20*, *p*. *7*). But infected bats might spread the virus back to humans.

Worse, introducing SARS-CoV-2 to



Biologist Winifred Frick used to study bats up close. She now urges a distanced approach to protect the animals from the new coronavirus.

North American bats carrying other types of coronaviruses could make the new virus more infectious. Either scenario could stoke fears about bats spreading disease, presenting a major hurdle for conservationists trying to bolster support for the animals.

Frick and colleagues recommend replacing fieldwork with distanced alternatives whenever possible. Researchers can pick through guano to identify bat species and reveal the viruses carried, and cameras outside caves and roosts can give a sense of abundance. Scientists can even resurrect evidence of pathogens from the preserved bat tissues in museums. But not all bat research can be socially distanced, and that means taking precautions, like ensuring members of field crews are healthy and wear personal protective gear. White-nose syndrome research already requires disposable suits and gloves (*SN: 6/8/19, p. 8*). Now, masks will be a regular part of the ensemble.

For Frick, speaking up for bats has always been a part of being a biologist. As human populations expand into shrinking bat habitat, viral spillover events and other harmful interactions become more likely. The pandemic has put the need to speak up "on steroids now," she says. — Jerimiah Oetting Editor's note: Jerimiah Oetting is a 2020 master's graduate from the University of California, Santa Cruz.

SCIENCE STATS NASA asteroid sampler took a big bite out of Bennu

NASA's OSIRIS-REx spacecraft is a cosmic rock collector. On October 20, scientists on Earth got word that the spacecraft had successfully grabbed rocks from a near-Earth asteroid called Bennu.

OSIRIS-REx (illustrated below) aimed to gather at least 60 grams. On October 29, the team announced the collector was full to capacity when it pulled away from Bennu, which means the craft carried about two kilograms of material. "Imagine a sack of flour at the grocery store," mission principal investigator Dante Lauretta of the University of Arizona in Tucson said at a news conference. OSIRIS-REx will return to Earth in 2023, where scientists will analyze the rocks in hopes of learning about solar system and Earth history (*SN: 1/19/19, p. 20*). — *Lisa Grossman*





MYSTERY SOLVED Beetle's sturdy secret isn't ironclad

The diabolical ironclad beetle's exoskeleton is so tough that the insect can survive getting run over by a car, and many would-be predators don't stand a chance of cracking a beetle open. *Phloeodes diabolicus* is basically nature's jawbreaker.

Now, analyses of the beetle's armor have revealed the secrets to its strength. Tiny interlocked and impact-absorbing structures help the insect survive crushing forces around 39,000 times its own body weight, researchers report in the Oct. 22 *Nature*. Zipperlike ridges connect the exoskeleton's top and bottom halves around vital organs and resist bending. A damage-resistant joint connects the exoskeleton's left and right sides like jigsaw puzzle pieces. When the beetle is squashed, tiny cracks form in the protein glue that holds together the joint's tissue layers. Those fractures help the joint absorb impacts without snapping. – *Maria Temming*



HUMANS & SOCIETY

Ecological shifts catalyzed human adaptability

Stone tool transition occurred alongside resource variability

BY BRUCE BOWER

An unforgiving environmental twist deserves at least some credit for the behavioral flexibility that has characterized the human species since our origins about 300,000 years ago, a study suggests.

For hundreds of thousands of years in parts of East Africa, food and water supplies remained fairly stable. But new evidence shows that starting about 400,000 years ago, hominids and other animals faced an environmental reckoning, says a team led by Rick Potts, a paleoanthropologist at the Smithsonian Institution in Washington, D.C.

The climate began to fluctuate dramatically. Faults caused by volcanic eruptions fractured the landscape. Large animals died out and were replaced by smaller creatures. These changes heralded a series of booms and busts in the resources hominids needed to survive, the team reports October 21 in *Science Advances*.

Around that time, hominids at a site called Olorgesailie in what's now Kenya transformed their culture. That shift, between about 500,000 and 320,000 years ago, was probably influenced by increasingly unpredictable periods of water and food scarcity, the scientists say.

Hand axes and other cutting tools made of local stone had dominated toolkits in the Olorgesailie area for 700,000 years before that transition. After that, Middle Stone Age tools, such as spearpoints made from rock from distant sources, gained popularity, Potts' team has previously found (*SN: 4/14/18, p. 8*). Middle Stone Age tools were smaller and more carefully crafted implements. Widely scattered hominid groups began to trade with one another to obtain rock suitable for toolmaking and other resources.

Potts has long argued that hominids at Olorgesailie evolved genetically and behaviorally to handle frequent climate shifts. But the new study indicates that ancient humans, perhaps building on the achievements of an earlier *Homo* population in the region, adapted to a number of environmental forces, not just climate change, he says. "A cascade of ancient ecological changes led to alternating periods of resource abundance and scarcity, likely helping to make us the most adaptable [hominid] species that ever existed."

Erosion at Olorgesailie has destroyed sediment layers dating to the Middle Stone Age transition. So the team hired a Kenyan company to drill as deeply as possible in the Koora basin, about 24 kilometers south of Olorgesailie. The 139-meter-long extracted core spans much of the last 1 million years, making it the best environmental record of that period for anywhere in Africa, Potts says.

Chemical and microscopic studies of the core revealed signs of volcanic eruptions having created faults that fragmented the landscape starting about 400,000 years ago. Small ponds and lakes then replaced larger lake basins at a time when rainfall became inconsistent. Intermittent, increasingly frequent dry periods led to severe water shortages.

Vegetation changes followed, core evidence indicates. Shifts back and forth from grassy plains to forests denied large animals, such as elephants, regular access to former grazing areas. Faults also Drilling in Kenya's Koora basin produced sediments recording much of the last 1 million years of environmental events in the area.

reduced the size of any available grazing areas. Smaller animals with diverse diets, including antelope and pigs, became prominent in the area during the Middle Stone Age. Tools may have been tailored for hunting and processing smaller prey, the researchers say.

Each boom and bust in resource availability during the Middle Stone Age generally lasted for a few thousand years, based on evidence from the core, Potts says. That time resolution is a big improvement over previous studies using global climate data to reconstruct African environmental changes that occurred over tens of thousands of years, says paleoanthropologist Manuel Will of the University of Tübingen in Germany, who did not participate in the investigation.

The team's findings "provide the best evidence yet for a link between environmental changes in East Africa and the spread of Middle Stone Age technology and increased mobility across the landscape," says paleoanthropologist Chris Stringer of the Natural History Museum in London. It's still unclear where in Africa, as well as when and by whom, Middle Stone Age tools were invented, but early humans would have found such implements invaluable for adapting to environmental disruptions, he says.

Olorgesailie's Middle Stone Age boomand-bust scenario may not apply to other parts of Africa where spearpoints and related implements didn't appear until later, cautions archaeologist Lyn Wadley of the University of the Witwatersrand in Johannesburg. In those settings, such tools may have proved useful even for groups that enjoyed relatively stable water and food sources.

The Pacific seeded big Ice Age events

Melting of Alaska's glaciers could have large-scale climate effects

BY GLORIA DICKIE

The retreat of North America's ice sheets in the latter years of the last ice age may have begun with catastrophic losses of ice into the North Pacific Ocean along the coast of modern-day Alaska and British Columbia.

In a study published online October 1 in *Science*, researchers report that these pulses of rapid ice loss from what's known as the western Cordilleran ice sheet contributed to, and perhaps triggered, the massive calving of the Laurentide ice sheet into the North Atlantic Ocean between 42,000 and 11,500 years ago. The collapse of the Laurentide ice sheet, which covered much of Canada and parts of the United States, ultimately led to major disturbances in the global climate.

The findings cast doubt on the longheld idea that hemispheric-scale changes in climate originate in the North Atlantic. The work also suggests that the melting of Alaska's remaining glaciers, though less extreme than past purges, could have farranging effects on ocean circulation and climate in coming centuries.

"People typically think that the Atlantic is where all the action is, and everything else follows," says paleoclimatologist Alan Mix of Oregon State University in Corvallis. "We're saying it's the other way around."

In 2013, Mix and colleagues pulled sediment cores from the Gulf of Alaska's seafloor to figure out how the Cordilleran ice sheet had changed before the end of the last ice age. These cores contained distinct layers of sediment deposited by the ice sheet's calved icebergs during four occasions over the last 42,000 years. Radiocarbon dating revealed that, surprisingly, the Cordilleran's ice purges preceded the Laurentide's periods of abrupt ice loss, known as Heinrich events, by 1,000 to 1,500 years every single time.

"We've long known that these Heinrich events are a big deal," says coauthor Maureen Walczak, a paleoceanographer also at Oregon State. "They have global climate consequences associated with increases in atmospheric CO₂, warming in Antarctica... and the weakening of the Asian monsoon in the Pacific. But we've not known why they happened."

Though scientists can now point the finger at the North Pacific, the mechanism is unclear. Mix and Walczak propose some ideas. Perhaps the freshwater deposited in the North Pacific traveled northward through the Bering Strait, across the Arctic Ocean and down into the North

Testing of sediment in the Gulf of Alaska (shown) suggests that the melting of a North American ice sheet into the North Pacific Ocean near the end of the last ice age sparked ice losses in the Atlantic.



Atlantic. There, the buoyant freshwater capped the ocean's denser saltwater, preventing deeper, colder water from reaching the surface. This process could have led to the water getting warmer, destabilizing the adjacent ice sheet.

Another theory: The lower elevation of the diminished Cordilleran ice sheet altered how surface winds entered North America. Normally, the ice sheet would act like a fence, diverting winds and water vapor southward as they entered North America. Without this barrier, the transport of heat and freshwater between the Pacific and Atlantic ocean basins was disrupted, changing the Atlantic's salinity and ultimately delivering more heat to the ice there.

Today, many of Alaska's glaciers, remnants of the Cordilleran ice sheet, are in a state of rapid retreat due to climate change. This melting ice, too, drains into the Pacific and Arctic oceans, raising sea levels and interfering with normal ocean mixing processes. "Knowing the failure of ice in the North Pacific seemed to presage really rapid ice loss in the North Atlantic, that's kind of concerning," Walczak says.

If the ice melt follows similar patterns to the past, it could yield significant global climate events. But Mix cautions that the amount of freshwater runoff needed to trigger changes in the global ocean and climate is unknown.

The timing of such changes is also unclear. If the Atlantic's past ice losses occurred due to a change in deep ocean dynamics triggered by Pacific melting, that signal likely took hundreds of years to reach the other remaining ice sheets. If, however, those past losses were triggered by a change in sea levels or winds, it would indicate that the world's remaining ice sheets could be affected a bit faster, though still not this century.

Records of climate change in the Pacific have been hard to come by, says Richard Alley, a glaciologist at Penn State. "These new data may raise more questions than they answer," he says. "But by linking North Pacific Ocean circulation ... to the global template of climate oscillations, the new paper gives us a real advance in understanding all of this."

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GENES & CELLS

Malaria hides in the dry season

Altered gene activity helps the parasite lie low in the body

BY ERIN GARCIA DE JESUS

Malaria parasites survive tough times by not being too clingy.

During Africa's dry season, when mosquitoes are scarce, malaria parasites have a hard time spreading to new hosts. So the parasites hide out in the human body by keeping the cells they infect from clinging to blood vessels, researchers report October 26 in *Nature Medicine*. Because of this, most infected cells get removed quickly from circulation and parasite levels in the body remain low, making people less sick and allowing the parasite to stay undetected.

Doctors have long observed that

malaria symptoms wane during the dry season, but the reason had been unclear.

Knowing how malaria parasites persist without causing disease, until mosquitoes return to ferry parasites to new victims, could help efforts to control malaria, says Martin Rono, a parasitologist at the KEMRI-Wellcome Trust in Kilifi, Kenya, who was not involved in the work.

The malaria parasite *Plasmodium falciparum* infects red blood cells as part of a complex life cycle. Inside a cell, the parasite produces proteins that dock on the cell's exterior and make it stick to blood vessels, allowing the parasite to replicate to high levels. Otherwise, infected cells would get removed from the body by the spleen.

Typically, only the early life stages of the parasite circulate in the blood, while older parasites thrive inside the cells adhered to blood vessels, says biologist Silvia Portugal of the Max Planck Institute for Infection Biology in Berlin.

In lab tests, heated deltamethrin proved to be a quick killer of mosquitoes (one shown in a colorized scanning electron micrograph).

mosquito-borne diseases like malaria. But "mosquitoes the world over are showing resistance to deltamethrin and [similar] compounds," says Bart Kahr, a crystallographer at New York University.

A heated form of deltamethrin may stand a better chance of killing these resistant pests, Kahr and colleagues report in the Oct. 27 *Proceedings of the National Academy of Sciences*. More effective pesticides could be a boon for regions like sub-Saharan Africa, where malaria is a major public health problem.

Kahr's team increased the potency of a deltamethrin dust spray by melting a vial of it — either by placing it for five minutes in an oil bath heated to 150° Celsius or by popping it in a 700-watt microwave for the same amount of time. Microscopic deltamethrin crystals in the original spray have a haphazard structure, but the melted deltamethrin crystals solidified into starburst shapes when they cooled.

Chemical bonds between molecules in

"It was very surprising," she says, to see that dry-season parasites behaved differently in the lab — the cells weren't sticking.

While at Heidelberg University Hospital in Germany, Portugal and colleagues identified about 600 people in Mali infected with malaria in 2017 and 2018. The researchers ruled out the possibility that either differences in parasite genetics or host immunity could explain the parasites' seasonality.

But when the team compared which genes were turned on or off in parasites taken from asymptomatic people in the dry season and symptomatic people in the wet season, 1,607 genes had distinct seasonal patterns.

When the wet season ends, the parasite may alter its genetics to make red blood cells less sticky — perhaps by making fewer of certain proteins or altering the proteins in some way. It's unclear which altered genes may affect stickiness.

the starburst-shaped crystals are not as strong as those in the original microcrystal structure. So, when a mosquito lands on a dusting of starburst-shaped crystals, the deltamethrin molecules should be absorbed more easily into the insect.

The team tested the more potent version of deltamethrin on lab-bred mosquitoes from two species, including one that transmits malaria. Altered deltamethrin knocked out about half of 80 exposed mosquitoes within about 20 minutes. It took several hours for the original spray to knock out half of a different group of 80 exposed mosquitoes.

Heat treatment for deltamethrin sprays "might increase their toxicity, but there are several obvious experiments that we would need to do before we would even think about adding this to the production system," says Janet Hemingway of the Liverpool School of Tropical Medicine in England, who studies mosquito insecticide resistance.

Scientists need to test the new version against pesticide-resistant mosquitoes, she says, and ensure the more toxic form is safe for people to be around.



earth & environment Heat enhances a mosquito killer

A simple chemical trick makes an insecticide more potent

BY MARIA TEMMING

A few minutes in the microwave made a common insecticide about 10 times as lethal to mosquitoes in lab experiments.

Deltamethrin is used in home sprays and bed nets to curb the spread of

DENNIS KUNKEL MICROSCOPY/SCIENCE SOURCE



Reinfections raise immunity questions

How strong and lasting is the body's defense against COVID-19?

BY ERIN GARCIA DE JESUS

Even as President Donald Trump claims his bout with COVID-19 has granted him immunity, reports of people getting the disease a second time are emerging.

The specter of reinfection has renewed a debate over whether letting communities attempt to achieve herd immunity, the point at which enough people are immune to a pathogen to slow its spread, is a viable or ethical strategy for ending the pandemic. Experts estimate that around 60 percent of a population would need to be infected with SARS-CoV-2, the virus that causes COVID-19.

Reinfections appear to be rare, but because SARS-CoV-2 is new, scientists are still studying to what extent immunity might protect a person. If immunity wanes quickly, that will set the stage for recurrent outbreaks unless a vaccine is available.

Scientifically speaking, long-term immunity means resistance gained through the immune system's exposure to a disease, either by infection or vaccination. Lasting immunity comes via both T cells that remember a pathogen and trigger a rapid response, and B cells that produce antibodies, proteins that fight off a pathogen. In some cases, these defenses are strong enough to prevent a repeat infection. In other cases, the immune response may make a second bout of a disease less severe or less easily transmitted to others.

For some illnesses, such as measles, antibodies may last in the blood for a lifetime. But for SARS-CoV-2, it's unknown how long antibodies stick around. Studies so far have shown that they can dwindle shortly after an infection, though in most people, levels stay relatively stable over a span of three to six months.

What's "promising" is that the majority of people with COVID-19 appear to be making neutralizing antibodies, says Aubree Gordon, an epidemiologist at the University of Michigan in Ann Arbor. Neutralizing antibodies can prevent a virus from infecting cells and replicating.

But some studies of B cells suggest there might not be great immune memory for the coronavirus. One study found that during a COVID-19 infection, the spleen and lymph nodes don't properly activate the cells types capable of becoming memory B cells, which rapidly produce new antibodies if a person is reexposed to a pathogen. Without that immunological memory, immunity to SARS-CoV-2 may not last very long if antibody levels do wane, researchers report in the Oct. 1 *Cell*.

In addition to developing neutralizing antibodies, COVID-19 patients typically develop an immune response involving T cells. Even recovered patients without a detectable antibody response have Since scientists don't know how long immunity to COVID-19 lasts, precautions such as wearing a mask may need to continue for some time.

these T cells in their blood, researchers report October 15 in *Emerging Infectious Diseases*.

But the role of T cells remains unclear. In people who were infected with the coronavirus responsible for the 2003– 2004 SARS outbreak, memory T cells persisted for up to 11 years, studies have shown. But that virus no longer circulates, so it's impossible to say whether those T cells can protect people.

Some people may already have memory T cells that can recognize pieces of SARS-CoV-2, left over from previous exposures to coronaviruses that cause the common cold, researchers report August 4 in *Science*. These "crossreactive" T cells might help reduce the length or severity of COVID-19 illness. On the flip side, they could make the disease worse, perhaps by overstimulating the immune system and causing a cytokine storm, which is involved in some severe COVID-19 cases.

The fact that there are only a small number of documented cases of people getting infected with SARS-CoV-2 twice has only added to the questions surrounding immunity. "We can't really say that reinfections are telling us a whole lot at this point," says Brianne Barker, an immunologist at Drew University in Madison, N.J., either about immunity or whether vaccines will provide long-term protection or will need to become part of our yearly routine, like flu shots.

And without knowing how long immunity lasts, and how much that varies from person to person, it's impossible to know whether ending the pandemic through herd immunity is even possible. What is clear, experts say, is that attempting to do so without a vaccine will lead to more illness and death.

"Throughout the United States, we are nowhere near herd immunity," Gordon says. "Taking the approach of herd immunity through natural infection will lead to hundreds of thousands of unnecessary deaths." BODY & BRAIN

Can supplements fight COVID-19?

With little direct evidence, scientists begin to investigate

BY LAURA BEIL

People have long turned to vitamins to try to protect themselves from disease. The ongoing pandemic is no different — especially with headlines that promise, "This one supplement may save you from COVID-19."

It also helps to have celebrity enthusiasts. When President Donald Trump was diagnosed with COVID-19, his pill arsenal included vitamin D and zinc. And in September, infectious diseases expert Anthony Fauci touted taking vitamins C and D as ways that might generally boost the immune system in an Instagram chat with actress Jennifer Garner. "If you're deficient in vitamin D, that does have an impact on your susceptibility to infection," he noted. "I would not mind recommending, and I do it myself, taking vitamin D supplements."

But whether over-the-counter supplements can actually prevent, or even treat, COVID-19 is not clear. Since the disease is so new, researchers haven't had much time to study it. Instead, scientists have mostly relied on fresh takes on old data. Some studies have looked at outcomes of patients who routinely take certain supplements — and found some promising hints. But so far, there's little data from the kinds of scientifically rigorous experiments that give doctors confidence when recommending supplements.

Here's what scientists currently know about three supplements that are getting plenty of attention around COVID-19.

Vitamin D

Called "the sunshine vitamin" because the body makes it naturally in the presence of ultraviolet light, vitamin D is one of the most heavily studied supplements (*SN:* 2/2/19, *p.* 16). The vitamin, a building block of hormones that helps strengthen the immune system, is also found in certain foods, including fish and fortified milk products.

A meta-analysis published in 2017 in *BMJ* suggested that a daily vitamin D supplement might help prevent respiratory infections, particularly in people who are deficient in the vitamin. Risk of deficiency is highest during dark winters at high latitudes and among people with darker skin, as the skin pigment melanin inhibits production of vitamin D.

"If you have enough vitamin D in your body, the evidence doesn't stack up to say that giving you more will make a real difference," says nutrition scientist Susan Lanham-New of the University of Surrey in England.

In May, in *BMJ Nutrition, Prevention & Health*, Lanham-New and colleagues published a summary of existing evidence and concluded that there's only enough to recommend vitamin D to help with COVID-19 prevention for people who are deficient. That paper made inferences from how vitamin D works against other respiratory tract infections and improves immune health.

And taking too much vitamin D can create new health problems, stressing certain internal organs and leading to a dangerously high calcium buildup in the blood. The recommended daily allowance for adults is 600 to 800 international units per day; the upper limit is considered to be 4,000 IU daily.

Few studies have looked directly at whether vitamin D makes a difference against COVID-19, but more than a dozen studies are now under way, including a large one led by epidemiologist and preventive medicine physician JoAnn Manson of Harvard Medical School and Brigham and Women's Hospital in Boston. That study aims to recruit 2,700 people across the United States, including individuals with newly diagnosed infections and close household contacts.

The goal is to determine whether newly diagnosed people given high doses of vitamin D-3,200 IU per day — are less likely than people who get a placebo to experience severe symptoms and need hospitalization. "The biological plausibility for a benefit in COVID is compelling," Manson says, given the nutrient's theoretical ability to impede the severe inflammatory reaction that can follow coronavirus infection. "However the evidence is not conclusive at this time."

Zinc

Zinc, a mineral found naturally in certain meats, beans and oysters, plays several supportive roles in the immune system, which is why zinc lozenges are hot sellers in cold and flu season. Zinc also helps with cell division and growth.

Studies of using zinc for colds — which are frequently caused by coronaviruses suggest that using a supplement right after symptoms start might make them go away more quickly. That said, a clinical trial from researchers in Finland and the United Kingdom, published in January in *BMJ Open*, did not find any value in zinc lozenges as a treatment for colds. Some researchers have theorized that inconsistencies in data for colds may be explained by varying amounts of zinc released by different lozenges.

In July, researchers in Germany wrote in *Frontiers in Immunology* that current evidence "strongly suggests great benefits of zinc supplementation" based on looking at similar infections, including SARS, caused by a different coronavirus. For example, studies suggest that giving zinc reduces the risk of death from a pneumonia infection. The researchers cite evidence that zinc might theoretically help prevent the new coronavirus from entering the body and help slow the virus's replication when it does.

In September, researchers from a Barcelona hospital reported that among 249 patients studied, those who survived COVID-19 had higher zinc levels in their blood plasma than those who died.

Overall, though, the jury is still out, says Suma Thomas, a cardiologist at the Cleveland Clinic Foundation. Thomas led a team that in June published a review of the evidence for popular supplements in the *Cleveland Clinic Journal of Medicine*. Given what's already known, zinc could possibly decrease the duration of infection but not the severity of symptoms, she says, particularly among people who are deficient. About a dozen studies are

Vitamin C may

help prevent

infection and

tamp down the

inflammatory

reaction that can

cause severe

symptoms.

now looking at zinc for COVID-19 treatment. Thomas and colleagues are comparing symptom severity and future hospitalization in COVID-19 patients who take zinc with and without high doses of vitamin C versus patients who receive ordinary care but no supplement. Results are expected soon, she says.

Vitamin C

Found naturally in fruits and vegetables, vitamin C is a potent antioxidant that's important for a healthy immune system and preventing inflammation.

Data on vitamin C are often contradictory, Thomas cautions. One review from Chinese researchers, published in February in the *Journal of Medical Virology*, noted that human studies find a lower incidence of pneumonia among people taking vitamin C, "suggesting that vitamin C might prevent the suscepti-

> bility to lower respiratory tract infections under certain conditions."

But for preventing colds, a 2013 review of 29 studies didn't support the idea that supplements of vitamin C could help in the general population. However, the authors wrote, given that vitamin C is cheap and

safe, "it may be worthwhile for common cold patients to test on an individual basis whether therapeutic vitamin C is beneficial."

About a dozen studies are under way or planned to examine whether vitamin C added to coronavirus treatment helps with symptoms or survival, including Thomas' study at the Cleveland Clinic.

In a review published in the November-

December *Nutrition*, researchers from Belgium concluded that vitamin C may help prevent infection and tamp down the dangerous inflammatory reaction that can cause severe symptoms, based on what is known about how the nutrient works in the body.

Melissa Badowski, a pharmacist who specializes in viral infections at the University of Illinois at Chicago College of Pharmacy, and colleague Sarah Michienzi conducted an extensive look at all supplements that might be useful against the coronavirus. There's still not enough evidence to know whether supplements are helpful, the pair concluded in June in *Drugs in Context*.

"It's not really clear if it's going to benefit patients," Badowski says.

While supplements are generally safe, she adds that nothing is risk free. The best way to avoid infection, she says, is still to follow the advice of epidemiologists and public health experts: "Wash your hands, wear a mask, stay six feet apart."



Why we don't talk enough about men's reproductive health

NEW FROM UC PRESS

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-Steven Epstein, author of *Inclusion: The Politics of Difference* in Medical Research



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ATOM & COSMOS

Sunny parts of the moon contain water

The molecules may be stuck between soil grains or in impact glass

BY MARIA TEMMING

Past observations suggest there's water on the moon. New telescope observations conclude those findings hold water.

Spacecraft have seen evidence of water ice in permanently shadowed craters at the lunar poles, as well as hints of water molecules on the sunlit surface. But water sightings in sunlit regions have relied on detection of infrared light at a wavelength that could also be emitted by other compounds containing hydrogen and oxygen.

Now, the Stratospheric Observatory for Infrared Astronomy, or SOFIA, has detected near the lunar south pole an infrared signal unique to water, scientists report October 26 in Nature Astronomy. "This is the first unambiguous detection of molecular water on the sunlit moon," says study coauthor Casey Honniball, a lunar scientist at NASA's Goddard Space Flight Center in Greenbelt, Md. "This shows that water is not just in the permanently shadowed

Observations from the SOFIA telescope support previous hints of water on the moon's sunlit surface.

MATTER & ENERGY Galileo gravity test still holds up

Different types of atoms fall with the same acceleration

BY EMILY CONOVER

According to legend, Galileo dropped weights off of the Leaning Tower of Pisa, showing that gravity causes objects of different masses to fall with the same acceleration. In recent years, researchers have taken to replicating this test in a way that the Italian scientist probably never envisioned – by dropping atoms.

A new study describes the most sensitive atom-drop test so far and shows that Galileo's gravity experiment still holds up - even for individual atoms. Two different types of atoms had the same acceleration within about a part per trillion, or 0.0000000001 percent, physicists report in a paper in press in Physical Review Letters.

Compared with a previous atom-drop test, the new research is a thousand times as sensitive. "It represents a leap forward," says physicist Guglielmo Tino of the University of Florence.

Physicist Mark Kasevich of Stanford University and colleagues compared rubidium atoms of two different isotopes, atoms that contain different numbers of neutrons in their nuclei. The team launched clouds of these atoms about 8.6 meters high in a tube under vacuum. As the atoms rose and fell, both varieties accelerated at essentially the same rate.

In confirming Galileo's experiment, the result upholds the equivalence principle, a foundation of Albert Einstein's theory of gravity, general relativity. That principle states that an object's inertial mass, which determines how much it accelerates when force is applied, is equivalent to its gravitational mass, which determines regions ... there are other places on the moon that we could potentially find it."

These observations could inform future missions to the moon that will scout out lunar water as a potential resource for human visitors.

SOFIA, operated by NASA and the German Aerospace Center, is a 2.5-meter telescope that rides aboard a jumbo jet to get clear views of the sky (SN: 3/19/16, p. 4). During a 2018 flight, the telescope detected 6-micrometer infrared light emanating from the moon's Clavius crater. This wavelength of light is generated by the vibrations of sunlight-heated water molecules, but not other compounds containing hydroxyl, which consists of an oxygen atom bound to a hydrogen atom.

"I thought it was really brilliant" to confirm the presence of water on the sunlit moon with observations at this wavelength, says Jessica Sunshine, a planetary scientist at the University of Maryland in College Park. Though involved in past observations that spotted hints of water on the moon. Sunshine was not involved in the new study.

Based on the brightness of the

how strong a gravitational force it feels. The upshot: An object's acceleration under gravity doesn't depend on its mass or composition.

So far, the equivalence principle has withstood all tests. But atoms, which are subject to the strange laws of quantum mechanics, could reveal weak points. "When you do the test with atoms ... you're testing the equivalence principle and stressing it in new ways," Kasevich says.

He and colleagues studied the tiny particles using atom interferometry, which takes advantage of quantum mechanics to make extremely precise measurements. During the atoms' flight, the scientists put the atoms in a state of quantum superposition, in which particles don't have one definite location. Instead, each atom existed in a superposition of two locations, separated by up to seven centimeters. When the two locations were brought back together, each atom



observed infrared light, Honniball's team calculated a water concentration of about 100 to 400 parts per million around the crater. That's less than half a liter of water per metric ton of lunar soil. This concentration was about what the team expected, based on past observations.

These water molecules are not frozen in ice, like the water in permanently shadowed regions of the moon. Nor is the water liquid, Sunshine says. "There's no moon puddles." Instead, the water molecules are thought to be bound inside some other material on the lunar surface.

"The only way for us to be seeing water on the [sunlit] moon is if it is sheltered from this harsh environment," says Honniball. Water molecules could be encased in glass forged by tiny impacts, or wedged between soil grains that shield the water from solar radiation.

Water could have formed on the moon itself, from hydrogen ions in the continual outward flow of charged particles from the sun reacting with oxygen on the surface. Or, if the water is stored in impact glass, it could have been delivered to the moon by micrometeorites.

interfered with itself in a way that precisely revealed its relative acceleration.

Many scientists think the equivalence principle will eventually falter. "We have reasonable expectations that our current theories ... are not the end of the story," says physicist Magdalena Zych of the University of Queensland in Brisbane, Australia. That's because quantum mechanics, which describes the counterintuitive physics of the very small, doesn't mesh well with general relativity, leading scientists on a hunt for a theory of quantum gravity that could unite these ideas. Many scientists suspect the new theory will violate the equivalence principle by an amount too small to have been detected with tests performed thus far.

But physicists hope to improve such atom-based tests in the future, for example by performing them in space, where objects can free-fall for extended periods of time. So there's still a chance to prove Galileo wrong.

Bat-winged dinosaurs were gliders

These species were a dead end on the path to bird flight

BY CAROLYN GRAMLING

Only two dinosaur species are known to have had wings made of stretched skin, like bats. But unlike bats, these dinos were capable of only limited gliding between trees, an analysis suggests. That gliding turned out to be a dead end along the path to the evolution of bird flight.

"They are a failed experiment," says paleontologist Alexander Dececchi.

Fliers with feathered wings, rather than membranous wings, appear in the fossil record just a few million years after the bat-winged dinosaurs. Those feathered fliers may have outcompeted the gliders, Dececchi, of Mount Marty University in Sioux Falls, S.D., and colleagues suggest October 22 in *iScience*.

The two bat-winged species — Yi qi (SN: 5/30/15, p. 8) and Ambopteryx longibrachium — lived about 160 million years ago. These crow-sized creatures were theropod dinosaurs, the same group that includes the ancestors of birds. So the discovery of bat-winged theropods shook up ideas about the evolution of bird flight. Scientists had thought that path, while a bit circuitous, centered around variations of just one basic, birdlike body plan.

But whether *Yi* and *Ambopteryx* were actually adept at flying, such as being

Even though it had batlike wings, the dinosaur Ambopteryx longibrachium (illustrated) was more of a short-distance glider than a true flier.



able to launch from the ground or flap their wings, wasn't clear. To assess flight capability, Dececchi and colleagues used laser-stimulated fluorescence imaging, which can pick up details of soft tissues such as membranes or cartilage in fossils, to reanalyze the animals' anatomy. After estimating body weight, wing shape and wingspan, the team simulated how those features might translate into flapping, gliding or launching.

The analyses confirm that these dinosaurs had vastly different wing structures from the feathered fliers — showing that these two flight strategies evolved independently. *Yi* and *Ambopteryx*, for example, had elongated forelimb bones between their membranous wings, as well as a special wristbone to help support the membrane. The wings of birds, on the other hand, consist of elongated metacarpals, similar to finger bones.

Yi and *Ambopteryx* were capable of gliding only short distances from tree to tree: The ratio of body mass to wing area was a bit too high for the animals to stay aloft to glide longer distances.

The dinosaurs also lacked other attributes of powerful fliers. For example, the orientation of the wings suggests they weren't designed for rotational flapping. And the dinos' breastbones show no evidence of places where key flight muscles attach in modern birds (*SN*: 4/14/18, p. 9).

That the bat-winged dinosaurs weren't great fliers isn't a surprise, says paleontologist Jingmai O'Connor of the Chinese Academy of Sciences in Beijing, who with colleagues described *Ambopteryx* in a 2019 study. No bat-winged dinosaurs appear in the fossil record after the Jurassic Period, so it already seemed likely that they weren't a success, O'Connor says.

What the animals do highlight is "the experimentation with different modes of flight," she says. Birds, it's clear, weren't the only flying dinosaurs — and these fossils reveal that flight itself evolved multiple times among dinosaurs.

A rope bridge restored an ape highway

Simple artificial structures could help join fragmented forests

BY CAROLYN WILKE

With acrobatic leaps, Hainan gibbons can cross a great gully carved by a 2014 landslide in the forest on China's Hainan Island. But when a palm frond caught by the vaulting apes to steady their landing started to sag, researchers rushed to provide a safer route across.

Though slow to adopt it, the gibbons increasingly traveled on a bridge made of two ropes that was installed across the 15-meter gap, the researchers report October 15 in *Scientific Reports*. Such cords might also help connect forests that have been fragmented by human activities and so aid conservation efforts for gibbons and other canopy dwellers.

"Fragmentation is becoming an increasing problem," says Tremaine Gregory, a conservation biologist at the Smithsonian's National Zoo and Conservation Biology Institute in Washington,

HUMANS & SOCIETY

Nudges help get people to court Simple measures reduced

arrest warrants for no-shows

BY SUJATA GUPTA

Imagine a police officer charges a man with disorderly conduct and issues a citation to appear in court. The man stuffs the slip in his wallet, where it's forgotten. A year later, he's pulled over for speeding and learns his failure to appear in court has resulted in a warrant for his arrest.

The situation is surprisingly common. From January 1, 2016, to June 14, 2017, New York City police officers issued 323,922 criminal summonses for minor infractions, such as being in a closed park after dark or carrying an open alcohol container outside. Showing up to court often results in the case being dismissed.

Still, about 40 percent of such New

D.C., who wasn't involved in the study. "It's probably going to be, along with climate change, one of the biggest challenges for biodiversity in [the coming] decades."

The Hainan landslide damaged an arboreal highway, a preferred route through the trees that the apes used to traverse the rainforest. Hainan gibbons (*Nomascus hainanus*) are almost strictly arboreal, and forest fragmentation can divide the already critically endangered primates into smaller breeding populations, says Bosco Chan, a conservation biologist at the Kadoorie Farm and Botanic Garden in Hong Kong. That can lead to inbreeding or local groups dying out.

Only about 30 individuals remain of this species, all living in a nature reserve on Hainan Island. For the group of nine gibbons studied, the researchers didn't



To cross a gully created by a landslide, some Hainan gibbons in China dangle and swing from a rope bridge installed by researchers, while others walk across.

want the animals to get hurt crossing the gap. Enter the rope bridge. Camera traps captured the gibbons taking to the ropes 176 days after the bridge's installation.

Eventually, the scientists observed the gibbons crossing the bridge about as frequently as the apes had traveled that stretch of forest before the landslide.

Though the scientists expected the animals would swing along under the bridge using their arms, Chan says, many preferred to walk as though on a tightrope, using one rope as a handrail, or to climb under the ropes using all limbs.

Yorkers miss their court date, usually scheduled for 60 to 90 days after a citation is issued, resulting in an arrest warrant. But punitive measures may not be necessary to bring some of these defendants to court, a study suggests.

Simple interventions – revamping the summons form to emphasize the court date as well as sending text reminders – help reduce no-show rates, researchers report online October 8 in *Science*. After gradually phasing in these "behavioral nudges" in New York City in 2016 and 2017, there were about 30,000 fewer arrest warrants from August 2016 to September 2019 than there would have been otherwise, the researchers estimate.

The changes are a more humane approach to criminal justice that also save money, the authors say. Sending every summons recipient three text reminders would cost \$4,500 per year, the team estimates. The roughly 30,000 averted warrants saved an estimated \$650,000 in court personnel time alone. "This is such an easy, cost-effective, win-win solution," says Alissa Fishbane, a managing director at ideas42, an international company that uses behavioral science to help solve social problems.

Fishbane and her colleagues economist Aurélie Ouss of the University of Pennsylvania and behavioral scientist Anuj Shah of the University of Chicago worked with New York City to redesign the summons form. The revised form shows the court date and warnings about the possibility of arrest at the top instead of at the bottom and on the back.

The team looked at the 40 days before and after officers started using the new forms. Before the switch, about 47 percent of defendants missed court; after the switch, 40.8 percent were no-shows.

The researchers also zoomed in on the 11 percent of defendants who provided a cell phone number on the new form. Among those 23,243 individuals, some received text message reminders about court dates. Almost 38 percent of people For now, the bridge provides a temporary solution while transplants of native trees grow and other trees regenerate.

Such artificial bridges provide a sensible, innovative approach to help gibbons get around safely, says Susan Cheyne, a primatologist based in Oxford, England, and vice chair of the International Union for Conservation of Nature's Section on Small Apes, who advised the Hainan project. On the ground, gibbons may get hit by cars, get into fights with dogs or be exposed to new parasites.

The gibbons' use of the bridge suggests that it's a "tool that other primate conservation groups could potentially use," Cheyne says, as these gibbons are a "relatively fickle species. They are not overly keen on using new things."

Beyond primates, other animals may use such crossings too. The team also saw two squirrels and another rodent use the bridge. Depending on where canopy bridges are located, marsupials or rodents could benefit, though observing such crossings can be a challenge for nocturnal creatures.

who did not get these reminders missed court dates, while a little less than 30 percent of those receiving the messages did.

New York City officers issued about 426,000 court summonses for minor infractions between August 2016 and November 2019. Assuming that about 40 percent of people don't show up to court, as was the case in 2015 before the intervention, that would have meant almost 175,000 arrest warrants. The team estimates that about 23,000 such warrants were avoided due to the new forms and nearly 7,900 due to the texts.

Over half of the city's summonses in 2016 and the first half of 2017 were issued in the poorest 30 percent of census tracts. And both interventions were the most effective among the poorest defendants. Poorer people likely miss court because their minds are overloaded with other concerns, says psychologist Jiaying Zhao of the University of British Columbia in Vancouver. This study "speaks to the psychological burdens of poverty."

LIFE & EVOLUTION

How octopuses 'taste' by touching

Unique cells in the arms detect prey's chemical defenses

BY JONATHAN LAMBERT

Octopus arms have minds of their own.

Each of an octopus's eight supple yet powerful limbs can explore the seafloor in search of prey, snatching crabs from hiding spots without direction from the brain. But how each arm can tell what it's grasping has been a mystery.

Now, researchers have identified cells that allow octopus arms to "taste." Embedded in the suckers, these cells let the arms do the double duty of touching and tasting by detecting chemicals made by many aquatic creatures. This may help an arm quickly distinguish food from rocks or poisonous prey, Harvard University molecular biologist Nicholas Bellono and colleagues report in the Oct. 29 *Cell*.

The findings give another clue about the unique evolutionary path octopuses have taken toward intelligence. Instead of being concentrated in the brain, twothirds of an octopus's nerve cells are distributed among the arms, allowing them to operate semi-independently.

"There was a huge gap in knowledge of how octopus [arms] actually collect information about their environment," says neurobiologist Tamar Gutnick, who studies octopuses at Hebrew University of Jerusalem. "We've known that [octopuses] taste by touch, but knowing it and understanding how it's actually working is a very different thing."

Bellono and colleagues weren't sure what they would find when they took a close look at the arms of a California two-spot octopus (*Octopus bimaculoides*). Detailed imaging identified what appeared to be sensory cells, some with fine branched endings, at the surface of suckers. The team isolated the cells and tested their responses to such stimuli as fish extract and pressure. One class of cells was similar to those that detect touch in a variety of animals. But cells Studying California twospot octopuses, like this one in a coffee mug at a Harvard lab, led to the discovery of special "taste" cells in the suckers.

that responded to fish extract had receptors, proteins that detect specific stimuli, that are unlike any seen in other animals.

The team inserted these "chemotactile" receptors into human and frog cells in the lab using genetic tools and then exposed the cells to chemical compounds an octopus might encounter. Only one class of molecules, insoluble terpenoids, elicited a response. Terpenoids, found in many marine creatures, are thought to be used in defense by some animals.

Terpenoid detectors might cue an octopus to quickly grasp something it touches lest the prey swim away, or withdraw and keep searching. This played out in the lab: Octopuses in tanks used broad, sweeping arm movements to explore terpenoid-free surfaces. But when touching a surface infused with terpenoids, an arm stopped, either quickly tapping the spot and moving on, or immediately withdrawing and avoiding that area.

It's not clear just what these behaviors mean, but they confirm that octopuses use these receptors to sense chemicals by touch. "We equate it to taste by touch just so that we can sort of understand what it might mean to the octopus, but it's very different than our taste," Bellono says.

His lab is working on identifying other compounds detected by these sensors, as well as investigating how the receptors may be tuned to respond to different stimuli depending on the context, such as how hungry the octopus is.

ATOM & COSMOS

Find hinting at life on Venus doubted

Further searches for signs of phosphine turn up empty

BY LISA GROSSMAN

It was one of those "big if true" stories. In September, scientists reported that Venus' atmosphere seems to be laced with phosphine, a possible sign of life.

Now there's increasing emphasis on the "if." As scientists take fresh looks at the data, and add new data to the mix, the phosphine claim is being doubted.

"It's exactly how science should work," says planetary scientist Paul Byrne of North Carolina State University in Raleigh, who was not involved in the phosphine research. "It's too early to say one way or the other what this detection means for Venus."

On September 14, astronomer Jane Greaves of Cardiff University in Wales and colleagues reported detecting phosphine in Venus' atmosphere (*SN: 10/10/20 & 10/24/20, p. 6*). The gas seemed too abundant to exist without a replenishing source. That source could be microbes, or some unknown chemistry, the team said.

The team initially spotted the signal with the James Clerk Maxwell Telescope in Hawaii, and then followed up with the powerful Atacama Large Millimeter/ submillimeter Array in Chile. It's the ALMA data that have sparked doubts.

The key observation was Venus' spectrum, or the plot of the light coming from the planet in a range of wavelengths. Different molecules block or absorb light at specific wavelengths. So dips in a spectrum can reveal a planet's chemistry.

Phosphine showed up as a dip at about 1.12 millimeters: If Venus' spectrum could be drawn as a straight line across all wavelengths of light, phosphine would make a deep valley at that wavelength.

But other sources, from Earth's atmosphere to the inner workings of the telescope itself, can introduce wiggles, or "noise," into that nice straight line. The bigger the wiggles, the less scientists believe that the dips represent interesting molecules. Any particular dip might be just a random, extra-large wiggle.

Astronomers can do a few things to smooth out data to let real signals shine through. One strategy is to write an equation describing the wiggles caused by the noise. Scientists can subtract the data that fit the equation to highlight the signal of interest, like blurring a photo's background to let a portrait subject pop. That's standard practice, says astrochemist Martin Cordiner of NASA's Goddard Space Flight Center in Greenbelt, Md.

But it's possible to write an equation that removes more than the noise. The simplest equation to use is y=mx+b, also known as a first-order polynomial, which describes a straight line. A second-order polynomial adds a term with x²; a thirdorder, with x³; and so on.

Greaves and colleagues used a 12thorder polynomial. "That was a red flag," Cordiner says, that maybe more noise was subtracted than is truly random, leading the team to find things in the data that aren't really there.

To check, scientists in the Netherlands applied a third-order polynomial equation to the ALMA data, and the

> Scientists have so far failed to corroborate a recent claim that Venus (shown in this artist's impression) is home to phosphine, a possible sign of life.

phosphine signal disappeared.

And when using the original noisefiltering equation on other parts of Venus' spectrum, where no interesting molecules should be, the team found five different signals of molecules that aren't really there. "Our analysis ... shows that at least a handful of spurious features can be obtained with their method, and therefore [we] conclude that the presented analysis does not provide a solid basis to infer the presence of [phosphine] in the Venus atmosphere," the team wrote in a paper posted October 19 at arXiv.org.

Meanwhile, astronomer Thérèse Encrenaz of the Paris Observatory and collaborators (including Greaves and some of her coauthors) also attempted to confirm phosphine's presence using a different wavelength in Venus' spectrum. The group looked at data collected between 2012 and 2015 from an infrared spectrograph called TEXES that operates in Hawaii. Those observations could have spotted phosphine in a lower part of the Venus sky than what ALMA could see. But there was nothing, the group says in the November Astronomy & Astrophysics.

There is no phosphine at the level of the cloud tops, Encrenaz says. That doesn't necessarily mean there's none higher up, but it's not clear how it would get there. "The reasoning in the paper by Jane Greaves was that phosphine was coming from the clouds," Encrenaz says.

The original detection might still be real. If phosphine varies with time, for instance, the gas might be there some of the times that astronomers look and not at others. It's too early to invoke that scenario, though, says Cordiner, who has submitted his own paper for publication questioning the phosphine signal. "There's no point of talking about the time variability of a signal if it isn't there."

Clara Sousa-Silva, an astrochemist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., was a coauthor of the original phospine paper. Other groups challenging the finding "is completely normal and what I expected (nay, hoped) would happen," she wrote in an e-mail. " I am hoping people will realize this is just what science looks like."



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Sixty Years Into the Search for E.T.

New methods ramp up the hunt for alien intelligence **By Maria Temming**

or about a week in April 1960, radio astronomer Frank Drake thought he might have discovered aliens.

At the National Radio Astronomy Observatory in Green Bank, W.Va., Drake had pointed a new 26-meter telescope at the star Epsilon Eridani. Within minutes, the instruments went wild. The telescope's readout device, a chart recorder that used a pen to scratch out signatures of incoming radio signals on paper, scribbled erratically. A speaker connected to the telescope blared a train of strong pulses — just the kind of transmission expected from an intelligent sender. Drake was stunned. Could finding E.T. really be this easy?

It wasn't. When the telescope found a signal

with the same pattern again several days later, a radio antenna pointed in a different direction also picked up the noise. The signal wasn't otherworldly at all; it was coming from an earthly source, maybe an airplane.

Drake never picked up any interstellar broadcasts during his two months observing Epsilon Eridani and another sunlike star, Tau Ceti (*SN:* 4/30/60, *p.* 282). But that first foray into the search for extraterrestrial intelligence, or SETI, sparked a growing field of efforts to scout out intelligent creatures among the stars.

Such beings, unlike the microbial life sought in places like Mars (*SN Online: 7/27/18*), would have the technology to deliberately signal Earth. Now, with recent discoveries in astronomy, new technologies and an influx of money, that search for an interplanetary pen pal is in a renaissance.

"It's really difficult to overstate how much the field has been transformed" in the last few years, says Andrew Siemion, director of the Berkeley

The Very Large Array in New Mexico, famous for appearing in the 1997 film *Contact*, will finally start its first search for alien signals with a dedicated SETI instrument in 2021.

SETI Research Center at the University of California, Berkeley.

Bigger and better telescopes are probing deeper into the night sky. Sophisticated computational tools are poring over massive datasets on increasing numbers of stars and at a wider variety of radio frequencies. Radio observatories around the world are performing regular observations as part of Breakthrough Listen — a \$100 million effort funded by Israeli-Russian billionaire Yuri Milner and his wife, Julia, to conduct the most comprehensive search for extraterrestrials yet (*SN Online: 7/20/15*). And some astronomers have branched out from radio SETI to search for other kinds of alien signals, like messages encoded in laser beams.

So far, SETI scientists haven't picked up a single alien signal. But they are undeterred. They've scoured only a tiny fraction of the places E.T. could be (SN: 10/27/18, p. 5). And SETI's collective observing power will be much greater in the coming decade than it was in the 2010s, Siemion says.

This, he says, is "a boom time for SETI."

Eyes on the sky

For decades, the hunt for intelligent aliens languished on the fringes of the scientific establishment (*SN: 3/30/19, p. 4*), viewed by many researchers as a "strange, boutiquey sort of thing that's not really astronomy," says Siemion, principal investigator for Breakthrough Listen. Short-lived U.S. federal funding for the field abruptly ended in 1993, after which "SETI went underground and became very insular," he says.

But SETI's profile is changing, as our understanding of the universe evolves. Back when Drake, a SETI pioneer, was making those first observations, we hadn't yet laid eyes on a planet around another star — and wouldn't for another 30 years. Just within the last decade, we've discovered thousands of exoplanets, giving new credence to arguments that life beyond Earth is entirely possible.

In February, Breakthrough Listen released the largest stockpile of SETI observations yet for members of the astronomical community to analyze. The dataset, collected by the Parkes radio telescope in Australia, the Green Bank Telescope in West Virginia and the Automated Planet Finder in California, included a survey of radio emissions from the disk of the Milky Way and the region around its central supermassive black hole.

"For finding very advanced civilizations, I think the galactic center is very exciting," Siemion says. He speculates that some super tech-savvy aliens could have built an extremely powerful radio transmitter there, charged by the Milky Way's supermassive black hole.

To find alien civilizations working with more modest radio equipment comparable to our own, searchers look to nearby stars. That was the approach that Sofia Sheikh, an astronomer at Penn State, took in analyzing Breakthrough Listen observations of 20 of the sun's stellar neighbors. All of those stars are in positions relative to Earth that would, in principle, allow aliens around the stars to see Earth orbiting in front of the sun – the same way that telescopes like NASA's Transiting Exoplanet Survey Satellite, or TESS, spot exoplanets (*SN: 2/2/19, p. 12*). Those aliens might therefore be able to detect Earth's presence and target our planet with a message.

Sheikh and colleagues came up empty in their search. "Reporting null results isn't fun," she says of her analysis, published in the July *Astronomical Journal*. But it does tell other astronomers "this particular space has already been searched, go search somewhere else," she says. Given the vast cosmic real estate where E.T. might be, checking out every little stellar neighborhood helps.

New observatories joining the Breakthrough Listen cohort will expand the search in the next few years. The MeerKAT array, located in the Karoo region of South Africa, will survey 1 million nearby stars. The Very Large Array near Socorro, N.M., seen in the 1997 film *Contact*, is getting its first SETI instrument, and Breakthrough Listen hopes the observatory will start looking for signs of aliens in data gathered for other research starting in 2021.

Building better filters

Getting more eyes on the sky is a key part of SETI. But while telescopes are heaping up a massive haystack of data, there's still the task of searching for any needles buried within. And it could take picking through the same data more than once. New computer algorithms can always revisit old observations to search for blips that previous analyses missed.

Often in radio astronomy, "the most interesting discoveries are not made on the first or the second

or even the third analysis of the dataset," Siemion says. For example, brief, brilliant flashes of radio waves from distant galaxies called fast radio bursts were first discovered in a reexamination of old data from the Parkes telescope (*SN*: *8/9/14, p. 22*).

In SETI, the perennial challenge is devising techniques to better distinguish potential alien signals from radio interference by earthly technology. SETI scientists are usually seeking the same kind of tight, well-defined radio transmissions that human electronics produce. Such signals are easily distinguishable from radio waves emanating from natural sources, such as stars or galaxies, which tend to vary slowly over time or be smeared out across many frequencies. But it can be hard for scientists to judge whether any promising signals they detect are coming from deep space or from a nearby cell phone or satellite.

One way of doing this is to point a telescope at a target, like a star, then somewhere else. Any radio signals that appear when the telescope is pointed in both directions are probably humanmade radio interference, as Drake learned. Conventional computer algorithms detect differences between on-star and off-star observations simply by comparing the amount of energy detected in each observation. But if a faint alien transmission overlaps in the sky with earthly noise, a basic energy-detection algorithm may mistakenly discount everything it sees as human-made noise.

Some researchers hope artificial intelligence will be better than rigid energy-detection algorithms at spotting subtle differences between on- and off-star observations. While at the Berkeley SETI Research Center, applied machine learning researcher Yunfan Gerry Zhang taught an AI to recognize radio interference from human



Two of the biggest radio dishes in the world, the Green Bank Telescope in West Virginia (left) and the Parkes telescope in Australia (right), both contribute observations to the Breakthrough Listen project to search for intelligent life.



technology by showing the AI thousands of observations from the Green Bank Telescope. Using its learned sense of what earthly radio interference looked like, the AI could accurately pick out human-made noise in on-star observations.

If such an algorithm were to detect radio signals from a star that didn't qualify as natural signals or human-made noise, the AI could flag that star for researchers as a potential source of alien transmissions. Zhang and his colleagues presented this strategy at the 2018 IEEE Global Conference on Signal and Information Processing in Anaheim, Calif., as a tool for finding oddities in future SETI investigations.

Looking for lasers

Radio waves, the focus of mainstream SETI, are not the only means of sending interstellar messages. Aliens could also encode information in nanosecond laser pulses. Though lasers were first suggested as potential interstellar beacons in 1961, most SETI searches have followed Drake in looking for radio communications — partly because radio waves are low energy, and so possibly a more cost-effective way to package interstellar mail.

But optical light could be a practical interstellar beacon if focused into a narrow laser beam, argue proponents of laser searches, called optical SETI or OSETI. Fast laser flashes would be detected as a bunch of photons, or particles of light, hitting a telescope all at once, as opposed to the steady trickle of incoming photons from background starlight. As a result, for the nanosecond duration of the laser pulse, it could outshine surrounding stars. No known astrophysical sources produce nanosecond optical blips.

"Optical SETI is still in its infancy, or early toddler phase," compared with radio SETI, says Shelley Wright, an astrophysicist at the University of California, San Diego. But if used along with radio scans of the sky, OSETI efforts can expand the search into an entirely different mode of communication.

In July 2019, the Very Energetic Radiation Imaging Telescope Array System, or VERITAS, at the Fred Lawrence Whipple Observatory near Amado, Ariz., joined Breakthrough Listen. This telescope quartet was built to watch for brief flashes of blue "Cherenkov" light generated by gamma rays from space hitting Earth's atmosphere. But the array's fast cameras are also well suited to looking for E.T.'s laser beams.

The VERITAS Breakthrough Listen effort involves both new optical stellar observations and a review of old VERITAS data, which the array has been collecting since 2007. Previous VERITAS analyses have yielded results, even if somewhat disappointing. Nine hours of observations taken from 2009 to 2015 of Tabby's star — once suspected, due to its bizarre periodic dimming, of holding an alien megastructure in its orbit — found no alien laser beacons (*SN Online: 1/3/18*).

Wright and colleagues hope to dramatically expand OSETI with new facilities. While VERITAS and other OSETI searches have targeted specific stars, Wright's team has drawn up a blueprint for four dedicated observatories to keep continual vigil for alien laser pulses across the observable sky.

This concept, dubbed PANOSETI, was described in July 2018 in Austin, Texas, at the SPIE Astronomical Telescopes + Instrumentation meeting. Each observatory would be a dome covered in 88 lenses with optical and near-infrared detectors. A pair of observatories in the Northern Hemisphere would keep watch over the northern sky, while a second pair in the south would keep tabs on the southern sky.

Two observatories in two different locations would have to keep watch over the same part of the sky to ensure that anything a single observatory detected wasn't a glitch or an effect caused by local light pollution, Wright says — the same way a pair of far-flung detectors of the Advanced Laser Interferometer Gravitational-Wave Observatory, or LIGO, team up to detect cosmic ripples called gravitational waves (*SN: 3/5/16, p. 6*). "Nobody would have believed LIGO without a secondary site," she says. Double-checking potential detections would be absolutely crucial for a claim as extraordinary as receiving a greeting from E.T.

Explore more

 Breakthrough Listen: breakthroughinitiatives.org/initiative/1

The proposed PANOSETI project would use two observatories in the Southern Hemisphere and two in the Northern Hemisphere to search for laser beacons from aliens. With Earth at its center, this simulation shows the observatories' views projected onto the night sky (magenta for the southern view and blue for the northern). As Earth rotates (shown left to right), the observatories' views of the universe would change.

FEATURE

Colugos are nocturnal, tree-living mammals. This female colugo found in Malaysia was nicknamed "Batwoman" by researchers. A baby colugo clings to its mother for months until it weans.

A NIGHT WITH COLUGOS

Following the expert gliders in Malaysia By Yao-Hua Law

y companions scanned the treetops with binoculars and a thermal-imaging monocular. I stared at the branches and leaves, pretending I knew what to look for. It was a cool June evening just before sunset on a village road on Langkawi Island, Malaysia.

"There's one! Up there," one of the biologists called out. I squinted at the spot, about five meters up the tree trunk, and saw only a brown knob speckled with gray. Where? Then the knob stirred. Its top edge rose and turned, and I was staring into a pair of bulging eyes set on a small head with a short snout.

My first colugo. The size of a house cat, colugos are nocturnal mammals that live in trees. Colugos are also called "flying lemurs," which is a misnomer because they cannot fly and they are not lemurs. A colugo has a cape of skin that stretches from its neck to the tips of its four limbs and tail. That skin, furry on top, helps colugos glide far and hide well in the canopy.

"Wait...Oh, it has a baby!" called zoologist Priscillia Miard of Universiti Sains Malaysia in Penang and leader of that evening's search. She passed me her binoculars as the team discussed the identity of this colugo.

A tiny head popped out from beneath the mother's fur, like a child peering out from under a blanket. Baby colugos cling to their mother's furless undersides until about age 6 months, nursing on nipples near mom's armpits.

I had seen two colugos just 15 minutes into our search!

The mother colugo lifted her tail. "It's pooping," said Miard, without the slightest note of concern that we were standing right below. Miard later told me that colugo feces are like dried lentils — nothing messy.

For an animal that is the closest living relative to all primates, having branched off about 80 million years ago, colugos remain a big mystery (*SN*: 9/3/16, p. 17). Today, the two living species of colugos are found only in Southeast Asia, though recent studies suggest that two is an imperfect count. Miard and other scientists have begun to upend what little knowledge exists about these mammals, revealing how colugos communicate and how they glide more than the length of a football field.

Into the night

Colugos popped unexpectedly into Miard's life three years ago. The then 28-year-old French researcher had spent five years in Borneo studying nocturnal primates, including tarsiers



Neighbors Colugos are found only in Southeast Asia. The Sunda colugo ranges from Vietnam to Indonesia (orange areas, left) and the Philippine colugo lives in the southern Philippines (right).



The large surface area of their gliding skin, or patagium, helps colugos achieve some of the longest glides among mammals. This composite of three images shows a colugo gliding in from the right and preparing to land on a tree.

and slow lorises. In 2017, Miard visited Langkawi, famous for its beaches and paddy fields, where she saw colugos "everywhere" — in orchards, on golf courses, at resorts and along well-traveled village roads. Because colugos were abundant and easy to find and observe in Langkawi, Miard pivoted to study them. In August, she successfully defended her Ph.D. thesis at Universiti Sains Malaysia for her research on colugo ecology.

But as I stood by her side looking up, Miard did not mention her Ph.D. She focused on the mother colugo — now a few dried lentils lighter — which seemed ready to start her night. The colugo climbed to the far end of a branch and turned her head toward the road. Then she leaped.

The colugo spun around, stretched her legs and tail, and glided like a magic carpet across the road to another tree trunk. Then she hopped, hopped up the tree into the leaves and out of sight.

She glided to four other trees over the next 15 minutes. By then, Miard and her teammates — biologists Muhammad Fizri bin Ahmad Zubir and Célia Lacomme — had recognized the mother colugo's fur coloration. They had been following her for some time, naming her "Batwoman" because, months ago, locals thought the researchers were looking into the trees for bats.

Streetlights and passing cars and motorcycles lit the road, but a few meters away, the trees were dark. Miard and Lacomme switched on their red-light head lamps to illuminate the treetops. Something moved on a nearby tree trunk. Another colugo! Miard pointed her camera, saw testicles and announced that the colugo was male.

Master gliders

All colugos are master gliders, considered among the best of the 60-odd species of mammals that can glide. One Sunda colugo (*Galeopterus variegatus*) was recorded gliding 145 meters, almost the length of three Olympic swimming pools.



Going the distance Among the 60-plus species of mammals that glide, including several gliders and flying squirrels, Sunda colugos have been recorded gliding as far as 145 meters. sources: G. BYRNES AND A.J. SPENCE/INTEGRATIVE AND COMPARATIVE BIOLOGY 2011; G. BYRNES ET AL/J. EXP. BIOL. 2011

That sustained glide was reported in 2011 in the *Journal of Experimental Biology* by Gregory Byrnes, a biologist at Siena College in Loudonville, N.Y., and colleagues. At the time, most researchers assumed gliding was an energy-efficient way for colugos to travel. Byrnes' team tested that idea by gluing data loggers onto wild Sunda colugos in Singapore and recording almost 260 glides among four individuals.

Sunda colugos often climb before gliding. In the study, a Sunda colugo could climb a total of 320 meters and glide 1,342 meters in one night. "No one ever took into consideration that in order to glide, you've got to climb," Byrnes says. His team fed colugo data into metabolic models of other treedwelling mammals to estimate how much energy colugos expend to both glide and climb. When climbing is included as part of gliding behavior, and in forests where treetops overlap, a colugo could save energy crawling through the canopy rather than gliding, he says.

The "big advantage" of gliding is that it saves colugos time, Byrnes says. Gliding lets an animal cross open space in a few seconds so that it can spend more time feeding or traveling even farther, he says.

Colugos pull off those long-distance glides with their gliding skin, known as a patagium. While other gliders like flying squirrels have a patagium that stretches to the hind feet, a colugo's patagium continues all the way to the tip of the tail. A more expansive patagium gives a colugo extra "wing area," which lifts and slows the animal, allowing a gentler descent than other gliders, Byrnes says. The extra skin also helps the animal glide far.

And there is more to the patagium than skin and fur. Byrnes and his collaborators have found that the thin patagium is rich

in muscles, and some parts are stiffer than others. A colugo may be able to flex those muscles to change the shape and stiffness of its patagium and thereby adjust its aerodynamics midair. Understanding the gliding biomechanics of colugos might help in the design of robotics and wing technology, Byrnes says.

That evening in Langkawi, Batwoman glided down the road, across the road and up the road. Never a sound. Once, she was gliding straight toward a tree, and just before impact, she turned, cut a sharp arc and landed on the next trunk. Wow.

High talk

When Batwoman reached her fifth tree of the night, another colugo swooped in from the dark and hopped up the trunk toward her.

Colugos were once thought to be solitary animals, Miard says. Social interactions were brief and rarely seen. But newer observations by Miard and others suggest that colugos form loose social groups of females or a mother and her offspring — even those that are weaned. Miard has seen up to six colugos in a tree. Males, though, seem to travel alone, joining groups of females only temporarily.

Miard trained her camera on the newcomer, which passed by Batwoman and continued into the canopy. Not a glance. Miard looked disappointed. "Oh no, he didn't even say hi."

To my ear, Batwoman hasn't made a sound. But she may have been calling in ultrasound, inaudible to humans. Miard and colleagues discovered ultrasound calls from colugos, reporting the finding in 2019 in *Bioacoustics*. A microphone picked up the ultrasound signals during a bat survey, and Miard tracked the source to colugos. Many nocturnal animals, including bats, tarsiers and slow lorises, communicate in ultrasound, probably to avoid detection by predators. Colugos likely do the same. In November, Miard and colleagues will play the ultrasound calls in the field and listen for colugo responses.

It's 8:15 p.m., dinnertime. Batwoman crawled into the thick foliage and gingerly pulled some leaves for a sniff. Miard explained that colugos eat mostly leaves. Batwoman shoved some leaves into her mouth and began to chew. Fizri and Lacomme recorded the observations on a behavior checklist on their smartphones.

"Wait, the baby is trying to eat leaves," said Miard, looking through the binoculars. Lacomme shined her red-light head lamp at Batwoman. The baby colugo reached out from under its mother, tugged a few small leaves and tried to nibble them. Maybe the baby is learning what to eat from its mother, Miard said. It was too dim for me to tell if the baby actually ate the leaves. Lacomme's red-light head lamp wasn't bright enough. White light might have offered a better view.

But Miard won't shine white light on nocturnal mammals. "When we use white light on colugos, they freeze, but not when we use red light," she told me later. The freezing, she says, is a sign that white light disturbs the nocturnal mammals.

Miard's concern makes sense. White light, which is commonly used in nocturnal animal studies, can quickly saturate the sensitive optic cells in nocturnal animals' eyes and cause temporary blindness, says primatologist Amanda Melin of the University of Calgary in Canada. "These moments of blindness are likely disorienting and potentially harmful," Melin says. "Red light is likely far less disruptive as it will be much lower intensity" than white light.

Eager pursuit

Around 9 p.m., another colugo glided in and joined Batwoman on a tree. This one seemed more interested than the last; he poked Batwoman and bit her sides. The newcomer, a male, wanted to mate, Miard said. But every time he got close, Batwoman pulled away.

Miard clutched her camera tight. Colugo romance makes prized footage. Gazing into the canopy, Miard backed away from the tree and onto the road — into the path of an oncoming car that just managed to stop before hitting her.

"F---, we are going to miss the most important part. We know they are going to make babies, but I can't see them," Miard said. She turned to Fizri: "Where's the thermal camera?"

Minutes later, Miard spotted the colugos near the top of the tree. "You are really lucky," she told me. "Many exciting things tonight."

Batwoman continued to test the male, which I decided to name "Eager." She glided to another tree, then another and yet another with Eager close behind. The colugos lingered on one tree. Miard sat by the road, camera in hand, eyes on Batwoman.

"Come on guys.... Please let him do it, please ... Batwoman," Miard muttered.

Our small group piqued the curiosity of locals. A couple,

standing at the porch of a nearby house, watched us for about 10 minutes, then came over. "It's a *kubong*," Fizri told them, giving the local Malay name for colugo.

The couple knew the name but not the animal. They thought colugos lived only in forests. "Does it eat fruit? Is it like a bat?" they asked in hushed tones. Fizri lowered his smartphone and began to explain colugo ecology. The opportunity to talk colugo with local residents and correct misconceptions is one of the reasons Miard likes to study colugos in villages.

Colugo conservation

Perhaps because they are nocturnal and well camouflaged, colugos live hidden in plain sight. Zoologist Dzulhelmi Nasir, now with the Malaysian Palm Oil Board, has studied colugos in Borneo. Most locals have never heard of colugos, he says. People often confuse the animals with flying squirrels or a giant fruit bat called *kluang* in Malay.

Confusion or misconceptions about the colugos can be deadly for the animals. In parts of Malaysia, orchard and plantation owners see colugos as fruit pests and kill them,



On an early evening in Malaysia in June, zoologist Priscillia Miard uses a thermal-imaging device to search for colugos, which have coats that camouflage them well against lichen-covered tree bark.



Colugos live their whole lives in trees. The gliders visit several trees in a night, eating mostly leaves rather than fruit.

Miard told me. But colugos rarely eat fruits and flowers, according to a study published in 2006 in *Biodiversity & Conservation*, as well as Miard's own unpublished research. Fortunately, here in Langkawi, there are few commercial orchards, and locals leave colugos alone.

But across Southeast Asia, colugos are losing their forest homes to agriculture and development. The region lost 293,000 square kilometers of forest from 2000 to 2014, an area about the size of Arizona, according to a 2018 report in *Nature Geoscience*.

On the International Union for Conservation of Nature's Red List of Threatened Species, the Sunda colugo and the Philippine colugo (*Cynocephalus volans*) are categorized as "least concern" for risk of extinction. The Sunda colugo, in particular, with its wide distribution from Vietnam to Indonesia, is unlikely to be threatened.

But that assessment might be too rosy. Those two species may actually be eight, or as many as 14, based on genetic evidence reported in 2016 in *Science Advances*. If so, instead of the Sunda colugo being one widely distributed species, there are several colugo species confined to smaller areas that may be more susceptible to local extinction.

Zoologists had always noted that colugos look different across Southeast Asia. By the 1950s, about 20 species and subspecies were recognized based on physical differences. But zoologists decided to simplify things and lump all subspecies into two species, says geneticist Victor Mason, an author of the 2016 report, who studied colugo phylogeny at Texas A&M University in College Station.

Mason and colleagues looked for signs of species diversity hidden in the genetic makeup of colugos, a task that required samples of colugo DNA from across Southeast Asia. The researchers turned to museum specimens in Singapore and the United States. "There's hundreds of colugo skulls just sitting in drawers in tiny boxes collecting dust" amassed more than a century ago by European explorers, says Mason, now at the University of Bern's Institute of Cell Biology in Switzerland.

Using DNA from the museum specimens, Mason and colleagues found up to 14 colugo groups with significant genetic differences. More work is needed to weigh these differences and review the diversity of colugo species. And more surveys of colugo populations and their whereabouts are needed, Miard says, to reliably tell if and where colugos are threatened.

The good news is that colugos appear to adapt well to forested human environments, including the villages in Langkawi. The animals feed on the leaves of five to seven different trees nightly, Dzulhelmi says based on his studies in Langkawi and Borneo. He says that if a township could plant enough trees in gardens, parks and zoos to support freeliving colugos, locals could see and learn about the animals and appreciate them.

After 50 minutes of courtship, Eager the male colugo has given up. Batwoman glided back up the road — with four humans on her tail — and began feeding again. We spotted a few more colugos that night, but we stayed close to Batwoman.

Around 11 p.m., Batwoman was still plucking leaves. Suddenly, I felt the air brush my hair — a colugo glided past me to land on a tree about three meters away. I moved in for a closer look at the only colugo I spotted before my guides. But it began to rain, and we ran for shelter.

The next morning, we moved our survey to a leafy resort on the island. In two hours, we found 17 colugos, all hugging trees, motionless in the daylight. I spotted two before Miard did and tried to hide my glee. But the thrill was not mine alone. Soon after we found the 11th colugo, Miard couldn't hold it in any longer: "I love colugos!"

Explore more

- Priscillia Miard et al. "Ultrasound use by Sunda colugos offers new insights into the communication of these cryptic mammals." *Bioacoustics*. 2019.
- Victor Mason *et al.* "Genomic analysis reveals hidden biodiversity within colugos, the sister group to primates." *Science Advances.* August 3, 2016.
- Gregory Byrnes *et al.* "Gliding saves time but not energy in Malayan colugos." *Journal of Experimental Biology*. August 2011.

Yao-Hua Law is a freelance science journalist based in Kuala Lumpur, Malaysia.

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Fossil Men Kermit Pattison WILLIAM MORROW, \$32.50

BOOKSHELF

Ardi and her discoverers shook up anthropology

She is the most controversial,

convention-defying, weirdest-looking fossil hominid ever found. Fittingly, the group that discovered this 4.4-millionyear-old adult female, nicknamed Ardi, includes the most controversial, convention-defying (and some would say weirdest-acting) fossil hunters and bone analysts to have ever wrestled with

the puzzle of how humans and our ancestors evolved.

In *Fossil Men*, journalist Kermit Pattison recounts intriguing backstories of the Ardi scientists and how they came to challenge popular views of hominid evolution. Many inci-

dents in the book show the courage and grit it took to find and excavate Ardi in Ethiopia's remote Middle Awash area, where local nomadic groups are prone to shoot at outsiders. Pattison also examines how Ardi's skeleton makes her a one-of-a-kind find.

Standing at the center of this ancestral spectacle is team leader Tim White, a paleoanthropologist at the University of California, Berkeley. A demanding and intense taskmaster in the field, White has a hard-earned reputation as one of the all-time great fossil hunters. Pattison describes White as having remarkably keen eyes for assessing fossil bones and a knack for brutal, sarcastic takedowns of evolutionary arguments (and scientists) he finds deficient. In a published review of an eminent anthropologist's book claiming that hominid evolution included many species, White called him a purveyor of "politically correct paleoanthropological pontification" that didn't rise to the level of fiction such as The Clan of the Cave Bear. Not surprisingly, White has amassed scientific enemies since the early 1970s, when he worked with members of the fossilhunting Leakey family in Africa. He takes his professional infamy in stride.

After helping to study and classify the famous Lucy partial skeleton following its discovery in 1974, White's friendship with Lucy's discoverer Donald Johanson broke up, much as his relationship with the Leakeys had. White then took a position at Berkeley in 1977, where he joined forces with archaeologist J. Desmond Clark to hunt for hominid fossils in the Middle Awash. There, remains older than 3.2-millionyear-old Lucy were likely waiting. Clark recruited Ethiopia's Berhane Asfaw to Berkeley's graduate anthropology program, the first of a series of Ethiopians the Ardi team trained as paleoanthropologists. Asfaw joined the White-led fossil expeditions and had headed an Ethiopian museum that now houses Ardi.

Pattison recounts a pivotal moment in the field when the team encountered a man named Gadi, a hunchbacked, gunwielding warrior from a local tribe called the Afar. White struck up a friendship with Gadi, who became a one-man security force for the researchers. In 1993, it was Gadi who noticed a tooth on the ground that was the first of 10 teeth the team found from the same hominid individual. These

clues led to the identification of a new species, *Ardipithecus ramidus*.

The first pieces of Ardi's partial skeleton – including much of the skull, hands, limbs and pelvis - were found the following year, about 100 kilometers south of where Lucy had been unearthed. Pattison uses anecdotes from the field, gleaned from interviews and White's trove of videos and photos from years of fieldwork, to describe the dangers and rigors of the three years it took to excavate Ardi's remains. Pattison also illuminates how an insistence by White's team on painstaking preservation of the fragile fossils and exhaustive comparisons to other species to reconstruct Ardi's body plan over the next 15 years clashed with many paleoanthropologists' desire to get quick access to Ardi for their own studies.

The literary flow slows as Pattison probes the ins and outs of Ardi's skeletal parts. But patient readers are rewarded with a vision of a somewhat apelike, somewhat monkeylike, somewhat humanlike creature (*SN: 1/16/10, p. 22*) that, its discoverers argue, destroys the influential view that early hominids looked much like chimpanzees after having evolved from a knuckle-walking ancestor.

For anyone interested in fossil hunting, evolutionary science and a hominid skeleton like no other, this book delivers. — *Bruce Bower*

The story of the discovery of Ardi, the hominid skeleton shown in this composite image, involves a colorful cast of characters and plenty of drama.

SOCIETY UPDATE

FROM THE INTERNATIONAL SPACE STATION

NASA astronaut Chris Cassidy answers questions about life in space

Ever wondered what an astronaut's job is like? Do you have questions that not even Google can help you answer? Here's your inside scoop into life in space! Spoiler alert: Astronauts don't eat the dehydrated ice cream sold in many museums. During a rare Earth-to-space call that aired live on October 2, 17 high school students participating in the Society for Science & the Public's *Science News* in High Schools program had the opportunity to pose questions to astronaut Chris Cassidy, who was aboard the International Space Station.



Cassidy answered these questions and more:

- What does it feel like when the spaceship is launching?
- Do you always fulfill or come close to fulfilling your goals on expeditions or have you failed before?
- What advice would you give to youth in STEM who are interested in space exploration?
- What do you think is the largest myth about living in space?
- What kind of phenomena have you observed in space that couldn't be seen or replicated on Earth?
- How do astronauts who speak different languages communicate with one another?

For Chris' insightful answers, head over to www.societyforscience.org/blog/nasa-astronaut-chris-cassidy



FEEDBACK



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Scientists made a toy boat float upside down on the bottom of a layer of levitating liquid, Maria Temming reported in "Toy boats defy gravity by floating upside down" (SN: 9/26/20, p. 32). "I was quite intrigued by the upsidedown boat. The explanation of buoyancy versus gravity does suggest an equilibrium for the upside-down boat, but it seems to be unstable in theory," reader David Edmonston wrote. "If the upside-down boat were pushed upward ever so slightly, then its buoyancy should increase, making the boat rise to the top of the liquid layer," Edmonston wrote. "If it were pushed downward, then its buoyancy should decrease, allowing it to fall below the underside of the levitated liquid. That would be an unstable equilibrium, like standing a pencil on its point. Is there more to the explanation? Is there surface tension involved? Upward force from the levitation?" he asked.

The boat does exist in an unstable equilibrium, **Temming** says. "Shaking the container holding the boat and liquid helps the upside-down boat maintain a steady position on the bottom of the liquid layer," she says. "Because the boat is constantly shaking up and down as well, its own vertical vibrations cancel out any external jostling that would knock the boat off its float. More massive boats require stronger shaking to resist being knocked down to the bottom of the container or up to the top of the liquid layer."

Spooky sound effects

A scale model of Stonehenge revealed that the complete structure would have amplified speech and improved musical sounds for people inside it, **Bruce Bower** reported in "Stonehenge enhanced sounds within" (SN: 9/26/20, p. 14).

"I've always found Stonehenge very interesting. It is in the middle of fields, but a busy road passes it about a half a mile or so away.... You get a weird thrill seeing it loom up out of the mist as you drive along," reader **Michelle Reeve** wrote. "Another weird acoustic effect is that although the road is visible from the monument ... strangely you cannot hear the traffic. Sound normally carries well over open ground," **Reeve** wrote. "It gives the impression of a ghost road from another dimension. A spooky effect!"

Energy matters

Spacetime ripples revealed that two black holes merged to form the first definitive example of a midsize black hole, **Emily Conover** reported in "Midsize black holes really do exist" (SN: 9/26/20, p. 7). Eight solar masses' worth of energy was carried away by gravitational waves during the merger. Reader **Jonathan Lis** wondered if matter was converted into that energy.

Matter particles aren't being converted into energy in this case, **Conover** says. Instead, other forms of energy are transformed into the gravitational wave energy. "The orbiting black holes have both kinetic and potential energy. It's that energy that gets converted into gravitational waves," she says. Because energy and mass are equivalent in general relativity, that means the total mass of the system decreases when the black holes merge.

Life story

Clumps of bacteria exposed to the harsh conditions of outer space might be able to weather a trip between Earth and Mars, **Jonathan Lambert** reported in "Bacteria can survive for years in space" (SN: 9/26/20, p. 10).

Reader **Daniel Jameson** wondered if such floating clumps of microbes could have seeded early Earth with life.

That idea is one of many theories for how life on Earth began, **Lambert** says. While there's no direct evidence that life descended from otherworldly microbes, amino acids and sugars have been found in outer space and within meteorites on Earth. That suggests space rocks could have delivered those and other necessary ingredients for life to the planet. Another theory is that early Earth formed the ingredients, and eventually life, on its own (*SN: 9/26/20, p. 22*).





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Ancient human nerve cells preserved as glass

Nearly 2,000 years ago, a cloud of scorching ash from Mount Vesuvius buried a young man as he lay on a wooden bed. That burning ash quickly cooled, turning some of his brain to glass.

This event in A.D. 79 in Herculaneum, a town at the western base of the volcano, preserved the man's usually delicate neural tissue in a durable, glassy form that scientists can now study. New scrutiny of the tissue has revealed signs of nerve cells with elaborate tendrils for sending and receiving messages (shown above), scientists report October 6 in *PLOS ONE*.

That the young man once possessed these nerve cells, or neurons, is no surprise; human brains are packed with roughly 86 billion neurons. But ancient brain samples are scarce. Those that do exist have become a soaplike substance or mummified, says Pier Paolo Petrone, a biologist and forensic anthropologist at the University of Naples Federico II in Italy. While studying the Herculaneum archaeological site, Petrone noticed something dark and shiny inside this man's skull. Those glassy, black fragments (one shown above right), Petrone realized, "had to be the remains of the brain."

He and colleagues used scanning electron microscopy to



study glassy remains from the man's brain and spinal cord. The researchers saw tubular structures as well as cell bodies that were the right sizes and shapes to be neurons. The team also found layers of tissue wrapped around tendrils in the brain tissue. This layering appears to be myelin, a fatty substance that speeds signals along nerve fibers.

The preserved tissue was "something really astonishing and incredible," Petrone says, because the conversion of objects to glass, a process called vitrification, is relatively rare in nature. "This is the first-ever discovery of ancient human brain remains vitrified by hot ash during a volcanic eruption." — Laura Sanders

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