SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
JUNE 8, 2019

Collapsars Spin Gold

A New Kind of Dementia

Southern Ocean's Secrets

Denisovans Lived on Top of the World

MEASLES ROARS BACK

SPECIAL REPORT

A resurgent virus spreads and triggers worldwide alarm

Better Than Free!

Eight carats of sparkling blue topaz for only $79! A $395 value. Plus, we'll give you back $100.*

We can't think of a better way to introduce you to the fine art of affording the extraordinary than with an absolutely extraordinary offer: Purchase the 8 carat ***Blue Topaz Decadence Ring*** for $79, and we'll sweeten the deal with $100 in Stauer Dollars with no minimum purchase good towards future orders of any of our hundreds of pieces of fine jewelry, vintage watches and luxury gifts. Basically, we're paying you to shop Stauer.

Eight carats of genuine blue topaz AND $100 to shop with? How can we offer such an outrageous deal? Here at Stauer we believe the finer things in life shouldn't cost a fortune. Celebration, romance, forgiveness—there are many reasons to indulge in something truly extraordinary. And, Stauer is your passport for doing exactly that. We found a similar ring for nearly $1,500, but we're offering you one for $79 because we buy big, we buy smart, we keep costs low, and choose to get our name out there by offering true value, not flashy ad campaigns with super models and yacht races. We like to think we're rewriting the rules of luxury one happy client at a time.

Satisfaction guaranteed or your money back. Experience the show-stopper beauty of the ***Blue Topaz Decadence Ring.*** If you're not happy, simply send it back within 30 days for a complete refund of the item price. *The $100 in Stauer Dollars is yours to keep for giving us a try.*

LIMITED AVAILABILITY. No one is practically giving away genuine gemstones along with $100 in discounts, so we can't guarantee our supplies will last long. In fact, we only have ~~1500~~, 1282 left for this ad only. Don't miss your chance to treat yourself to an absolutely phenomenal deal and then some. Call today!

"Blue topaz is one of the most beautiful and popular gemstones today."
— *Jewelry Notes* online magazine dedicated to jewelry

Blue Topaz Decadence Ring (8 ct.) ~~$395~~†

Your Ring Cost With Offer Code — *only* **$79** + S&P

***plus** receive (2x $50) $100 in Stauer Dollars with no minimum purchase toward your next order!*

You must use the offer code to get our special price.

1-800-333-2045

Offer Code: BTR118-01

Customers love Stauer Blue Topaz Rings...

★★★★★

"Love at first sight! The color of the topaz rivals a perfect blue sky... one of my favorite pieces from Stauer!"
— N.B., Mattapoisett, MA

ACCREDITED BUSINESS **Rating of A+**

CONSUMER AFFAIRS ACCREDITED

† Discount is only for customers who use the offer code versus the listed original Stauer.com price.

8 ctw genuine oval blue topaz; checkerboard cut • Gold-finished .925 sterling silver setting • Whole ring sizes 5–10

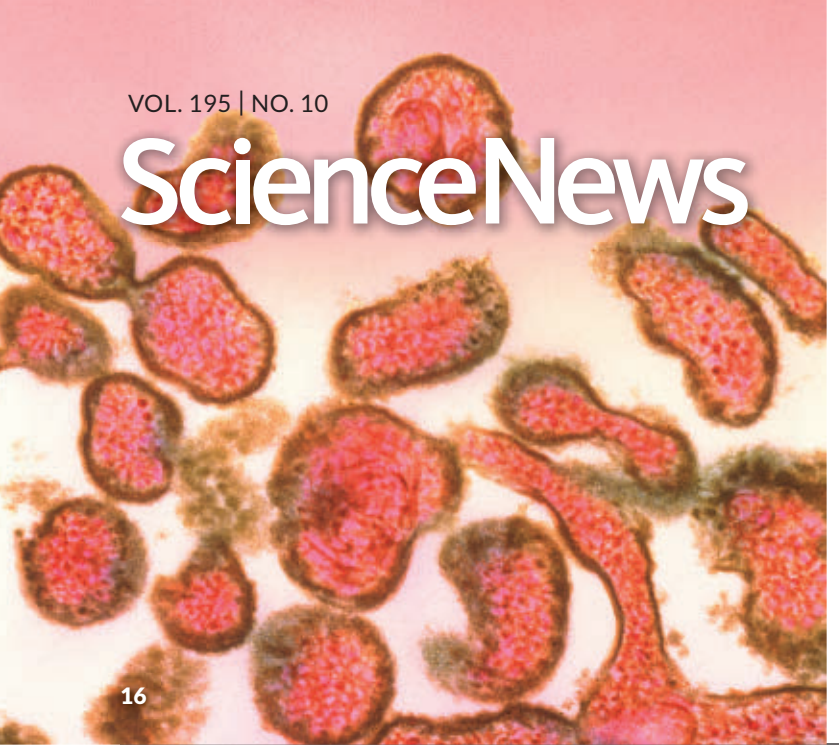
Stauer®

14101 Southcross Drive W., Ste 155, Dept. BTR118-01
Burnsville, Minnesota 55337 www.stauer.com

Stauer... *Afford the Extraordinary.*®

VOL. 195 | NO. 10

ScienceNews


16

Features

News


12


4

Departments

SOCIETY UPDATE
Recent articles from *Science News for Students*

COVER Measles spreads rapidly in communities where immunization rates drop below 92 percent. *carduus/iStock/Getty Images Plus*

FROM TOP: NIBSC/SCIENCE SOURCE; ROCKY RAYBELL; BILAL HUSSEIN/ASSOCIATED PRESS

Resurgence of measles is a tale as old as human history

Late last year, researchers reported a discovery from a 5,000-year-old mass grave in Sweden: DNA from the bacterium that causes plague. The people in that grave were probably felled by an epidemic that spread via trade routes from southeastern Europe and contributed to sharp population declines across the continent (*SN: 1/19/19, p. 12*), a precursor to the Black Death that wiped out up to half of Europe's population in the 14th century.

Infectious microbes come and they conquer: It's a story repeated again and again throughout human history. And we humans are often unwitting agents of our doom, spreading pathogens as we travel. That was true for Old World ills like smallpox and measles that traveled with Christopher Columbus and his crew to the Caribbean island of Hispaniola and devastated the indigenous Taino people. It was also true for the Spanish flu of 1918–1919 that killed about 50 million people worldwide and was spread by troop movements in World War I.

And we see it again with this year's surge in measles outbreaks. Cases worldwide are increasing rapidly, according to the World Health Organization. The United States had seen 880 cases as of May 17, the greatest number since the disease was declared eliminated in this country in 2000.

In this issue's special report, we explore why growing numbers of Americans hesitate to get their children vaccinated (Page 16). The reasons may surprise you. Just saying that vaccines are safe often doesn't allay people's fears. With that understanding, doctors are trying new ways of connecting with people who refuse or put off getting vaccines for their families.

We also look far beyond our borders to see the challenges that other countries face in their efforts to eradicate measles (Page 22). Because it spreads so easily, the virus is a tough foe, as our data visualization on Page 32 explains. And we're still learning about how measles attacks; our article on Page 20 explains how it wipes out the immune system's memory, leaving people more susceptible to other diseases for months or years. It's a foe that no one should take lightly. *—Nancy Shute, Editor in Chief*

Subscriber alert

Some *Science News* subscribers have recently received unauthorized "renewal notices." These deceptive notices have been sent by independent solicitation companies without the approval of *Science News* or its publisher, Society for Science & the Public. Their renewal rates are generally higher than our usual rates. Companies operate under numerous names but might include Pacific Magazine Billing or Global Publication Processing.

Any notice from *Science News* will always include our logo, refer to your account status and request that payments be made to our processing center in Kettering, Ohio. If you receive a notice that doesn't appear to be from *Science News* or an authorized agent, do not respond to it. If you have questions, call customer service at 800-552-4412 or e-mail subscriptions@sciencenews.org.

If You're Over 50 and Driving at Night, Night-Lite® Night Driving Glasses May Save Your Life... Mine Too

Drivers' Alert: ***Night driving is a top cause of car accidents. Your ability to perceive and judge distance is severely impaired at night. Do you know how to protect yourself?***

The National Safety Council says nighttime is "The most dangerous time to drive." The new technology making headlights brighter and more blinding than ever is a key contributor to making it even harder to see while driving at night.

Safe driving is serious business, so we did our research and looked to the very best in optic innovation and technology... Eagle Eyes®.

Night-Lites® lens technology helps filter out high-intensity glare and softens harsh lights from high beams and overly bright LED signage. Exclusive micro-infused yellow lenses with optical grade anti-reflective backside coating are designed for optimal clarity and definition to create a better visual experience. And, 2x scratch guard inner and outer lens coating helps keep the lenses in pristine condition, longer.

Prescription? No problem. FitOn® Night-Lites® are premium, high-performance night driving glasses designed to fit comfortably over your existing prescription eyewear. The Techlon™ Polycarbonate frames provide durability and a comfortable featherweight feel.

Own the road all night long. Don't compromise your safety and the safety of others. Eagle Eyes® Night-Lites® lens technology can improve your night vision and help you see things in a whole new light.

Your satisfaction is 100% guaranteed. If you don't experience a positive difference in your night vision, send the ***Eagle Eyes® Nite-Lites®*** back within 30 days for a complete refund of the item price.

"You are likely to experience poor vision when night driving due to the intermittent brightness of headlights and streetlights on the road." — Vision Eye Institute

"Nationwide, 49% of fatal crashes happen at night, with a fatality rate per mile of travel about three times as high as daytime hours." — Forbes Magazine

A.

Night-Lites® Classic Aviators helps filter out high-intensity glare while stainless steel frames define a sleek silhouette.

FitOn® Night-Lites® fit over your regular glasses

B.

★★★★★

Night-Lite® Aviators

"They definitely improved my night vision and significantly reduced eye strain, especially in rainy conditions. I don't drive nights without them."
—K. P.

Eagle Eyes® Night-Lites®

A. Aviator Night-Lites® (Gold) ~~$99~~ **$49†** ***Save $50***

B. FitOn® Night-Lites® (Tortoise) ~~$99~~ **$49†** ***Save $50***

You must use the insider offer code to get our special price.

1-800-333-2045

Your Insider Offer Code: ENL137-01.

Please use this code when you order to receive your discount.

ACCREDITED BUSINESS
Rating of A+

• Stainless Steel Frame • Night-Lite® Yellow Non-Polarized Lens Technology • Anti-Reflective Coating • Carrying case with custom lens pockets • Microfiber cleaning cloth

† Special price only for customers using the offer code versus the price on Stauer.com without your offer code.

Stauer® 14101 Southcross Drive W., Ste 155, Dept. ENL137-01, Burnsville, Minnesota 55337 **www.stauer.com**

Stauer... *Afford the Extraordinary.®*

Excerpt from the June 14, 1969 issue of *Science News*

50 YEARS AGO

Solar power from moon to Earth

An almost unlimited supply of electricity could be generated on the moon's surface by huge arrays of solar cells and beamed to Earth by laser. Sunlight falling on a crater ... could produce from 10,000 to 100,000 megawatts of power. By comparison, a large hydroelectric dam on Earth produces about 100 megawatts. Solar cells would be more efficient on the moon than on Earth ... because of the lack of dimming clouds.

UPDATE: There are no solar panels on the moon yet, but scientists are still looking at ways to harness the sun's energy in space to use as electricity on Earth. A 2012 NASA report proposed a bell-shaped satellite of solar cells that could supply solar energy to Earth, costing roughly $20 billion to launch. China and Japan are further along. China plans to launch small solar power stations into the stratosphere by 2025; Japan has its sights set on a similar one-gigawatt solar plant, generating as much energy as a typical nuclear power plant on Earth, by the 2030s.

When these day-old chicks are 10 to 12 weeks old, they will get to work monitoring mosquito activity. They are being raised by the sentinel chicken program in Charlotte County, Fla.

THE SCIENCE LIFE

Chickens stand guard against vectorborne disease

For 40 years, they've held the front line in Florida's fight against mosquito-borne diseases. The chickens standing sentinel in cities, marshes, woodlands and backyards are clucking good at their job.

In 2018, chickens from over a third of Florida's counties provided weekly blood samples that revealed if they had been bitten by mosquitoes carrying the West Nile virus, or viruses that cause Eastern equine encephalitis and Saint Louis encephalitis.

If a chicken's blood tests positive for antibodies to a virus, authorities know the pathogen is circulating. If enough birds test positive in an area, officials can boost mosquito-killing measures, such as pesticide spraying, to halt disease spread.

Chickens offer "a really good way of monitoring" certain virus activity, says biologist Thomas Unnasch, who studies vectorborne diseases at the University of South Florida in Tampa. The birds "are sampling literally hundreds or thousands of mosquitoes every day." (Chickens can't keep tabs on dengue or Zika; the mosquitoes carrying those viruses tend to bite people rather than birds.)

A field-worker draws blood from a vein under the wing of a sentinel chicken in Charlotte County, Fla. A lab tests the blood for antibodies to certain mosquito-borne diseases.

Last year, 833 chickens tested positive for West Nile virus in Florida, and 39 people did, according to the state's health department. For Eastern equine encephalitis virus, 154 chickens and three people tested positive.

In people, these viruses are relatively rare, but can be deadly. Chickens don't get very sick, though. "You don't usually see any symptoms at all," Unnasch says. Chickens and people that test positive also can't transmit the viruses. Both are considered "dead-end hosts," with the viral concentration in the blood too low to infect another mosquito that bites. Instead, cardinals, robins and other birds keep the viruses circulating.

The chickens also provide valuable intel on how viruses spread. Data from 2005 to 2016 show Eastern equine encephalitis virus is active year-round in the Florida Panhandle, making the area a source from which the virus moves, Unnasch and colleagues report May 1 in the *American Journal of Tropical Medicine and Hygiene*.

Sentinel chickens are also deployed in other locations, including Los Angeles and Mobile, Ala. —*Aimee Cunningham*

BOTH: COURTESY OF CHARLOTTE COUNTY, FLA.

MYSTERY SOLVED

Charged particle plasma paints STEVE purple

We're a step closer to understanding the atmospheric light show called STEVE.

Short for Strong Thermal Emission Velocity Enhancement, STEVE is a rare sky glow that appears closer to the equator than auroras do (*SN: 4/14/18, p. 5*). Unlike the shimmery green ribbons of the northern lights, STEVE consists of a mauve band of light stretching east to west, sometimes with a row of vertical green stripes called the picket fence.

Satellite data and celestial photos reveal that heated atmospheric particles make STEVE's mauve ribbon, while electron showers from space create the picket fence, researchers report online April 16 in *Geophysical Research Letters*.

Learning about the atmospheric conditions that create these sky glows may help researchers anticipate the effects of space weather on satellite signals, says Don Hampton, a space physicist at the University of Alaska Fairbanks who wasn't involved in the study.

Space physicist Toshi Nishimura of Boston University and colleagues analyzed data from satellites that had passed near two STEVE events in 2008 and 2016. The satellites observed particles and electromagnetic waves in the atmosphere and near-Earth space. The team found that STEVE's purple smear comes from a westward stream of plasma. Charged particles in the plasma, flowing at about 5 kilometers per second, heat other atmospheric particles through friction, causing them to emit purple light. It's not yet clear which molecules produce this purple hue.

"With the picket fence, the story is a little bit different," says coauthor Bea Gallardo-Lacourt, a space physicist at the University of Calgary in Canada. Electrons rain down from space and excite oxygen molecules, making them glow green. A similar process causes auroras closer to the poles (*SN: 8/9/14, p. 32*). "Something special is happening" at the latitudes where STEVE appears that allows electrons to tumble into the atmosphere and create the picket fence, she says. — *Maria Temming*

Satellite data are helping uncover the atmospheric processes behind STEVE, a weird sky glow composed of a purple streak and sometimes columns of green light beams.

INTRODUCING

Meet *T. rex*'s tiny cousin

It lived 92 million years ago and looked like a *Tyrannosaurus rex* — except tiny. Only a meter tall at the hip, the dinosaur had scientists stumped. Two partial skeletons had been found in the late 1990s in New Mexico. Other fossils in Asia and North America have since helped to flesh out *T. rex*'s family tree and to confirm the creature as kin. The dinosaur, now named *Suskityrannus hazelae*, had some of the skeletal traits of its later, megapredator relatives, scientists report online May 6 in *Nature Ecology & Evolution*. The animal's skull was built for a strong bite, and three metatarsal foot bones were pinched together in a way thought to strengthen the ankle — handy for running or holding down prey. — *Maria Temming*

Suskityrannus hazelae (illustrated) offers a glimpse into the evolution of tyrannosaurs.

SCIENCE STATS

How humans are putting species in peril

A new and sweeping analysis of some 15,000 studies conducted over the last five decades reveals that about 1 in 8 animal and plant species is threatened with extinction, some within decades. That's almost 13 percent of Earth's biodiversity. And in many species' cases, human activities are largely to blame, according to a May 6 report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Here are some of the ways humans are changing the planet, by the rough numbers. — *Carolyn Gramling*

1 million
Species threatened with extinction

33 percent
Ocean fish stocks overharvested in 2015

75 percent
Land area "severely altered" by human activity

10x
Rise in marine plastic pollution since 1980

1 degree Celsius
Average global warming since preindustrial times

7.6 billion
People on Earth (double the 1970 population)

FROM TOP: ROCKY RAYBELL; ANDREY ATUCHIN

HUMANS & SOCIETY

Denisovans lived the high life

Enigmatic hominids arrived at Tibetan Plateau before humans

BY BRUCE BOWER

Denisovans reached "the roof of the world" at least 160,000 years ago.

Found in a cave on the Tibetan Plateau, a partial lower jawbone represents a Denisovan who is the oldest known hominid to reach the region's cloud-scraping heights, researchers report in the May 16 *Nature*.

The fossil suggests that these perplexing, extinct members of the human lineage weathered the plateau's frigid, thin air long before humans did. Many researchers had assumed that, as far as hominids go, only *Homo sapiens* settled in that high-altitude, low-oxygen environment, probably no earlier than 40,000 years ago (*SN: 12/22/18 & 1/5/19, p. 6*).

"It blows my mind that Denisovans lived on the Tibetan Plateau," paleoanthropologist and study coauthor Jean-Jacques Hublin of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, said at an April 29 news conference.

Until now, Denisovans were known only from a handful of fossils unearthed in Siberia's Denisova Cave, and from ancient DNA extracted from a few of those specimens. Researchers regard Denisovans, who inhabited Denisova Cave from about 300,000 to 50,000 years ago (*SN: 3/2/19, p. 11*), as close relatives of Neandertals.

The jaw's microscopic protein structure and anatomy peg it as Denisovan, geoarchaeologist Fahu Chen of the Chinese Academy of Sciences in Beijing and colleagues report. However, the team wasn't able to extract Denisovan DNA from the fossil. Rocky material attached to the bottom of the jaw enabled the calculation of its minimum age.

Found in 1980 by a Buddhist monk as he explored a cave on the plateau in Xiahe, China, the jaw adds to evidence that *Homo* evolution in Asia was a complicated affair, Hublin said. Denisovans and Stone Age *H. sapiens* occasionally interbred, leaving Denisovan DNA in present-day Asians, Melanesians and Australians. Recent research also shows that two different Denisovan populations left a genetic mark on Papua New Guineans, one perhaps as recently as 15,000 years ago (*SN: 4/27/19, p. 15*).

Scientists also knew that modern Tibetans had inherited a genetic variant from Denisovans that aids survival at high altitudes (*SN: 8/9/14, p. 8*). That discovery fueled suspicion that Denisovans had ascended into mountainous parts of Asia far from Denisova Cave, which sits only 700 meters above sea level. Baishiya Karst Cave, where the new fossil was discovered, is 3,280 meters above sea level. Denisovans probably evolved a genetic tweak to deal with the Tibetan Plateau's thin air long before passing that gene to *H. sapiens* via interbreeding, Hublin said.

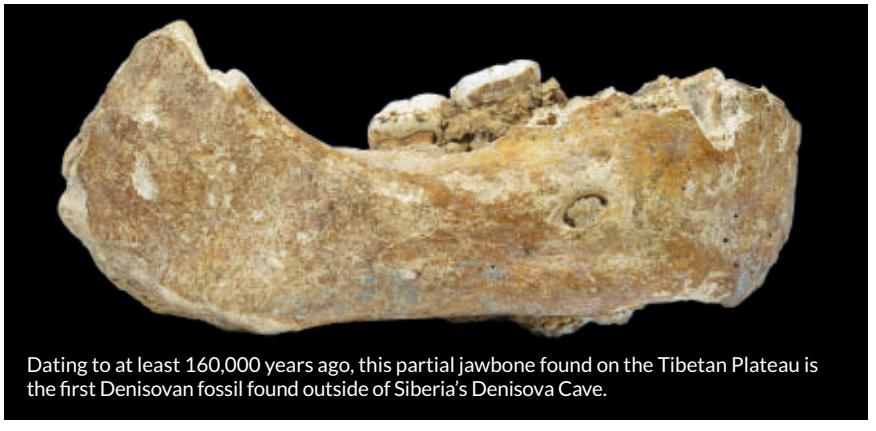
Like teeth previously found in Denisova Cave, two molars preserved in the Xiahe jaw are larger than those of Neandertals and resemble teeth of older *Homo* species. A molar at the back of the Xiahe jaw had not fully erupted, indicating that the individual was an adolescent at the time of death. The jaw itself is strongly built and shorter than those of Neandertals.

Two other Stone Age *Homo* jaws, one dredged from ocean waters near Taiwan and the other unearthed in northern China (*SN Online: 1/16/19*), resemble the Xiahe find. Those fossils might also come from Denisovans, says paleoanthropologist Chris Stringer of the Natural History Museum in London.

In addition to analyses of the Xiahe jaw and teeth, fragments of six proteins extracted from the fossil have chemical sequences that match corresponding protein sequences of Denisovan fossils from Denisova Cave more closely than those of Neandertals, *H. sapiens* and modern apes. Proteins, which preserve better than DNA, contain amino acid sequences that differ between various animal species and therefore can be helpful in studying ancient species when DNA isn't available, says study coauthor Frido Welker, a bioarchaeologist at the Max Planck Institute for Evolutionary Anthropology and the University of Copenhagen.

Analyses of ancient proteins show great promise for identifying evolutionary relationships among fossil hominids, Stringer says. Preserved proteins may help determine, for example, whether the Taiwanese and northern Chinese jaws come from Denisovans, especially if those specimens don't yield any DNA.

The Xiahe fossil fits a scenario in which Denisovans lived in much of East Asia, says paleoanthropologist Antonio Rosas González of the National Museum of Natural Sciences in Madrid. But he sees no answer at this point to the mystery of whether Denisovans belonged to a genetically diverse Neandertal species or represented a distinct *Homo* species with close ties to Neandertals. ■



Dating to at least 160,000 years ago, this partial jawbone found on the Tibetan Plateau is the first Denisovan fossil found outside of Siberia's Denisova Cave.

DONGJU ZHANG/LANZHOU UNIV.

ATOM & COSMOS

Rover gets glimpse of moon's innards

Minerals spotted on the surface may come from the mantle

BY MARIA TEMMING

A mission to the farside of the moon may have found bits of the moon's interior.

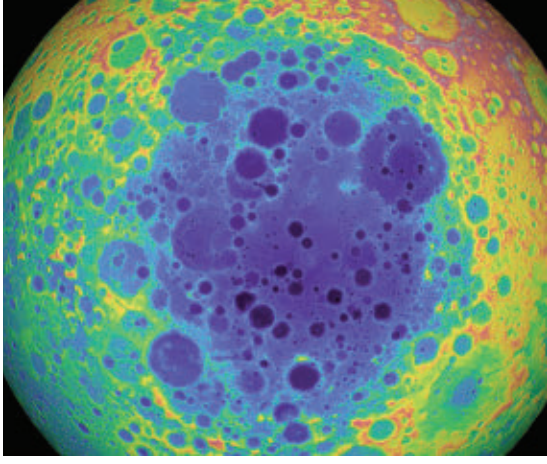
The Yutu-2 rover, deployed by China's Chang'e-4 spacecraft, detected soil that appears rich in minerals thought to make up the lunar mantle, researchers report in the May 16 *Nature*.

"Understanding the composition of the lunar mantle is key to determining how the moon formed and evolved," says geophysicist Mark Wieczorek of the Côte d'Azur Observatory in Nice, France, who was not involved in the work. "We do not have any clear, unaltered samples of the lunar mantle" from past moon missions.

In January, Chang'e-4 touched down in the South Pole–Aitken impact basin. The collision that formed this enormous divot is thought to have been powerful enough to punch through the moon's crust and expose mantle rocks to the surface (*SN: 11/24/18, p. 14*). While exploring the basin, Yutu-2 recorded the spectra of light reflected off lunar soil at two spots.

The data revealed a chemical makeup quite different from normal lunar soil, says study coauthor Dawei Liu, a planetary scientist at the Chinese Academy of Sciences National Astronomical Observatories in Beijing. One site appears to be about 48 percent olivine and 42 percent low-calcium pyroxene — minerals that are thought to be ingredients in the lunar mantle — and only 10 percent is high-calcium pyroxene, a component of lunar crust. The other site shows 55 percent olivine, 38 percent low-calcium pyroxene and 7 percent high-calcium pyroxene.

"There need to be some follow-up observations" to confirm that this material really is from the mantle, says Daniel Moriarty, a lunar geologist at NASA's Goddard Space Flight Center in Greenbelt, Md. Some crustal material can create signatures that mimic olivine's.



On the farside of the moon, the Yutu-2 rover has found what appears to be lunar mantle material on the surface of a massive impact basin (blue and purple region).

If the material is from the mantle, the makeup could help clarify the moon's history. Billions of years ago, scientists think, the moon was partially or completely molten. As the moon cooled and solidified, materials of different densities separated into the mantle and crust. There are many models for how this process occurred, Moriarty says. These models predict different abundances of minerals like olivine and pyroxene in the upper mantle, so samples of the interior could help determine which models best describe how the moon evolved. ■

ATOM & COSMOS

Moon seems to be tectonically active

Apollo-era seismic recordings are linked to surface faults

BY CAROLYN GRAMLING

The moon may still be kicking. Rumbles recorded decades ago by four seismometers at Apollo landing sites are probably linked to young faults, scientists say. Eight of those moonquakes occurred within 30 kilometers of fault scarps, steplike cliffs that mark where one side of a fault has thrust up or slipped down. If true, the finding suggests that the moon is still tectonically active today, researchers report online May 13 in *Nature Geoscience*.

Unlike on Earth, the moon's quakes aren't produced by the movements of numerous, large tectonic plates. Instead, like Mercury and Mars, the moon has basically one plate, says planetary scientist Thomas Watters of the Smithsonian Institution in Washington, D.C.

As a one-plate planetary object cools over time and the interior contracts, the hard outer shell compresses and cracks. That compression can produce quakes. As the moon's interior has cooled, its radius is thought to have shrunk by about 100 meters. But whether the moon is still tectonically active has been a mystery.

Previously, while examining images from NASA's Lunar Reconnaissance Orbiter, Watters and colleagues found numerous cliffs called lobate scarps, which represent thrust faults, where the surface is contracting as the moon cools. The team estimated the scarps are no older than 50 million years. Watters suspected they might be much younger.

So the team turned to moonquakes detected from 1969 to 1977 by seismometers installed by Apollo astronauts. Most moonquakes were small and originated deep inside the moon. But 28 were larger and shallower, originating within just 200 kilometers of the surface.

Pinpointing the origins of the shallow quakes, and linking them to faults, was tricky, because the seismometers are clustered close together. The team used a mathematical program to identify epicenters, and then mapped them to scarps. Epicenters over 30 kilometers away from any scarp were considered unrelated.

"We found eight of these within that 30-kilometer cutoff distance," Watters says, close matches suggesting that the moon is still actively contracting.

"I would have been surprised the moon was tectonically active had you asked me 10 years ago," says Berlin-based planetary geologist Amanda Nahm of the Arctic Planetary Science Institute. "The more we learn about these small bodies, the more we realize that they are so much more interesting and dynamic than previously thought." ■

GSFC/NASA, UNIV. OF ARIZONA

GENES & CELLS

Genetics of snail twists unraveled

CRISPR confirms which gene sets the direction of shell swirls

BY TINA HESMAN SAEY

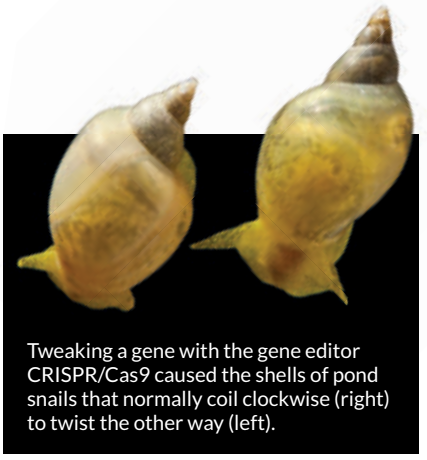
A genetic spin doctor sets snail shells to swirl clockwise, new research confirms. And the twist in this story comes at the beginning — when snail embryos are just single cells.

Most pond snails (*Lymnaea stagnalis*) have shells that coil clockwise, but a few turn to the left, curling counterclockwise. Researchers had strong evidence that a mutation in a gene called *Lsdia1* caused the counterrevolution, but there was a possibility that the similar *Lsdia2* gene might be involved. The two genes are 89.4 percent identical, so teasing out which was responsible was tricky.

Working at the Tokyo University of Science, chemist and biologist Reiko Kuroda and colleague Masanori Abe snipped *Lsdia1* with the gene editor CRISPR/Cas9. The snip made a mutation in the gene that could be passed on to future generations. Snails that inherited two edited copies of the gene developed left-coiling, or sinistral, shells, say the researchers, who have relocated to the Chubu University in Kasugai, Japan.

The accomplishment, reported online May 14 in *Development*, marks the first time scientists have made heritable changes in snail genes, says evolutionary geneticist Angus Davison of the University of Nottingham in England. Teams led by Davison and Kuroda had previously published evidence independently that *Lsdia1* is responsible for the twist, but the new work provides the definitive proof, Davison says.

In the new study, Kuroda and Abe also found that *Lsdia1* causes the internal scaffolding — the cytoskeleton — of all of a snail's cells to skew to the left or right very early on, when a snail embryo is just a single cell. Finding that early twist solves a mystery: When does asymmetry start?



Tweaking a gene with the gene editor CRISPR/Cas9 caused the shells of pond snails that normally coil clockwise (right) to twist the other way (left).

Like snails, humans and many other organisms are asymmetrical, with internal organs growing on particular sides of the body. That asymmetry is necessary to fold intestines that are many times the length of the body into a relatively small space in an orderly manner, says Martin Blum, a developmental biologist at the University of Hohenheim in Stuttgart, Germany. Two genes, *nodal* and *Pitx*, are involved in giving rise to internal asymmetry, by being produced on only one side of the embryo. Gene-edited snail embryos turned on those genes in a pattern that is a mirror image to that of right-coiling snails, creating lefties, the researchers found.

"Now we know [asymmetry] starts in the symmetrical embryo," Blum says. *Lsdia1*'s protein tugs on the cytoskeleton, which leads cells to divide in a spiral pattern. That somehow causes *nodal* and *Pitx* to become active on one side of the embryo. "This riddle is solved," he says, but there are still a few steps missing to connect how the skewing of cell division leads to activity of the two genes. Kuroda says she is working to fill in the details. ■

LIFE & EVOLUTION

Vaccines may help bats fight fungus

In the lab, inoculation protected against white nose syndrome

BY HELEN THOMPSON

Vaccines could give bats a better chance at surviving white nose syndrome, the fungal disease that has ravaged bat colonies in North America. In the lab, vaccination led to fewer infected bats developing lesions and more bats surviving, scientists report May 1 in *Scientific Reports*.

White nose syndrome, caused by the fungus *Pseudogymnoascus destructans*, has killed about 7 million bats in the United States since 2006. The white fuzz grows across the skin when the animals hibernate, eventually making them wake up, fly around and waste energy needed to survive winter (*SN Online: 1/29/16*).

"It's just devastating," says veterinarian Elizabeth Falendysz of the U.S. Geological Survey National Wildlife Health Center in Madison, Wis.

Falendysz and colleagues made two vaccines by implanting raccoon poxviruses with DNA instructions for making one of two fungal proteins, to trick the bat immune system into fighting the fungus.

Wild little brown bats (*Myotis lucifugus*) were vaccinated before being exposed to the fungus. Of 10 bats given a combination of both vaccines, only one developed lesions within the experiment's 100-day hibernation period. Because the bats don't survive well in captivity, dwindling sample sizes made it hard to compare these numbers to other treatments. But 14 of 23 bats, or 61 percent, that didn't get this vaccine combo developed lesions.

A second trial confirmed the results and found that bats that survived lost on average about 34 percent of their body weight; bats that died had lost about 55 percent. Slowing the fungal growth or reducing the infection's intensity may have helped vaccinated bats sleep more peacefully and maintain more weight and energy, the team suspects. Oral versions of the vaccine offered the best protection.

"Mortality rates are extremely high for some species that get white nose syndrome, so even modest gains in immunity and survival could make a big difference," says Winifred Frick, a biologist at the University of California, Santa Cruz.

The researchers hope to develop a vaccine spray that bats would lick from their fur as they groom themselves and spread as they nuzzle other bats. ■

COURTESY OF KURODA LAB

BODY & BRAIN

Another form of dementia is named

'LATE' disorder mimics Alzheimer's and afflicts the very old

BY LAURA SANDERS

A newly described dementia strikes people in their last decades of life. The disease, aptly named LATE, comes with symptoms that resemble Alzheimer's disease but is thought to be caused by something completely different.

Reporting online April 30 in *Brain*, an international team of scientists and clinicians describes the disease and christens it LATE, which stands for the more technical "limbic-predominant age-related TDP-43 encephalopathy." Peter Nelson, a neuropathologist at the University of Kentucky in Lexington, helped organize a meeting in 2018 that addressed a growing realization: "There's this disease, and it doesn't have a name," he says.

Estimates vary, but it's possible that about a quarter of people age 85 and older have LATE, Nelson says. "This is a disease that really attacks the very latest portion of the human aging spectrum."

LATE comes with memory trouble and dementia — symptoms that mirror Alzheimer's, Nelson says. But instead of the plaques and tangles that mark the brains of Alzheimer's patients, LATE is characterized by the misbehavior of a lesser-known protein called TDP-43. That protein accumulates and spreads through parts of the brain that are key to thinking and memory, including the hippocampus.

But the spread of TDP-43 and other signs of LATE, such as damage to the hippocampus, can be found only after a person has died.

With no surefire clinical tests to identify LATE in a living person, the disease is diagnosed largely after ruling out other disorders, says neurologist Michael Greicius of Stanford University, who was not involved in the study.

The researchers hope that giving the disease a name and description will make it easier to spot. Take a hypothetical 80-year-old with memory loss who tests negative for signs of Alzheimer's in the brain and whose MRI shows a smaller-than-normal hippocampus, Greicius says. "There, I think this notion of LATE is going to start rising quickly to the top." Still, he cautions that "this is a disorder that we're beginning to get a handle on. We're not quite sure yet."

Greicius also points out that brains, particularly older ones, often contain a mix of problems, each of which might contribute to dementia. That makes pinning symptoms on TDP-43 a challenge. "The minute you have other pathologies in there, it's really hard to tease those out," he says. Many brains with LATE also show some signs of Alzheimer's, a commingling that may confound easy diagnoses.

There's a growing realization that many different, and perhaps interconnected, pathways can lead to dementia. "Grappling with this complexity is necessary," Nelson says, and could ultimately point to subsets of people who could be treated for their particular form of dementia, should a therapy become available.

That complexity may also be behind some of the recent failures of drugs to treat Alzheimer's, Nelson says. People who actually had LATE, not Alzheimer's, may have been included in those clinical trials, masking potentially positive results, he says. ■

HUMANS & SOCIETY

Ancient pouch held shaman's stash

A leather bag found in the Andes has yielded rare clues to South American shamans' hallucinatory visions about 1,000 years ago. One artifact in the bag, a pouch stitched out of three fox snouts (shown), contains chemical traces of five mind-altering substances from at least three plants, say bioarchaeologist Melanie Miller of the University of Otago in Dunedin, New Zealand, and colleagues. Residues include two primary ingredients of ayahuasca, a vision-inducing concoction still used by South American ritual specialists, the scientists report online May 6 in the *Proceedings of the National Academy of Sciences*. Cocaine residue suggests that the pouch also held coca leaves.

The leather bag, found in Bolivia's Cueva del Chileno rock-shelter, also held two wooden tablets used for snorting or snuffing, a snuffing tube, a pair of llama-bone spatulas, a possible headband and dried plant fragments tied to strings. The objects show influences of the ancient Tiwanaku society, the scientists say. Tiwanaku shamans entered altered states to communicate with ancestors and supernatural beings. — *Bruce Bower*

COURTESY OF JUAN V. ALBARRACIN-JORDAN AND JOSÉ M. CAPRILES

Eye proteins found in some deep-sea fishes such as the tube-eye (shown) raise the possibility that the animals can see color in the deep ocean.

LIFE & EVOLUTION

Fishes in the dark depths may see color

Eye chemistry hints at the ability to perceive more than just gray

BY SUSAN MILIUS

Some fishes in the deep, dark sea may see their world in more than just shades of gray. A survey of 101 fish species reveals that four from the deep sea have a surprising number of genes for light-sensitive eye proteins called rod opsins, researchers report in the May 10 *Science*.

Depending on how the fishes use those light catchers, the discovery might challenge the idea that deep-sea fishes don't see color, says evolutionary biologist Zuzana Musilová of Charles University in Prague.

To see, most vertebrates rely on two types of light-detecting cells. Cones use two or more kinds of opsins and need decent amounts of light to work. Rods generally use only one opsin, RH1, which works in dim light. That opsin variety in cones, but not in rods, lets vertebrates see a range of colors in well-lit conditions but leaves them color-blind in the near dark.

Musilová and Fabio Cortesi of the University of Queensland in Brisbane, Australia, sailed on ships with equipment that reached into the ocean to grab fish. Deep-sea fish came from the "twilight" zone, 200 to 1,000 meters below the surface, where sunlight becomes only a subtle lessening of darkness.

The four deep-sea fishes with the special eyes come from three lineages that have independently evolved genes for more than one kind of RH1 rod opsin, Musilová, Cortesi and colleagues report. A glacier lantern fish (*Benthosema glaciale*) has genes for five forms of RH1; a tube-eye (*Stylephorus chordatus*) has six genes. Two kinds of spinyfin have even more, 18 genes for the longwing spinyfin (*Diretmoides pauciradiatus*) and 38 for the silver spinyfin (*Diretmus argenteus*).

Finding even two rod opsins would have been notable. The silver spinyfin's tally is "astounding," says evolutionary

ATOM & COSMOS

Gold's origins tied to collapsars

Collapsed stars may have made many heavy elements

BY EMILY CONOVER

The gold in your favorite jewelry could be the messy leftovers from a newborn black hole's first meal.

Heavy elements such as gold, platinum and uranium might be formed in collapsars — rapidly spinning, massive stars that collapse into black holes as their outer layers explode in a rare type of supernova. A disk of material swirling around the new black hole as it feeds can create the conditions necessary for the astronomical alchemy, scientists report in a study published in the May 9 *Nature*.

"Black holes in these extreme environments are fussy eaters," says study coauthor and astrophysicist Brian Metzger of Columbia University. They can gulp down only so much matter at a time; what they don't swallow blows off in a wind that is rich in neutrons — just the right conditions for the creation of heavy elements, computer simulations reveal.

Astronomers have puzzled over the origins of the heaviest elements. Lighter elements like carbon, oxygen and iron form inside stars, before being spewed out in stellar explosions called supernovas. But to create heavier elements, an extreme environment densely packed with neutrons is required. That's where a chain of reactions known as the r-process can occur, in which atomic nuclei rapidly absorb neutrons and undergo radioactive decay to create new elements.

Scientists had suspected that when two dead stars known as neutron stars collide, the r-process could occur in material churned up by the merger. Astronomers clinched the case when they spotted the formation of a medley of heavy elements after a collision between two neutron stars (*SN: 11/11/17, p. 6*).

The neutron star explanation on its own has shortcomings, though. These dense, dead stars can take a long time to coalesce. But heavy elements have been found in stars that formed early in the universe's history. It's not clear whether a neutron star merger could happen fast enough to explain the elements in those early stars.

Collapsars, however, can occur shortly after stars begin to form. That phenomenon could be a prolific producer of heavy elements. A single collapsar might generate 30 times as much r-process material as a neutron star merger and generate a few hundred times the Earth's mass in gold, Metzger says. The researchers report that collapsars might be responsible for 80 percent of the r-process elements in the universe, with neutron star mergers making up the rest.

biologist Megan Porter of the University of Hawaii at Manoa. But she and others warn against jumping to conclusions about how fishes use this variety, because there were no tests of fish behavior.

Considering where these fishes live, such tests may not be possible, Musilová says. But in the fish that were caught, the researchers checked which genes were turned on in the retina. That confirmed that the silver spinyfin uses at least 14 of its 38 RH1 genes to make proteins.

The researchers also put the silver spinyfin's RH1 genes into bacteria, which made fish opsins. Tests showed that those opsins have the potential to capture faint daylight and a range of blue and green light from bioluminescent creatures.

The authors are rightly "cautious" in not claiming that these fishes see color, says Almut Kelber of Lund University in Sweden, who has studied low-light color vision in frogs. The results, for example, don't say whether different RH1 opsins cluster in individual rods or are scattered so that different rod cells carry different opsins. To differentiate colors, rod opsins would need to be in different cells. ■

The study sheds light on the 2016 discovery that the dwarf galaxy Reticulum II experienced a cataclysm early in the universe's history that left r-process elements in the galaxy's stars (*SN: 5/14/16, p. 9*). Scientists had proposed that a neutron star merger seeded the galaxy. Now, a collapsar is another candidate.

It's still not clear if collapsars happen frequently enough, or if they produce the right amount of material, to explain the abundance of heavy elements in the universe. "The jury's still out," says astrophysicist Alexander Ji of Carnegie Observatories in Pasadena, Calif., who coauthored the 2016 Reticulum II study.

"Now we're really excitedly thinking about how you might be able to tell the difference" — whether collapsars or neutron stars better explain galaxies like Reticulum II, Ji says. Future observations of the aftermath of the supernovas produced by collapsars could also help address that question. ■

MATH & TECHNOLOGY

AI uses art to control monkeys' brains

Neural manipulation may lead to new mental health treatments

BY MARIA TEMMING

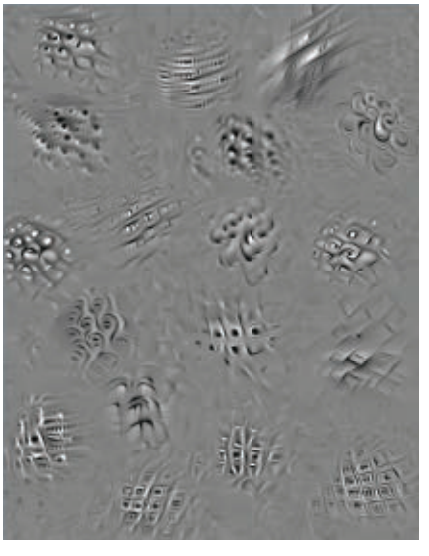
Artwork created by artificial intelligence does weird things to the primate brain.

When shown to macaque monkeys, AI-generated images caused nerve cells in the monkeys' brains to fire more than did pictures of real-world objects. The AI also designed patterns that activated specific neurons while suppressing others, researchers report in the May 3 *Science*.

This level of control over neural activity using images may lead to new kinds of neuroscience experiments or treatments for mental disorders.

The AI responsible for the mind-bending images is an artificial neural network, a computer model composed of virtual neurons. This AI was modeled after the ventral stream, a neural pathway in the brain involved in vision. The AI learned to "see" by studying a library of about 1.3 million labeled images. Researchers then instructed the AI to design pictures that would affect specific ventral stream neurons in the brain.

Viewing any image triggers some neural activity. But neuroscientist Kohitij Kar and colleagues at MIT wanted to see whether the AI's deliberately designed images could induce specific responses of the team's choosing. The team showed images to three macaques fitted with neuron-monitoring microelectrodes.



An artificial intelligence program designed patterns (examples shown) that controlled the activity of specific vision-related nerve cells in macaque brains.

P. BASHIVAN, K. KAR AND J.J. DICARLO/*SCIENCE* 2019

In one experiment, the AI aimed to create patterns that would activate neurons at a specific site in the ventral stream as much as possible. In 40 of 59 neural sites tested, AI-made pictures caused neurons to fire more than any image of a real-world object, such as a car or a face. AI images generally caused neurons to fire 39 percent more than their maximum response to real-world images.

In another test, the AI crafted patterns meant to make neurons at one target site go wild, while minimizing the activity of others. For 25 of 33 sites, AI-created images isolated neural activity to the target site better than real-world images.

"This is magnificent technical progress," says neuroscientist Arash Afraz of the National Institute of Mental Health in Bethesda, Md. In neuroscience experiments, researchers sometimes want to induce certain brain activity patterns to learn what different neurons are responsible for, he says. "The direct way of doing that is to roll your sleeves up, open up the skull and stick something in there," like electrodes. AI-generated images may offer a noninvasive way to do that.

AI-rendered images that orchestrate neural activity may also lead to new treatments for mental health problems like post-traumatic stress disorder, anxiety or "anything that would have to do with mood," says study coauthor and computational neuroscientist Pouya Bashivan. Similar to the way that people use light therapy boxes to assuage seasonal affective disorder or look at peaceful nature scenes to calm down (*SN: 11/10/18, p. 16*), people may someday be soothed by gazing upon images that an AI made to boost mood. ■

HUMANS & SOCIETY

Horrors of war affect some kids more

Environmental sensitivity raises PTSD risk for Syrian children

BY BRUCE BOWER

After her husband's death in Syria's civil war, Amouna Sharekh Housh gathered her eight children and headed for safety in neighboring Lebanon. At the border, Islamic State militants demanded that Housh hand over her children. She refused, even when a soldier put a gun against the head of her then 9-year-old son, Manar. After passing through that checkpoint, the still-intact family moved into a refugee camp. Their house was a tent, food was scarce and sanitation was absent.

A year later, the family was struggling. Housh's children were now jittery and emotionally volatile. Manar had taken a particularly bad turn. He suffered from post-traumatic stress disorder, a condition that includes having tormenting thoughts and dreams about distressing events, feeling detached from others, staying in a constant state of high alert and reacting violently to minor frustrations. Housh shared her family's trials with workers at a Beirut therapy and vocational training center run by the New York City–based nonprofit Art of Hope and gave them permission to tell her story on the organization's website.

Housh's family is one drop in a sea of tears pouring out of Syria. Since civil war erupted in 2011, the Office of the United Nations High Commissioner for Refugees estimates that over 5 million Syrians have fled the country while 6.6 million people remain but are displaced from their homes. UNHCR has registered about 1 million Syrian refugees in Lebanon; more than half are 17 or younger.

Housh's family also highlights another sad fact of war: Everyone suffers, but some more than others.

Most people who live through violent conflict and other extreme traumas experience emotional turmoil but don't develop PTSD. A few, like Manar, suffer severe psychological wounds that don't heal without outside help. Even then, there are no guarantees.

A recent study of Syrian refugees in Lebanon offers a peek at why some kids rebound while others wilt in the face of wartime horrors. Children fleeing war zones are especially likely to develop PTSD if, before military conflict turned their worlds upside down, two factors were in play, say Lebanese psychiatrist Elie Karam and colleagues. First, PTSD-prone youngsters grew up especially aware of and responsive to good and bad aspects of their families, schools and neighborhoods. Second, those environmentally sensitive kids encountered few or no early adversities, such as a serious illness or constantly fighting parents.

"Highly sensitive children who are sheltered from early adversities end up being least prepared to cope with wartime experiences," Karam says. He is the president of the Institute for Development, Research, Advocacy and Applied Care, a nonprofit mental health organization in Beirut.

Karam's study, published in the June *British Journal of Psychiatry*, joins a growing effort to examine how environmental sensitivity affects well-being and mental health. This line of research builds on long-standing observations of two types of kids. "Orchid children" benefit from nurturing surroundings and do particularly badly when neglected or treated harshly. "Dandelion children" do pretty well in both good and bad environments and don't dramatically profit from enriched surroundings.

A research review led by psychologist Corina Greven of Radboud University Medical Center in Nijmegen, Netherlands, concludes that an individual's environmental sensitivity hinges on a genetic tendency to think about personal and social experiences in great depth, develop a heightened sense of empathy and quickly feel overstimulated by various sensations. In the March *Neuroscience & Biobehavioral Reviews*, the scientists say that this trait is best classified as sensory processing sensitivity.

In one measure of the trait's prevalence, about 20 to 35 percent of surveyed British children and adults score high on a scale of sensory processing sensitivity. A comparable proportion score low. The rest are in between these orchid and dandelion ranges.

Studying young Syrian refugees is revealing how environmental sensitivity and other factors contribute to PTSD risk. Here, children play at a refugee camp in Lebanon.

BILAL HUSSEIN/ASSOCIATED PRESS

Sheltered shock

There are no prevalence estimates for environmental sensitivity in war-ravaged countries. But Lebanon's influx of refugees inspired Karam and colleagues to determine whether environmental

sensitivity, childhood adversities and war experiences, either alone or in concert, up the odds of refugee children developing PTSD. Karam's team is the first to study environmental sensitivity as a potential contributor to PTSD.

A total of 549 Syrian refugees, ages 7 to 17, participated in the study. Volunteers were students in 31 Beirut-area schools also attended by Lebanese students. The Syrian students took surveys that assessed 20 PTSD symptoms, 25 types of war exposure (from being unable to leave home because of shootings and bombings to witnessing torture or death) and 29 childhood adversities (including physical abuse and a lack of food).

A 12-item questionnaire measured environmental sensitivity. Students rated the extent to which, for example, they find it unpleasant to have a lot going on at once, love nice smells, feel uncomfortable when hearing loud noises and dislike changes in their lives. Higher scores indicated greater sensitivity.

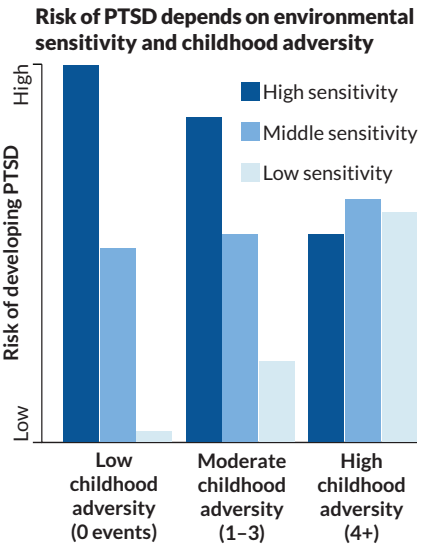
Not surprisingly, many students showed some signs of PTSD. But those who scored low in environmental sensitivity and reported few childhood hardships seemed most resilient, exhibiting few PTSD symptoms. Hardest hit were highly sensitive children who reported few childhood adversities.

In between were those who had faced many childhood misfortunes, defined as four or more such hardships. Those refugees had a moderate number of PTSD symptoms regardless of the environmental sensitivity score. That finding underscores how even temperamentally resilient youngsters can crumble in the face of too many misfortunes.

Steeled for resilience

Karam's results go beyond previous examinations linking childhood hardships with later trauma-induced disturbances that didn't account for differences in how orchid and dandelion children respond to life's bad turns.

Consider an example reported in the *Archives of General Psychiatry* in 2005. In the six months after the September 11, 2001 World Trade Center attacks in New York City, public schoolchildren there who reported a history of traumas had elevated rates of depression and anxiety disorders, including PTSD.



Two influences Syrian refugee children who scored high on a test of environmental sensitivity but experienced low or moderate levels of prewar adversity had a high likelihood of developing PTSD. High levels of prewar adversity put kids at risk for PTSD regardless of the environmental sensitivity score.

But the study couldn't say why some youngsters who had early adversities suffered serious mental problems after the twin towers fell, while others forged on relatively unscathed. The newly reported PTSD risks among Syrian refugee children "help us appreciate that orchid and dandelion children respond to war and other adversities in different ways," says J. Lawrence Aber, a New York University professor of psychology and public policy who coauthored the 2005 study.

It's likely that highly sensitive young Syrian refugees gained some sort of protection against PTSD from having dealt with earlier problems at home and elsewhere, says child psychologist Jay Belsky of the University of California, Davis. "It is almost like those with a supportive early life have not been steeled against adversity," Belsky says.

Psychologist Michael Pluess of Queen Mary University of London, a coauthor of Karam's study who has collaborated with Belsky, agrees. Highly sensitive kids may benefit from manageable challenges that don't become overwhelming, suggests Pluess, who directed the development of the environmental sensitivity scale administered to the Syrian children.

That's plausible, Aber says, but there's no research to confirm that possibility. And tracking orchid and dandelion children before, during and after an armed conflict is a tall order.

The long view

Situated across the border from Syria's violent chaos, Karam's team can't conduct such an investigation. But the researchers have begun a long-term study of how environmental sensitivity and early adversities promote or deter mental problems in refugee children. Since 2018, Karam's group has recruited more than 1,000 Syrian children and teenagers living in refugee camps into the study, which will last at least four years. Researchers will regularly assess each youngster's family situation, current and past adversities and emotional support available from family and friends. Participants' environmental sensitivity will also be tracked over time.

Hair samples and saliva from volunteers will enable investigators to monitor stress hormone levels and compare kids' genetic makeups.

Karam plans to examine whether self-reported early adversities heralded the appearance of any particular coping skills in highly sensitive refugee kids. He also wants to see if highly sensitive kids acquired special stress resistance following positive experiences, such as spending their early years with supportive parents.

In the meantime, his team is offering psychological treatment to young refugees in the study who show signs of PTSD and other emotional problems. Getting parents' consent for such treatment is challenging. Although people everywhere can be reluctant to seek mental health care, refugees in Lebanon tend to have little education and no knowledge of what mental health workers do.

"Some parents come forward to get treatment for their children, but many don't," Karam says. Still, in a sea of tears, small victories count for a lot. ■

E.G. KARAM *ET AL*/*BJPSYCH* 2019

EARTH & ENVIRONMENT

Few of Earth's long rivers run free

Free-flowing rivers are becoming an endangered species. Only about a third of the world's longest rivers flow along their entire lengths unchained by dams or reservoirs, scientists report in the May 9 *Nature*.

The study is the first global map of river "connectivity," the ability of river water to move freely downstream, across floodplains and into and out of aquifers. Connectivity is vital to protect freshwater biodiversity, support fish stocks and deliver sediment to coastal regions threatened by rising seas.

Geographer Günther Grill of McGill University in Montreal and colleagues used satellite data to map 12 million kilometers of rivers. Of the world's 246 rivers that are longer than 1,000 kilometers, only 37 percent run unimpeded. Most of the free-flowing rivers are in remote areas, such as the Arctic and the Congo. — *Carolyn Gramling*

ATOM & COSMOS

A nearby kilonova would brighten the sky day and night

If two neutron stars collided relatively close to Earth, the resulting kilonova would shine day and night with the brightness of the moon squeezed into a small dot. "At night, it would be by far the brightest thing up there," says physicist Imre Bartos of the University of Florida in Gainesville.

The first such burst of light and energetic particles seen in real time was spotted in 2017 (*SN: 11/11/17, p. 6*). That event, which occurred 130 million light-years away and was visible only with telescopes, proved that kilonovas sprinkle the universe with heavy elements.

While unlikely to happen nearby anytime soon, a kilonova occurred before the solar system formed about 1,000 light-years from where Earth is now, Bartos and physicist Szabolcs Marka of Columbia University reported in the May 2 *Nature*. That event seeded the solar system with elements that make up the planets today.

Wanting to make this distance more visual, Bartos and University of Florida colleague Nihar Gupte simulated the light spectrum from the 2017 kilonova as it would appear 1,000 light-years away. It would start out bluish and turn red over a few days to a week as debris from the kilonova smothered bluer wavelengths of light. After about a week, the kilonova would fade to nothing, Bartos and Gupte report May 7 at arXiv.org. — *Lisa Grossman*

A nearby kilonova, a burst following a collision of neutron stars, would shine brighter than the stars over New York City. Simulated images show a kilonova after one day (left) and after seven (right).

N. GUPTE AND I. BARTOS/ARXIV.ORG 2019, KING OF HEARTS/WIKIMEDIA COMMONS (CC BY-SA 3.0)

MATTER & ENERGY

Antimatter follows quantum rules

For the first time, researchers have performed a version of the famous double-slit experiment with antimatter.

The double-slit experiment demonstrates a tenet of quantum physics: that pointlike particles are also waves. In the experiment, particles travel through a pair of slits in a solid barrier. On a screen on the other side, an interference pattern typical of waves appears. Crests and troughs emerging from each slit reinforce or cancel each other out as they overlap, creating alternating bands of high and low particle density on the screen.

This kind of experiment has revealed the wave-particle duality of photons, electrons, atoms and even large molecules. But it's difficult to get a strong, uniform beam of antiparticles to do the experiment with antimatter. Now, a double-slit–style experiment, reported May 3 in *Science Advances*, has confirmed the wavelike nature of the electron's antimatter counterpart: the positron.

Positrons generated through the radioactive decay of sodium-22 traveled through two successive rows of vertical rods less than a micrometer thick. Gaps between the rods, each a few hundred nanometers across, worked like the slits in the classic experiment. Positron waves propagated out to a nuclear emulsion detector, where the positrons altered silver bromide crystals' chemical structure.

The detector "is like a photographic film," says physicist Marco Giammarchi of the National Institute of Nuclear Physics in Milan. Under a microscope, the film revealed an interference pattern, with alternating stripes of high and low positron density. — *Maria Temming*

GENES & CELLS

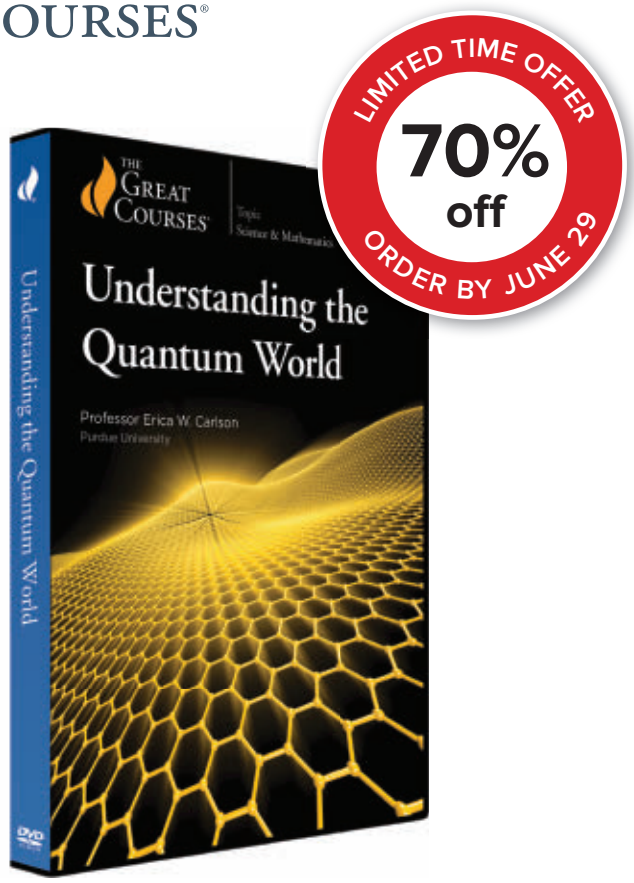
Gene may explain why some dog breeds have trouble breathing

Dogs with flat faces aren't alone in their struggle to breathe. It turns out that Norwich terriers can develop the same wheezing — caused not by the shape of the snout but possibly by a wayward gene.

DNA from 401 Norwich terriers revealed that those suffering a respiratory tract disorder shared the same variant of gene *ADAMTS3* that's associated with swelling around airways. Nearly a third of the dogs had two copies of the variant. Those dogs scored worse on tests of airway function than dogs with just one copy or normal versions of the gene, geneticist Jeffrey Schoenebeck of the University of Edinburgh's Roslin Institute and colleagues report May 16 in *PLOS Genetics*.

The variant also turned up in bulldog DNA. That finding hints that a smooshed snout is not the only factor behind bulldogs' labored breaths. — *Cassie Martin*

THE GREAT COURSES®



Meet Schrödinger's Cat and Other Quantum Ideas

The word "quantum" evokes mystery and unreality such as the baffling paradox of Schrödinger's cat—a hypothetical pet that is simultaneously both dead and alive in a quantum experiment. Yet quantum mechanics is one of the most successful theories of reality ever developed, describing exactly how matter and radiation work, and leading to such inventions as lasers, atomic clocks, flash drives, and much more.

Taught by award-winning Professor Erica W. Carlson of Purdue University, **Understanding the Quantum World** addresses these paradoxes in 24 stimulating half-hour lectures that explain the basics of quantum theory using minimal mathematics. Professor Carlson does this with ingenious analogies, insightful graphics, experiments involving everyday objects, and an inquisitive and playful approach to an immensely rich and rewarding subject. In fact, quantum mechanics just might be the most entertaining branch of physics ever.

Offer expires 06/29/19

THEGREATCOURSES.COM/9SN

1-800-832-2412

Understanding the Quantum World

Taught by Professor Erica W. Carlson
PURDUE UNIVERSITY

LECTURE TITLES

1. Particle-Wave Duality
2. Particles, Waves, and Interference Patterns
3. Observers Disturb What They Measure
4. Bell's Theorem and Schrödinger's Cat
5. Quantum Paradoxes and Interpretations
6. The Position-Momentum Uncertainty Relation
7. Wave Quantization
8. Quantum Wave Shapes and the Periodic Table
9. Interference of Waves and Sloshing States
10. Wave Shapes in Diamond and Graphene
11. Harmonic Oscillators
12. The Energy-Time Uncertainty Relation
13. Quantum Angular Momentum and Electron Spin
14. Quantum Orbital Angular Momentum
15. Quantum Properties of Light
16. Atomic Transitions and Photons
17. Atomic Clocks and GPS
18. Quantum Mechanics and Color Vision
19. A Quantum Explanation of Color
20. Quantum Tunneling
21. Fermions and Bosons
22. Spin Singlets and the EPR Paradox
23. Quantum Mechanics and Metals
24. Superconductivity

Understanding the Quantum World
Course no. 9750 | 24 lectures (30 minutes/lecture)

SAVE UP TO $190

DVD	~~$269.95~~	NOW $79.95
Video Download	~~$234.95~~	NOW $59.95

+$10 Shipping & Processing (DVD only)
and Lifetime Satisfaction Guarantee

Priority Code: 174058

For over 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free apps for iPad, iPhone, Android, Kindle Fire, or Roku. Over 700 courses available at www.TheGreatCourses.com.

One-year-old Bella Huang shares her displeasure at receiving the measles, mumps and rubella vaccine in Seattle in March. Nobody likes to see their baby in pain, even for a few seconds, and that discomfort makes some parents hesitant about vaccinating their children.

Easing Parents' Fears

Changing the doctor's office conversation to prevent measles

By Aimee Cunningham

About six years ago, Emily Adams, a mother of two in Lakewood, Colo., briefly counted herself among the vaccine hesitant. Her family had changed insurance plans, and while her older daughter was up-to-date on shots, her infant son fell behind.

"We were no longer on schedule, just because of life," she says. Adams remembers mentioning her son's situation to a friend, who suggested Adams hold off longer. The friend recommended some books discounting the science behind vaccines. Adams began reading, which led to about six months of feeling unsure about continuing to immunize her son.

In the end, Adams did not find the books convincing. She credits her sister, a molecular biology doctoral student at the time, with helping her sort through her concerns. Today, both of Adams' children are fully vaccinated.

Adams eventually found other parents like her — "crunchy," she says — with shared views on the environment, homemade baby food, cloth diapers and a belief in vaccination. She also became involved with Colorado Parents for Vaccinated Communities, which advocates for pro-vaccine policies. Adams has had conversations about vaccines with some doubting friends, who have "seemed really open when I've said things gently." She's even changed a few minds.

The circumstances that led to Adams' hesitancy illustrate the cracks in the country's foundation of infectious disease prevention, cracks that are creating vulnerable communities.

And vaccine hesitancy, defined as the delay in acceptance or the refusal of vaccines despite their availability, is a growing problem. Blue Cross Blue Shield Association analyzed U.S. claims data for more than 840,000 insured children born from 2010 to 2013 and followed until age 3. The percentage of kids with at least one documented parental refusal of a vaccine rose from 2.5 percent for those born in 2010 to 4.2 percent for the 2013 babies, the group reported in 2018.

That hesitancy has consequences. The 2019 measles outbreaks in the United States — 880 cases reported in 24 states as of May 17 — have mostly hit those who are not vaccinated (*SN Online: 4/29/19*).

It's an all-hands-on-deck situation, experts say. Boosting immunizations requires strong and effective public health campaigns to counteract false claims from anti-vaccination groups. It also depends on parents who support vaccines being vocal about that support, and state legislators placing stricter limits on religious or personal/philosophical exemptions that allow children to skip vaccines required for entry into school.

And while not every parent has a science expert in the family like Adams does, most have someone knowledgeable to turn to: a child's doctor. Parents consider their pediatrician or family practitioner to be a trusted source of information on vaccines, studies show. And physicians — who report encountering more vaccine hesitancy in recent

880

Number of reported measles cases in the United States as of May 17

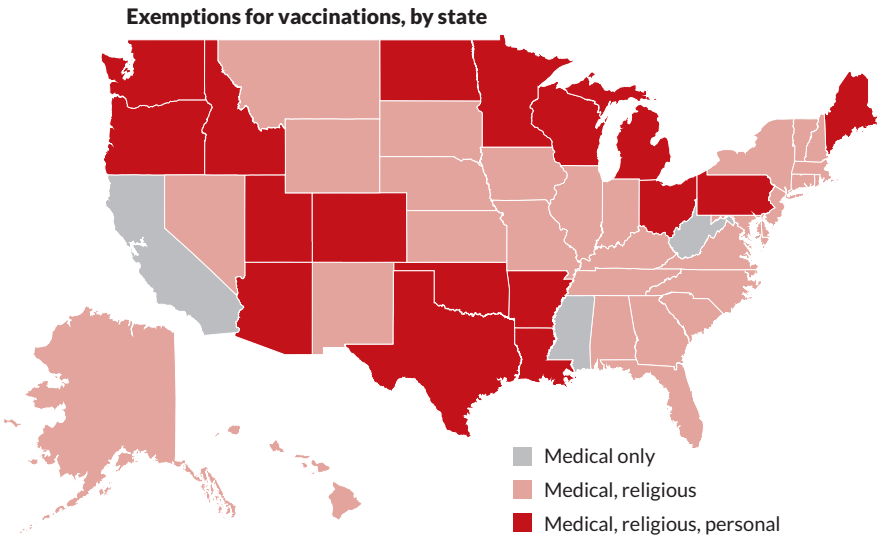
Special Report: Measles Roars Back

In 2000, it looked like the United States had won the war against measles. The highly infectious disease had been eliminated here, and the audacious goal of achieving the same elsewhere seemed within reach. Worldwide deaths had dropped to about 110,000 in 2017 from 2.6 million in 1963, the year a vaccine was introduced. But measles is back with a vengeance.

In the first four months of this year, the United States has seen more cases than in any year since 1994, most of them in communities where vaccination levels are lower than needed to keep the virus at bay. Hard-won progress is slipping away as cases spike globally, with more than 168,000 known infections this year, a 50 percent increase from the same period last year.

This special report explores the complex forces driving measles' resurgence and efforts to combat it worldwide. Doctors are trying different ways to communicate with the many people who worry about vaccine safety. Countries are tailoring their public health efforts to meet unique challenges. And scientists are learning more about what makes measles so dangerous, including its effects on the body long after the rash has faded. Measles spreads like wildfire as soon as immunization efforts wane, the World Health Organization's Ann Lindstrand says. "That's what we see right now."

OPPOSITE PAGE: LINDSEY WASSON/REUTERS



The state of exemptions All states allow people to opt out of vaccinations for medical reasons. Seventeen states also allow both religious and personal exemptions. In May, Washington removed the personal exemption for the measles, mumps and rubella vaccine only. Other states are considering limits on exemptions as well.
SOURCE: NATIONAL COUNCIL OF STATE LEGISLATORS

years — are seeking effective ways to make the case for vaccination.

Evidence is just beginning to surface on how to get that done. One promising method that focuses on the pediatrician-parent conversation is motivational interviewing. The aim is to learn what motivates the parent and work together to come up with a course of action.

The approach has been used for decades to help people change unhealthy behaviors, such as smoking or excessive drinking. Now physicians are examining whether discussing shared health goals can bring vaccine-hesitant parents on board.

1.3
percent
of U.S. children born in 2015 had no vaccinations by age 2 years

Not all or nothing

"It's very important to realize that vaccine-hesitant people are a very heterogeneous group," says Kathryn Edwards, a vaccine researcher and infectious disease pediatrician at Vanderbilt University School of Medicine in Nashville.

Parental beliefs and worries related to vaccines run the gamut. Some don't think vaccines are tested enough for safety. Some worry about toxicity or neurodevelopmental problems. Those fears have been debunked but continue to spread online.

Some parents feel children get too many vaccines (the visit for a 2-month-old can include as many as six). There are parents who question the necessity of vaccination for diseases they've never seen. Others worry about the immediate effects for their baby: the pain of each jab, the redness and swelling at the injection site, the possibility of a fever.

Edwards coauthored a 2016 American Academy of Pediatrics clinical report on countering vaccine hesitancy. She's been practicing medicine for more than four decades and has seen children die of vaccine-preventable diseases.

"I want children to be free of disease because I have seen how much better it is to prevent disease than to treat it," she says. It's important to remember, too, that parents' intentions are to do what's best for their children, she adds.

Doctors "don't need to come on with a bazooka" when they encounter a vaccine-hesitant parent, Edwards says. "You need to listen to what their question is" and let that guide the conversation.

Having questions doesn't necessarily mean a parent is against all vaccines; only a small minority are. In a 2010 telephone survey of 1,500 U.S. parents with a child from 6 to 23 months old, 3 percent of respondents had declined all shots for the child, researchers reported in *Academic Pediatrics* in 2012. The U.S. Centers for Disease Control and Prevention keeps tabs on national vaccination rates. Of U.S. children born in 2015, 1.3 percent, or 47,700, were completely unvaccinated by the age of 2 years, the CDC reported in 2018, but that percentage could be due to parental refusal or lack of access to health care.

U.S. guidelines recommend 10 vaccines, which have from one to four doses, to protect against 14 diseases by age 2. Elementary school years and adolescence bring additional doses and several new vaccines. Many parents who are vaccine hesitant accept some vaccines but not others, delay certain shots or follow an alternative vaccine schedule. Data from over 9,000 U.S. parents who completed the 2011 National Immunization Survey showed that 15 percent had refused and 27 percent had delayed at least one vaccination for their 19- to 35-month-old child, as reported in 2016 in *PLOS ONE*.

By kindergarten, the vast majority of children have received vaccines commonly required to start school, according to the CDC. Coverage of selected vaccines — including measles, mumps and rubella, or MMR — during the 2017–2018 school year varied by state and by vaccine. Rates ranged from a low of 80 to 90 percent (Colorado, District of Columbia, Idaho, Kansas, Washington) to close to 100 percent, the CDC reported in October.

Maintaining herd immunity to prevent infectious disease outbreaks means vaccination rates need to reach a threshold, which varies by disease. For measles, it's around 92 to 95 percent

T. TIBBITTS

(see Page 32). The measles outbreaks in the United States are hitting communities in which not enough people have gotten the MMR vaccine (*SN Online: 4/29/19*).

Around 95 percent of pediatricians surveyed said they provide information on vaccines to hesitant parents, as reported in 2016 in *Pediatrics*. Based on the doctors' reports, their efforts moved more than 30 percent of parents who had declined a shot to change their minds and allow immunization.

The right nudge

So how to reach those whose minds seem set? What might help hesitant parents gain confidence in vaccines? A study of 61 vaccine-hesitant mothers of children 5 years old or younger from the Philadelphia and San Francisco/Oakland regions provides some answers. As reported in 2018 in *Vaccine*, the women identified a number of factors that could boost their confidence, such as receiving information on why vaccines are needed, possible side effects and the ingredients vaccines contain.

These mothers also wanted health care providers to be empathetic and understanding. One mom in the study made that point, saying she wanted doctors to be better about listening "instead of just requiring vaccines and being pushy."

Researchers are studying different methods of providing vaccine information and supporting parents, through conversation or with fact sheets, educational websites or chat rooms. Often these studies have measured whether a method changes a parent's attitude about vaccines, and some have succeeded. Fewer studies have assessed whether that change led parents to vaccinate.

An approach that includes motivational interviewing has been shown to actually improve vaccination rates. And yet this technique isn't about trying to convince a hesitant parent to vaccinate, says Amanda Dempsey, a pediatrician at the University of Colorado Anschutz Medical Campus in Denver. "This is really much more about trying to become a partner with the parent," she says.

One of the ways the pediatrician does this is by asking permission to share. For example, say a pediatrician notes during a visit that the child will receive vaccine X, and the parent says no. Just asking, "why not?" could put the parent on the defensive, says Sean O'Leary, a pediatric infectious disease specialist and Dempsey's colleague.

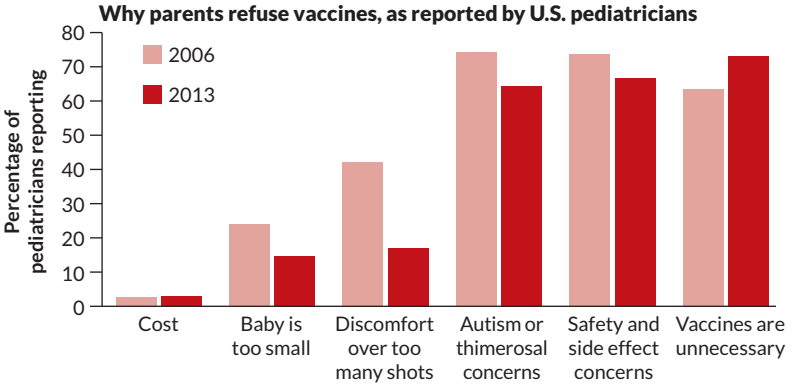
Instead, the pediatrician asks if the parent is OK with sharing what the concern is and then acknowledges the concern once voiced. "Then that's where you say 'You know, I've looked into this quite a bit. Would it be OK if I shared with you what I've come to find out?'" O'Leary says.

Dempsey, O'Leary and colleagues studied whether an intervention that includes motivational interviewing could change rates for human papillomavirus vaccination, which was introduced in the United States in 2006 and is recommended for adolescents at age 11 (*SN Online: 4/28/17*). By 2017, only 65.5 percent of 13- to 17-year-olds had gotten the first shot in the HPV vaccine series.

The researchers created a suite of tools that included HPV fact sheets, a parent education website and training on motivational interviewing for physicians to use with parents who resist vaccination. Sixteen pediatric or family medicine practices in the Denver area with more than 43,000 adolescent patients participated. Half of the practices received the intervention, the other half did not.

Practices that had the intervention experienced a jump of 11.3 percentage points (from 31.6 to 42.9 percent) in patients getting the first shot of the series. Practices that didn't get the intervention saw a smaller increase, 1.8 percentage points (from 37.1 to 38.9 percent), the researchers reported in 2018 in *JAMA Pediatrics*. Next up, Dempsey says, is to test whether motivational interviewing can boost infant vaccination rates.

The current measles outbreaks crystallize how crucial these conversations are. "We need to ... communicate in more effective ways," Edwards says. "These diseases are an airplane ride away." ■



No-go Parents offer a variety of reasons for refusing a vaccine for their child, according to two surveys of U.S. pediatricians, in 2006 and 2013. (Thimerosal is used as a preservative but was removed from all childhood vaccines, except for some flu vaccines, in 2001.)
SOURCE: C. HOUGH-TELFORD *ET AL/PEDIATRICS* 2016

Explore more

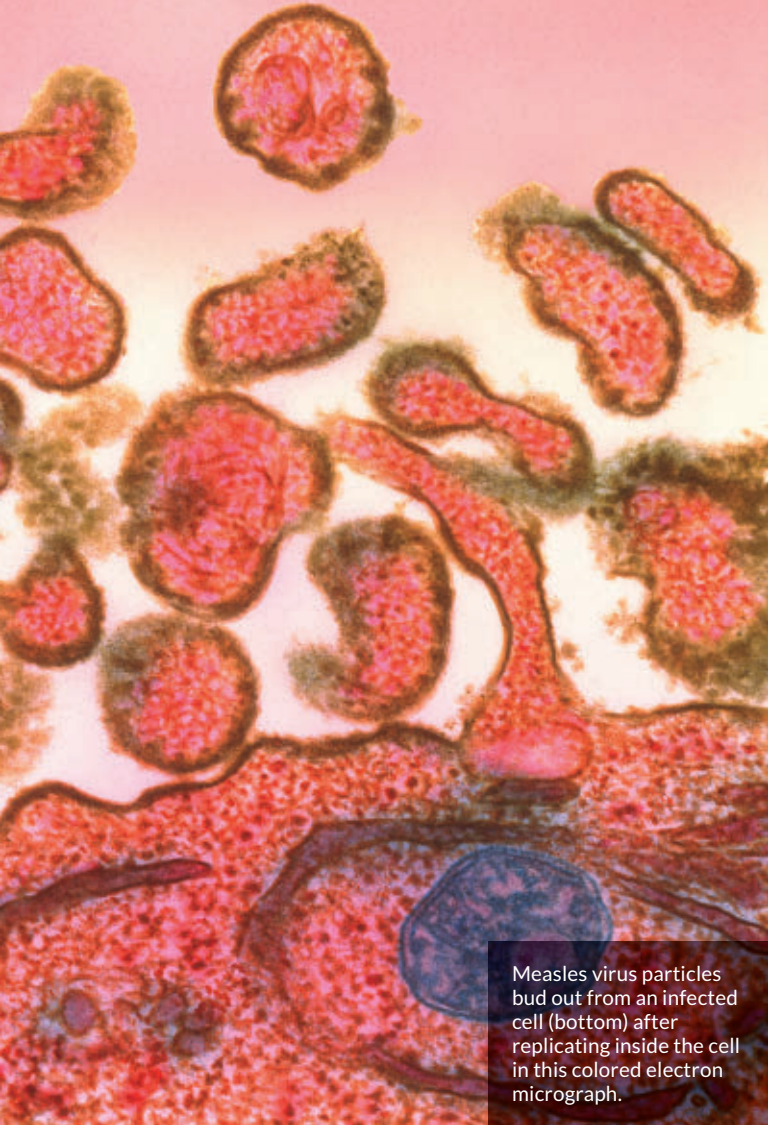
- Catherine C. McClure, Jessica R. Cataldi and Sean T. O'Leary. "Vaccine hesitancy: where we are and where we are going." *Clinical Therapeutics*. August 2017.

T. TIBBITTS

Measles erases immune memory

The virus leaves people prone to other infections for years

By Laura Sanders



Measles virus particles bud out from an infected cell (bottom) after replicating inside the cell in this colored electron micrograph.

NIBSC/SCIENCE SOURCE

The most iconic thing about measles is the rash — red, livid splotches that make infection painfully visible. But that rash, and even the fever, coughing and watery, sore eyes, are all distractions from the virus's real harm — an all-out attack on the immune system.

Measles silently wipes clean the immune system's memory of past infections. In this way, the virus can cast a long and dangerous shadow for months, or even years, scientists are finding. The resulting "immune amnesia" leaves people vulnerable to other viruses and bacteria that cause pneumonia, ear infections and diarrhea.

Those aftereffects make measles "the furthest thing from benign," says infectious disease epidemiologist and pathologist Michael Mina of Harvard University. "It really puts you at increased susceptibility for everything else." And that has big consequences, recent studies show.

Details about which immune cells are most at risk and how long the immune system seems to suffer — gleaned from studies of lab animals, human tissue and children before and after they had measles — have created a more complete picture of how the virus mounts its sneak attack.

This new view may help explain a larger-than-expected umbrella of safety created by measles vaccination. "Wherever you introduce measles vaccination, you always reduce childhood mortality. Always," says virologist Rik de Swart of Erasmus University Medical Center in the Netherlands. The shot prevents deaths, and more than just those caused by measles. By shielding the immune system against one virus's attack, the vaccine may create a kind of protective halo that keeps other pathogens at bay, some researchers suspect.

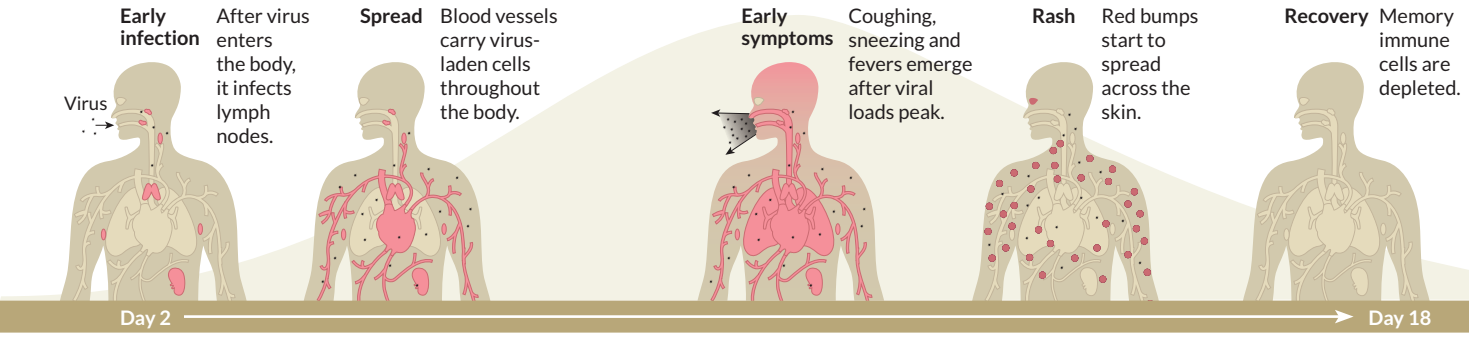
Locking onto a target

After an infected person coughs or sneezes, the measles virus can linger in the air and on surfaces for up to two hours, waiting to make its way into the airways of its next victims. Once inside, the virus is thought to target immune cells found in the mucus of the nose and throat, the tiny air sacs in the lungs or between the eyelids and cornea. These immune cells are decorated with a protein called CD150 that allows the virus to invade, experiments on lab animals suggest.

The virus quickly replicates inside the cells, then spreads to places packed with other immune cells — bone marrow, thymus, spleen, tonsils and lymph nodes. "The virus has an enormously strong predilection to infect cells of the immune system," says Bert Rima, an infectious disease researcher at Queen's University Belfast in Northern Ireland. Rima and colleagues traced the immune system invasion in preserved human tissue, reporting results in 2018 in *mSphere*. Eventually, newly made viral particles move into the respiratory tract, where they can be coughed out to sicken more people.

An acute measles infection, which usually lasts several weeks, can sometimes bring ear infections, pneumonia and, rarely, a deadly brain swelling. On their own, those are worrisome outcomes, says Anthony Fauci, director of the National Institute of

Viral cycle After the initial infection, measles-packed cells spread widely throughout the body before the symptoms, including a red, bumpy rash, appear. Viral load (shown in beige behind the bodies) peaks between seven and 10 days after infection. In the aftermath, the body has fewer memory immune cells. SOURCE: B.M. LAKSONO, ERASMUS MC, ROTTERDAM, NETHERLANDS



Allergy and Infectious Diseases in Bethesda, Md. But the loss of immune cells can also leave people vulnerable to infections that the immune system would normally be able to handle.

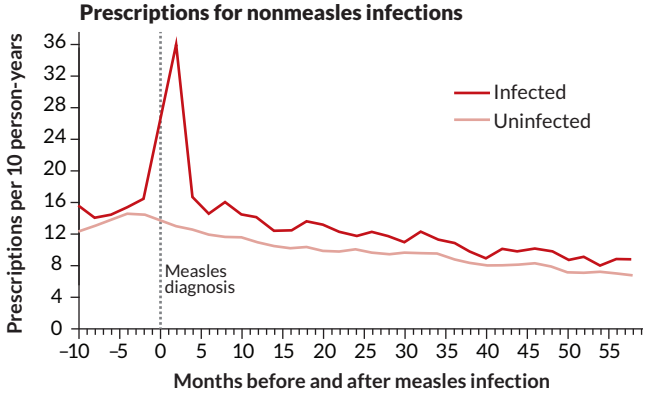
In 2013, de Swart and colleagues saw an opportunity to study the immune effects of the virus in children who are part of an insular community of Orthodox Protestants in the Netherlands, called the Dutch Bible Belt. Parents there refuse vaccinations, a decision that ushers in regular bouts of measles. The community's last measles outbreak ended in 2000; it was just a matter of time before the virus took hold again.

The researchers got permission from parents to take blood samples from healthy, unvaccinated children to study their immune cells. Then, the researchers waited for an outbreak, so they could test the kids again after an infection.

De Swart didn't have to wait long. Just as the researchers began collecting blood, an outbreak emptied classrooms, packing sick siblings into dark living rooms to protect their sensitive eyes. As the virus ripped through the community, de Swart and colleagues collected before and after samples from 77 children who contracted measles.

"The virus preferentially infects cells in the immune system that carry the memory of previously experienced infections," de Swart says. Called memory B and T cells, these cellular protectors normally remember threats the body has already neutralized, allowing the immune system to spring into action quickly if those threats return. After a measles infection, the numbers of some types of these memory cells dropped, creating an immune amnesia, the researchers reported in 2018 in *Nature Communications*.

Lasting harm U.K. children who had measles (red line) were more likely to receive prescriptions for medicine for other infections than children who hadn't gotten measles (pink line) over the following months and years. SOURCE: K. GARDROEN *ET AL/BMJ OPEN* 2018



BOTH: E. OTWELL

Long road to recovery

The immune system might take months, or even years, to bounce back from this memory loss. Researchers including de Swart and Mina compared health records of U.K. children from 1990 to 2014. For up to five years after their bout of measles, children who had previously had the virus experienced more diagnosed infections than children who hadn't. Children who'd had measles were 15 to 24 percent more likely to receive a prescription for an infection than children who never had measles, the researchers reported in 2018 in *BMJ Open*.

Mina and colleagues found similar results for deaths from nonmeasles infections in children in England, Wales, the United States and Denmark, before and after the introduction of the measles vaccine. When measles was rampant, children were more likely to die from other infections.

When the researchers looked out several years after the measles infections, the connection between measles and nonmeasles deaths grew stronger (*SN: 5/30/15, p. 10*). "Every little blip in the mortality data could be explained by the measles incidence data over the previous 30 months," Mina says. It's not clear how the immune system eventually recovers its memories. With new methods that can measure these cellular memories, Mina and others hope to understand that rebuilding process.

Most children get over measles uneventfully. "The immune system is incredibly resilient," de Swart says. Still, measles is not an innocent childhood disease. For some people, the consequences can be severe. But there's a vaccine for that. "At the end of the day, we know how to prevent this potentially lethal disease," Mina says. "It's so simple." ■

Explore more

- Brigitta M. Laksono *et al.* "Measles virus host invasion and pathogenesis." *Viruses*. July 2016.

As shown here in 2018, Colombia set up border stations to vaccinate Venezuelans who were fleeing unrest at home so that measles wouldn't spread in Colombia.

GLOBAL HOT SPOTS

Almost everyone must get vaccinated to stop measles' spread

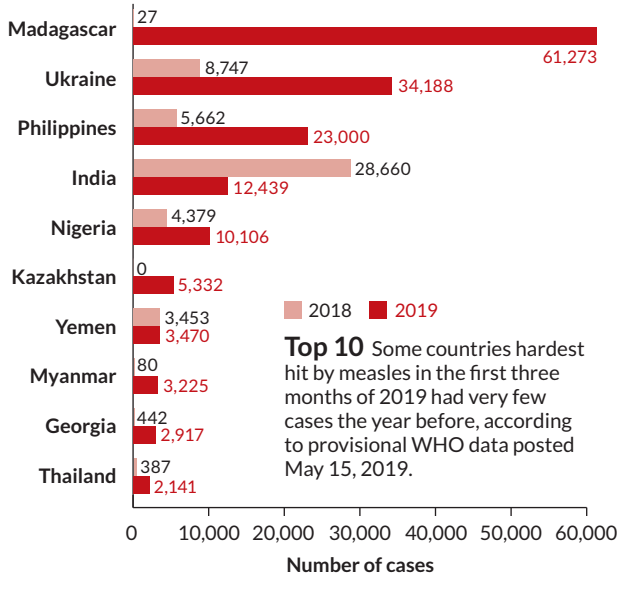
By Sujata Gupta

In the first four months of 2019, 179 countries reported 168,193 cases of measles. That's almost 117,000 more cases than reported during the same period last year. Actual numbers are probably much higher; the World Health Organization estimates that only 1 in 10 cases are reported. With this uptick, none of the world's regions will meet the WHO's 2020 goal to eliminate the disease, says pediatrician Ann Lindstrand, vaccine lead for immunization systems at the WHO in Geneva.

Even after a country attains elimination — defined as the absence of the continuous transmission of measles for a year or more — maintenance programs must be relentless, says Robert Linkins, a global measles expert at the U.S. Centers for Disease Control and Prevention in Atlanta. "Kids are born every day needing vaccines.... You have to keep up."

Political instability, conflict and poverty limit vaccine availability. When civil war broke out in Côte d'Ivoire in late 2010, for example, the percentage of individuals getting vaccinated against measles plummeted to 49 percent in 2011. Many countries are facing stressors and challenges to vaccination. Here are snapshots from a few countries that are in the thick of it.

Countries with the highest measles counts from January through March 2019



Top 10 Some countries hardest hit by measles in the first three months of 2019 had very few cases the year before, according to provisional WHO data posted May 15, 2019.

When this photo was taken in late February at a military hospital in Madagascar, 926 children and young adults had died of measles in the island country since the previous October.

PHOTOS, FROM TOP: SCHNEYDER MENDOZA/GETTY IMAGES; MAMYRAEL/GETTY IMAGES

Colombia

On March 8, 2018, a 14-month-old boy from Venezuela arrived in Medellin, Colombia, and soon developed spots. Lab testing confirmed he had measles. Colombia hadn't seen a case of measles since 2015. Public health officials went on high alert.

A political and economic crisis has thrown Venezuela's health system into disarray, and vaccination rates fell, Linkins says. With Venezuelans fleeing home by the thousands, Colombian officials knew the disease could cross into their country.

In 2017, working closely with the CDC and the WHO, Colombian officials sent vaccinators to high-risk municipalities and set up vaccination stations at the Venezuela-Colombia border. From May to July 2018, more than 11,000 Venezuelans were vaccinated as they entered Colombia.

From March 2018 through April 2019, Colombia had reported only 302 cases of measles and no deaths. Colombian officials "were able to recognize people quickly and launch a charge," Linkins says. "That's a success story in my mind."

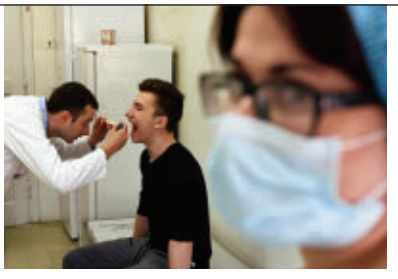
This young child in the Philippines is treated for a measles infection in February. The disease can cause respiratory problems.

Philippines

A dengue vaccine crisis dealt a blow to measles vaccination in the Philippines. Soon after the government approved a dengue vaccine in 2015, news emerged that it was making children sick. And there were reports that some children were dying from rare but serious reactions. The dengue vaccination program was suspended less than two years later. The episode led to "a huge upsurge in the Philippines of anti-vaxxers," says Lotta Sylwander, a UNICEF representative who was based in the Philippines until March. Even before the debacle, other challenges to vaccinations existed, including corrupt government officials, supply shortages and distributing the vaccine to the country's thousands of far-flung islands, Sylwander says. These issues plus growing vaccine hesitancy triggered a severe measles outbreak in late 2017 that still rages today. As of late March, the country had reported 23,000 cases this year and 333 deaths, mainly in young children.

Ukraine

Hit hard by political turmoil and vaccine hesitancy, Ukraine has seen a jump in measles cases. The first three months of 2019 had more than 34,000 cases. The outbreak is no surprise: In 2016, only 42 percent of children who needed the shot had received even a first dose.



A teen prepares for a measles vaccination in Ukraine. Many are playing catch-up to get the shots they need.

Several factors explain the low vaccination rates, says UNICEF's Lotta Sylwander, who is based in Kiev, Ukraine's capital. From 2009 to 2016, the eastern European country often ran out of vaccines, especially in its conflict-ridden eastern region.

Ukrainians also have a history of vaccine skepticism. During the Soviet era, the government vaccinated everyone. But many children received faulty vaccines that had not been properly refrigerated. "Even though children were vaccinated, they became sick," Sylwander says. Mistrust of government vaccination programs remains high (the recent U.S. measles outbreak in Washington state was focused in a tight-knit community of Ukrainian and Russian immigrants).

Ukraine's outbreak has spurred people to get vaccinated. And government programs over the last few years targeting vulnerable communities appear to be taking hold. The percentage of Ukrainian children who had received the measles vaccine jumped to 86 percent in 2017, according to WHO estimates. The challenge is reaching older children and teens who never got the shot.

Madagascar

One of Africa's poorest countries, Madagascar leads the world in measles cases, with more than 61,000 reported from January through March 2019 — a huge rise from just 27 total infections in the first three months of 2018. Less than 60 percent of the total population is vaccinated, and the country requires only a single dose of the vaccine.

The recent outbreak began in September 2018 and swept through the island. Between October 2018 and March 2019, more than 1,200 had died.

In response, Madagascar began targeted campaigns and vaccinated more than 7.2 million children. From October 22 to November 9, 2018, the campaign focused on children ages 9 months to 5 years in four regions of the capital, Antananarivo. Preliminary results suggest that 84 percent of those children have been vaccinated. A second campaign launched in January is aimed at children between 9 months and 9 years across 13 regions.

Lindstrand says those efforts appear to be working; the number of new cases is dropping. The country plans to introduce a second dose later this year, which boosts an individual's protection from 95 to 99 percent.

FROM TOP: PICTURE ALLIANCE/GETTY IMAGES; YURI DYACHYSHYN/GETTY IMAGES

SOCCOM floats, dropped from ships into the Southern Ocean, drift for months to years sending data via satellite on ocean temperature, salinity and CO_2 levels.

SOCCOM PROJECT/FLICKR (CC BY 2.0)

Southern Ocean — CLIMATE FRIEND OR FOE?

The waters surrounding Antarctica may not be absorbing as much carbon as expected

By Alexandra Witze

The vast stretch of icy water that separates Antarctica from other continents is a dark mystery to most people. Polar explorer Ernest Shackleton, one of the few who have been to the Southern Ocean, regarded its storm-wracked seas with fear and awe. After ice floes trapped and crushed the three-masted *Endurance* in 1915, Shackleton made an epic rescue attempt, sailing 1,300 kilometers to bring help to his stranded crew. He crossed the Southern Ocean's waters in a small open boat, threatened by what he called "uprearing masses of water, flung to and fro by Nature in the pride of her strength."

Yet this remote, tempestuous ocean also benefits humankind. Scientists estimate that each year, the Southern Ocean slurps up more than 40 percent of the carbon dioxide that people release by burning fossil fuels for electricity, heat and transportation. That makes the ocean a powerful support system for slowing the buildup of heat-trapping greenhouse gases in the atmosphere. The more carbon this immense body of water takes up, the less accumulates in the atmosphere to warm the planet.

But certain spots in the Southern Ocean may be working against the waters' carbon storage role. Scientists have begun to make ambitious new measurements of how much CO_2 it absorbs, using deep-diving floats that travel to far corners of the ocean. Last September, with the new data in hand,

researchers reported that rather than sucking up CO_2, parts of the ocean near Antarctica are actually burping the gas back into the atmosphere during the dark and cold of winter. That suggests the Southern Ocean is more of a fair-weather friend than scientists had hoped.

These details have oceanographers trying to flesh out a more complete picture of how much carbon the Southern Ocean can actually soak up, and how quickly. If less of that carbon is going into the Southern Ocean than scientists had thought, then it must be going somewhere else — either staying in the atmosphere, or being absorbed by a different ocean or by trees and other plants on land.

Researchers probably need to revise their ideas about where the planet's carbon is flowing. "To me, that's one of the most exciting things," says Alison Gray, an oceanographer at the University of Washington in Seattle. "What are the implications for the global picture? Have we been missing something all along?"

Polar explorer Ernest Shackleton wrote of the Southern Ocean's ferocity after his crew abandoned the ice-trapped *Endurance* during an Antarctic expedition in 1915.

Distinctive waters

Continents help shape how water circulates within the Atlantic, Pacific and Indian ocean basins. In contrast, water flows unimpeded all the way around the Southern Ocean (*SN: 9/16/17, p. 36*), which is often defined as extending from 60° S latitude down to Antarctica. "It's unique in its geometry, which makes it unique in its circulation," says Nicole Lovenduski, an oceanographer at the University of Colorado Boulder.

The pattern with the biggest effect on CO_2 levels in the Southern Ocean is the strong overturning circulation, which helps connect the deep waters with the surface.

One set of currents pulls surface water down, carrying carbon and sequestering it from the atmosphere. Researchers track water by lowering sampling bottles into the ocean at different depths, shutting the bottles tight, then raising them to the surface to be tested in a laboratory. By measuring the isotopes, or chemical variations, of carbon in the samples, scientists can date how old the water is. Anything younger than the start of the Industrial Revolution, about 150 to 200 years ago, probably contains carbon that was belched out by coal-burning power plants or other human sources. Most of this human-made carbon in the Southern Ocean is tucked away in the uppermost 500 meters.

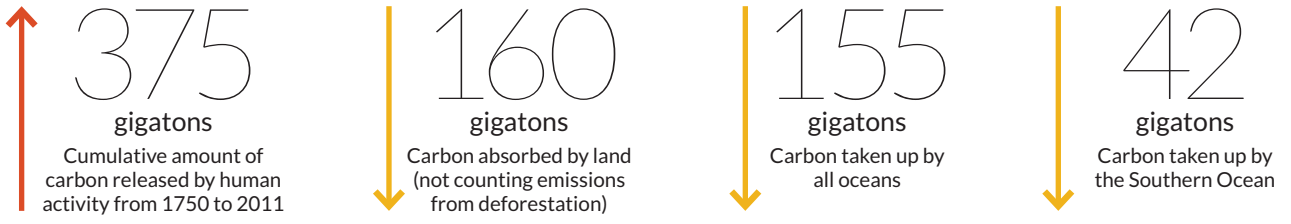
A second set of currents brings water from down deeper up toward the surface. This ancient water is too old to contain human-made carbon, but it does contain natural carbon from the remains of organisms like plankton that have lived and died in those depths. When the water reaches the surface, it releases some of that old, natural carbon into the atmosphere. "Oftentimes that water hasn't seen the atmosphere for hundreds of years," says Lovenduski, who coauthored a review paper about the Southern Ocean's carbon variability in the January *Annual Review of Marine Science*.

These patterns of downwelling and upwelling are different all around the Southern Ocean, so some patches of water absorb carbon while others emit it. Oceanographers have been trying to figure out which of these patterns is more dominant — is the Southern Ocean overall releasing more or less carbon than it soaks up each year? Sometimes the conclusions depend on which part of the ocean the researchers are looking at.

Computer simulations suggest that early in the industrial era, the Southern Ocean may have been an overall source of carbon, putting out more than it absorbed. But sometime around 1930, Lovenduski's calculations suggest, the levels of CO_2 in the atmosphere got so high that the ocean was essentially forced into absorbing the gas from the air — it switched from emitting carbon to storing it.

Researchers have had a hard time confirming this because there are so few observations in the Southern Ocean. Oceanographers would occasionally measure CO_2 by putting buoys into the water or by sampling from ships outfitted with specialized equipment. But very few ships dare ply the Southern

Carbon in and out Of all the carbon that humans have released into the atmosphere since the start of the Industrial Revolution, land and the oceans take up some. The Southern Ocean is considered a big player, absorbing a substantial chunk of the carbon that all oceans take up, but researchers need a better handle on its role. SOURCES: CLIMATE CHANGE 2013/INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE; T.L. FRÖLICHER *ET AL/J. OF CLIMATE* 2015



ROYAL GEOGRAPHICAL SOCIETY/ALAMY STOCK PHOTO

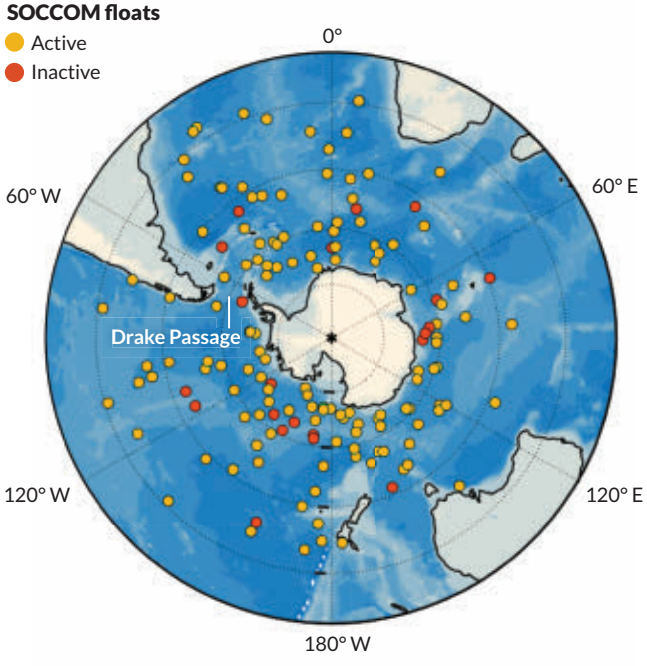
Some of the longest-running measurements of CO_2 in the Southern Ocean come from ships that travel the Drake Passage, like the *Laurence M. Gould* (shown), which resupplies U.S. Antarctic bases.

Ocean other than along the Drake Passage, the relatively narrow route between the tip of South America and Antarctica; the seas are so rough even there that journeys are rare, and mostly limited to the summer.

Scientists took what observations they did have, and then combined those with simulations to estimate what might be happening in the parts of the ocean not directly studied. By the 2000s, scientists generally agreed that the Southern Ocean was overall a carbon sink. "That seemed like great progress at that point," Lovenduski says.

But in 2014, researchers began dropping the first of 200 special floats all around these southernmost waters as part of a project known as Southern Ocean Carbon and Climate Observations and Modeling, or SOCCOM. These 1.3-meter-long yellow cylinders gather data on water temperature, salinity, oxygen content and pH, or acidity, which is used to estimate CO_2 levels. (When seawater absorbs carbon dioxide, it converts the compound into bicarbonate, a mild acid.) More than 150 floats have been deployed as of early May, with more than 130 of them still sending data.

Far and wide More than 150 SOCCOM floats are drifting around the Southern Ocean. Data on CO_2 levels down to two kilometers deep reveal surprises in how much of the gas the ocean emits in winter. The red dots are floats that have contributed data but have since stopped.
SOURCE: SOCCOM PROJECT (FUNDED BY NSF, SUPPLEMENTED BY NASA, ARGO PROGRAM AND NOAA)



SOCCOM floats drift into remote corners of the Southern Ocean throughout the year. The floats collect information as they bob up and down through the uppermost two kilometers of water. To transmit their data via satellite, they occasionally rise to the surface. Some floats even travel and gather data beneath the sea ice surrounding Antarctica. They can sense when ice is above them, so they don't try to surface at the wrong time. "It's just revolutionary," Gray says.

Analysis of the first three years of SOCCOM data has transformed scientists' views of how carbon is flowing into and out of the Southern Ocean. Last September, in *Geophysical Research Letters*, Gray and colleagues reported data collected by 35 of the first SOCCOM floats from 2014 to 2017. In the coldest, darkest months of July through September, the ocean was belching CO_2 at various spots around Antarctica.

"The ocean in winter is a much stronger source of CO_2 than we expected," says Peter Landschützer, a marine biogeochemist at the Max Planck Institute for Meteorology in Hamburg who's been studying this area. Nobody had seen this before simply because nobody had ever looked during the harsh winter.

The localized CO_2 belches might be related to seafloor topography, Lovenduski says. When ocean currents hit an underwater mountain or ridge, they could be forced upward toward the surface, where they release their carbon. Lovenduski is modeling how this process might happen, and why it might be more common in winter than in summer.

So much CO_2 is being emitting from these hot spots that the Southern Ocean may not be doing much to help humankind after all. Before the initial SOCCOM results, researchers had calculated that the entire ocean was absorbing about a gigaton of carbon each year (roughly half of what humans produce). The SOCCOM data told a very different story: At least

FROM TOP: ASAR STUDIOS/ALAMY STOCK PHOTO; TANYA MAURER/MONTEREY BAY AQUARIUM RESEARCH INSTITUTE

during those three years, the ocean was spitting out as much as it sucked up. "It hit us all a bit by surprise," Landschützer says. Enough of a shock that not everyone believed it.

Creative data collection

To find out what's really going on in Antarctica's waters, researchers need more info. Gray has been working with Landschützer and others to see what new SOCCOM data from a larger number of floats might reveal. The scientists are also studying how to reconcile the float data with information gathered from ships, like the icebreaker *Laurence M. Gould*, that regularly ply the Drake Passage. These ships have typically measured less CO_2 being emitted from the Southern Ocean than the SOCCOM floats do. That may be because the ships mostly stay within that narrow path without venturing into the distant reaches of the Southern Ocean.

> "The ocean in winter is a much stronger source of CO_2 than we expected."
>
> PETER LANDSCHÜTZER

Combining the SOCCOM data with the ship-based estimates, the scientists think they can confirm that carbon belching is happening in certain parts in winter — though maybe not as powerfully as suggested by Gray's team in September. Team member Seth Bushinsky, an oceanographer at Princeton University, will present these latest findings in Montreal in July at a meeting of the International Union of Geodesy and Geophysics.

Other groups are throwing all kinds of measurement tools at the Southern Ocean to assess CO_2. Dorothee Bakker, a marine biogeochemist at the University of East Anglia in Norwich, England, even wants to strap pH sensors to the heads of seals and let them collect observations as they dive deep for food during the Antarctic winter. "Anything to get more data," she says.

In December, oceanographers with a U.K. government project called CUSTARD, for Carbon Uptake and Seasonal Traits in Antarctic Remineralisation Depth, tethered a kilometers-long string of instruments to the seafloor off the southwestern tip of South America. This mooring is measuring things like oxygen, nutrients and CO_2 levels. The goal is to better understand how water downwells in this area, taking carbon with it.

Another new approach relies on a small, uncrewed sailboat built by Saildrone of Alameda, Calif. The Saildrone craft navigates autonomously across the seas, snapping photographs, clocking wind speeds and wave heights, and measuring CO_2 levels hourly. In January, two bright-orange Saildrones left New Zealand on a private expedition to circumnavigate 15,000 nautical miles, or about 28,000 kilometers, around Antarctica. Heavy seas damaged one and forced it to return to port, but the second had already made it halfway around Antarctica by May, soldiering on through waves as high as a three-story house.

The Saildrone will occasionally rendezvous with SOCCOM floats, which will bob up to the surface to measure CO_2 at around the time the Saildrone passes by. Comparing the CO_2 numbers from the two devices offers an accuracy cross-check, says Adrienne Sutton, an oceanographer at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle who has been working with Saildrone staff.

As the Southern Ocean transitions into winter, researchers hope to see whether the Saildrone will also pick up wintertime CO_2 belching. "There's no one platform out there that can measure everything well," Sutton says. "I'm interested in whether Saildrone can be part of that mix in the Southern Ocean."

More changes

Getting today's Southern Ocean carbon estimates right is crucial to forecasting. "The ultimate goal is to say what our climate is going to look like in 20 years or in 50 years," Gray says.

How will the chemistry of the ocean change in the future, and how will that affect living organisms? Putting more CO_2 into the ocean makes it more acidic in ways that can harm marine critters. In March in *Nature Climate Change*, Lovenduski and colleagues estimated that the chemistry of the Southern Ocean could change so quickly that, by the end of this century, some parts could become toxic for small sea snails, an important part of the marine food web.

There are other big unknowns. How will changes in the Antarctic environment affect the Southern Ocean's carbon uptake? As the Antarctic ice sheet melts (*SN: 7/7/18, p. 6*), for instance, it could send enormous pulses of freshwater into the Southern Ocean that could upset whatever is happening today.

The Southern Ocean is "still going to help us out," absorbing at least part of humankind's self-created climate mess, Landschützer says optimistically. "The only question is by how much." ■

Autonomous sailboats known as Saildrones are a new way of gathering oceanographic data. A Saildrone like this one is attempting to circumnavigate Antarctica, gathering data on CO_2 in the Southern Ocean.

© SAILDRONE, INC.

Explore more

- Nicolas Gruber, Peter Landschützer and Nicole S. Lovenduski. "The variable Southern Ocean carbon sink." *Annual Review of Marine Science*. January 2019.

In the Smithsonian's new "Deep Time" exhibition, *T. rex* is posed chomping down on a *Triceratops*.

EXHIBIT

Dinosaur hall gets a makeover

After five years, the Smithsonian National Museum of Natural History in Washington, D.C., is finally reopening its dinosaur hall on June 8. Visitors may come for fan favorites like *Tyrannosaurus rex* and *Stegosaurus* — and these fossils are gorgeously presented. But the new, permanent exhibition, the "David H. Koch Hall of Fossils — Deep Time," has a much grander story to tell about the history of life on Earth, how organisms have interacted with each other for eons and how they've interacted with Earth and its climate.

"David H. Koch Hall of Fossils — Deep Time"
OPENS JUNE 8
SMITHSONIAN NATIONAL MUSEUM OF NATURAL HISTORY | *Washington, D.C.*

Counterintuitively, the exhibition starts with humans.

Many exhibitions about the evolution of life tend to open with abstract concepts: the chemical formula for life or primordial microbes that lived in shallow seas. But the "Deep Time" designers wanted visitors to immediately feel their own part in the story, says exhibition project manager Siobhan Starrs. So the exhibition starts in the present and moves backward through time.

"The big, big starting point is that life is all connected, through billions of years of time," she says. Scientists refer to that vastness of time on a geologic scale as deep time, a term suggesting a long, durable thread connecting the past to the present.

That sense of connectedness leads to another central theme: Putting life in context and moving beyond typical predator-prey scenes to give a better sense of the world in which creatures lived. Mixing fossils with other media, such as murals and statues, the exhibition depicts snapshots of life in the past. A woman gathers hickory nuts near a giant mastodon, while a saber-toothed tiger lurks nearby. A giant sloth with sheathed claws stretches up to snatch fruit from an orange tree. An *Allosaurus* curls its tail around a clutch of eggs.

Not all of the scenes are so peaceful: A *T. rex* chomping on a *Triceratops*, placing one foot firmly on the prey's back to hold it in place, is sure to be a crowd-pleaser. But even that scene, Starrs notes, is meant to convey a more subtle story. Nearby, a shallow pond contains turtles, clams and mussels. "Even the *T. rex* had a context; it didn't live in isolation."

Deeper in time, visitors come to the story of plant evolution and the great swamp forests of the Carboniferous Period, about 359 million to 299 million years ago. One stunning section simulates discoveries made within a coal mine, with fossils of giant trees embedded in the ceiling and walls.

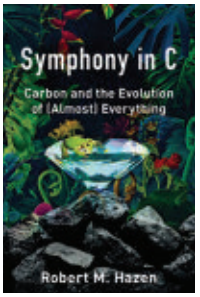
Using deep time as a framing concept "allows us to tell a story about changing ecosystems and changing environments through time, and how they interact with one another," says Scott Wing, the museum's curator of paleobotany. Compared with previous ways of presenting the history of life, he says, "it's a profound shift in how we think about ourselves, and how we think about the natural world around us."

The new exhibition is a big step forward from the previous fossil hall in other ways. For example, "Deep Time" includes a tribute of sorts to its predecessor, with a vertically mounted fossil of a *Stegosaurus* that had been embedded for decades in the museum's floor. Scientists excavated the *Stegosaurus* and disassembled other long-displayed fossils and were once again able to examine the bones closely.

That led to some surprises, says dinosaur curator Matthew Carrano. Two different species of *Camptosaurus* once on display turned out to be the same species, he says. A *Triceratops* skeleton turned out to be a "Frankenfossil," a mix of bits that weren't all from *Triceratops*.

The exhibition's final area returns to the present and looks toward the future, exploring interactions between Earth's changing climate and the planet's life-forms, as well as how human actions might further alter climate. That casting forward is another thing that sets the new exhibition apart, Starrs says. The hope is that after experiencing the fossil hall, "the visitor is now thinking on a deep time scale," she says: Not just how humans might currently be altering Earth's climate but also what legacy people will leave behind thousands or even millions of years into the future. — *Carolyn Gramling*

SMITHSONIAN INSTITUTION



Symphony in C
Robert M. Hazen
W.W. NORTON & CO., $26.95

BOOKSHELF

The story of carbon takes center stage

Carbon is by no means the most abundant element in the cosmos, but it is undoubtedly the most important to life as we know it. For every 1,000 hydrogen atoms in the universe, there are only five or so carbon atoms. But every cell in the human body — indeed, every living cell on Earth — relies on carbon as the chemical backbone of all organic molecules.

In *Symphony in C*, geophysicist Robert Hazen provides a deep dive into the history, culture and science surrounding carbon. And that history is far longer than cosmologists once presumed. Although the vast majority of the universe's carbon is forged inside stars, about a trillionth of today's carbon was assembled from subatomic particles almost 13.8 billion years ago, just 15 to 20 minutes after the Big Bang. This means that a fraction of the carbon in your body is not "star stuff," as astronomer Carl Sagan once exclaimed — it's even older than the universe's first stars.

Carbon is not just important for living things. Its unusual chemistry gives it an unmatched ability to react with other atoms to form both small, simple molecules and large, complex ones, making it a building block for everything from polymers to pharmaceuticals and nanomaterials. As Hazen describes, carbon's chemical diversity yields materials that include the darkest surfaces and the brightest pigments, as well as the slipperiest lubricants and stickiest glues.

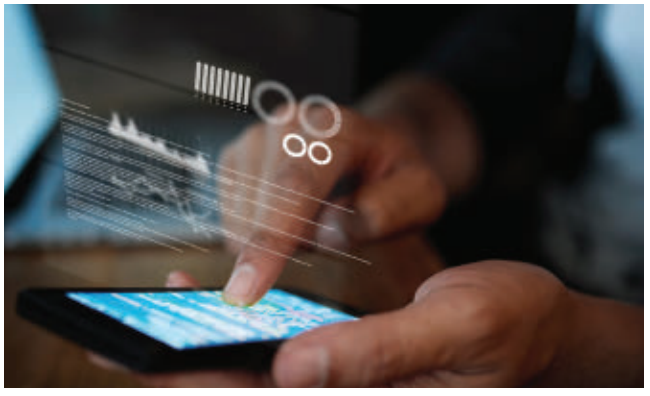
Like many musical symphonies, Hazen's book is arranged in four parts, paralleling the Greeks' basic elements of earth, air, fire and water. Individual tales in carbon's story explore its presence in our planet's minerals (*SN: 10/15/16, p. 22*), the role of carbon-bearing gases in keeping our early planet warm under a faint young sun (*SN: 5/4/13, p. 30*), carbon's ubiquitous presence in fossil fuels that we burn and its role in the origin and evolution of life in Earth's ancient oceans.

Symphony in C is chock-full of facts, but Hazen admits there's much we don't know about carbon, including exactly how much Earth holds, how the element moves from the atmosphere into the depths of the mantle and then back to the surface, and whether those movements, which help regulate climate, have changed substantially since our planet was young.

Covering topics from carbon's ancient origins to the threats that carbon compounds pose to our future climate, Hazen's book is a fascinating read. *Symphony in C* chronicles cutting-edge science that's helping researchers make better sense of the carbon-rich world around us. — *Sid Perkins*

Science News for Students

***Science News for Students* (sciencenewsforstudents.org)** is an award-winning, free online magazine that reports daily on research and new developments across scientific disciplines for inquiring minds of every age — from middle school on up.



You can fight back against cyberattacks

Glitches and bugs can show up in any new piece of software or software update. Teams of investigators known as white hat hackers are looking to fix those defects and protect computer systems from cybercriminals who exploit those problems. Many hackers target individuals or companies, but others can target an entire country. As 14-year-old Grant Thompson learned, anyone can find new cybersecurity risks. His reward for informing Apple of a big iPhone bug: a company donation to his college fund. — *Kathryn Hulick*

Read more: www.sciencenewsforstudents.org/cyberattacks

Strange lake belches flammable gas in the high Arctic

Limnologist Katey Walter Anthony first visited Alaska's Lake Esieh in September 2017. An area of its surface larger than a football field roiled and fizzed. Huge bubbles popped at the surface. She collected some of the escaping gas, lit a match and the gas caught fire. She calculated that this lake was spewing huge amounts of methane, some 2,000 kilograms (4,400 pounds) each day. Thawing permafrost is behind the growing, Arctic-wide release of this potent greenhouse gas, which is a major source of global warming. The data from Lake Esieh and other Arctic lakes (one shown here) could point to a potentially bigger climate threat from methane than scientists had first suspected. — *Douglas Fox*

Read more: www.sciencenewsforstudents.org/flammable-gas

Life on Earth is mostly green

If you were writing to an alien pen pal in a distant galaxy, how would you describe life on Earth? You might want to focus on its greenery. A recent census of all living things found plants are the most common, at least by biomass, weighing in at about 450 gigatons of carbon. That's 83 percent of the total biomass of all life on Earth, which is about 550 gigatons. At 1.2 gigatons, arthropods such as insects, spiders and crustaceans make up about 60 percent of the animal kingdom's biomass, which is about two gigatons. Mammals make up only 0.167 gigatons and humans weigh in at 0.06 gigatons. Bacteria exceed the combined biomass of birds and mammals. — *Mara Johnson-Groh*

Read more: www.sciencenewsforstudents.org/green-earth

FROM TOP: PEOPLEIMAGES/E+/GETTY IMAGES; UNIV. OF ALASKA FAIRBANKS; QUICKSHOOTING/ISTOCK/GETTY IMAGES PLUS

APRIL 13, 2019

Jet-setter

Scientists spotted the asteroid Bennu (shown below) ejecting plumes of dust, an activity never before seen on an asteroid, **Lisa Grossman** reported in "Bennu spits streams of dust into space" (*SN: 4/13/19, p. 10*). The story inspired online reader **Doug** to riff on an Elton John classic: "Bennu and the jets."

D.N. DELLAGIUSTINA *ET AL/NATURE ASTRONOMY* 2019

Join the conversation

E-MAIL editors@sciencenews.org

MAIL Attn: Feedback
1719 N St., NW
Washington, DC 20036

Connect with us

Blast from the past

*Ice core and tree ring data indicate that nearly 3,000 years ago, Earth was blasted with one of the strongest solar storms ever to pummel the planet, **Carolyn Gramling** reported in "Big solar storm hit Earth in 660 B.C." (*SN: 4/13/19, p. 15*).*

Reddit user **diffcalculus** wondered what kind of damage such a storm would cause today.

Earth hasn't experienced a solar storm of that intensity in the modern era, so it's hard to say. But solar storms weaker than the 660 B.C. event have been known to knock out power grids, satellites and radio communications, **Gramling** says. A solar storm in 1989 sent so much energy across North America that it shut down the power grid in Quebec, Canada.

Thanks to a fleet of satellites and spacecraft, the sun is under constant surveillance. If a potentially disruptive solar storm were heading this way, emergency officials would know and could prepare by switching off key components on satellites or switching on backup systems to protect power grids (*SN Online: 4/9/12*).

Get a grip

*A vacuum-driven robotic gripper can lift objects that weigh more than 120 times its own weight. The gripper can also gently handle fragile items like soft fruits and wine glasses, **Maria Temming** reported in "Origami design helps a robot lift heavy cargo" (*SN: 4/13/19, p. 5*).*

Online reader **Dahak** wondered about the lightweight gripper's durability.

As a general rule, durability is a major challenge when building a soft robot, **Temming** says. "There's always a trade-off between sturdiness and pliability." Although the gripper had a strong grasp, its soft rubber and latex skin developed holes and needed to be replaced after testing. The researchers also made a more durable version out of plastic and nylon. "But tests showed that robot had a poor grip and could not carry as heavy a load as the rubber and latex gripper," **Temming** says. "The researchers plan to test different materials to optimize the gripper's strength and durability. Adding things to the robot's skin like anti-slip tape or gecko-inspired adhesives might improve grip, they say."

Arachnid record

*A Peruvian spider is the fastest-known arachnid. It uses its web to fling itself at prey at a maximum acceleration of about 1,100 meters per second squared, **Emily Conover** reported in "Spider slingshots itself at extreme speeds" (*SN: 4/13/19, p. 5*).*

Readers on Twitter wondered how the spiders withstand accelerations 110 times that of Earth's gravity.

"Unfortunately, we don't have an answer for that yet," says biophysicist **Saad Bhamla** of Georgia Tech in Atlanta. But the spiders' smaller size relative to humans, as well as their simpler brain structure and blood pumping system, may make the arachnids more resilient to large g-forces, he suggests. **Bhamla** and colleagues are currently studying the spiders in more detail.

Correction

The feature "Down on the (cricket) farm" (*SN: 5/11/19 & 5/25/19, p. 28*) incorrectly stated that discoid roaches thrash on their backs before releasing young in sacs. Females do not have to lie on their backs to give birth, and the young escape the sac before leaving the mother's body. Also the quiet house crickets mentioned are juveniles. Adults of this species chirp during the day as well as at night.

This number helps explain why measles is so contagious

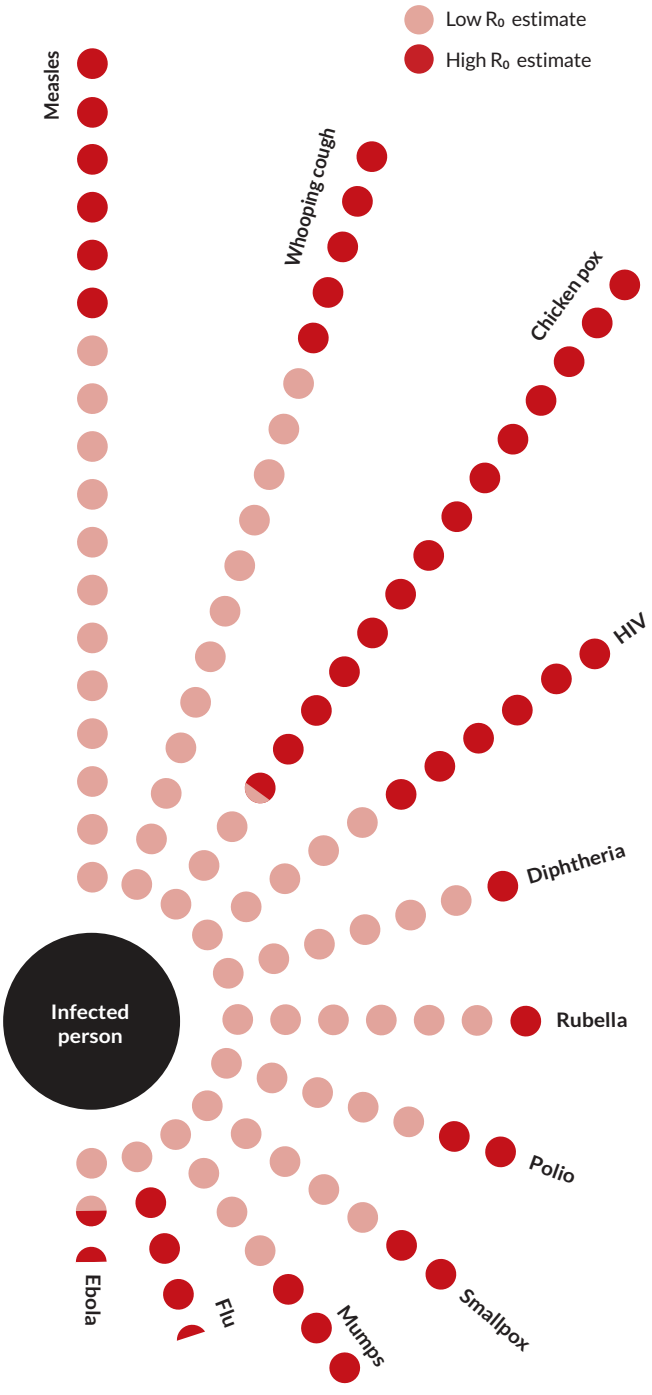
Two ongoing outbreaks have dominated headlines in recent months. Since the beginning of the year, measles has sickened at least 880 people in 24 U.S. states as of May 17 (see Page 16). In Congo, Ebola has racked up at least 1,826 cases and killed 1,218 people since August 2018.

Those numbers are scary, but another number, or rather a range, illustrates the potential for the diseases to do damage. It's the basic reproduction number, or "R_0," a ratio that describes how contagious an infectious disease is. If one person is infected in an unvaccinated population, R_0 gives an estimate of how many people would get sick from that individual, on average.

Measles has a high R_0 compared with other infectious diseases, with estimates ranging from 12 to 18. Ebola has a much lower R_0, generally ranging from 1.5 to 2.5 (see graphic at right). Given Ebola's nightmarish symptoms and recent body count, that might be surprising. But R_0 is a measure of contagiousness, not deadliness, and the transmission method is part of what matters. Measles is airborne whereas Ebola spreads through bodily fluids, so the odds of contact are lower.

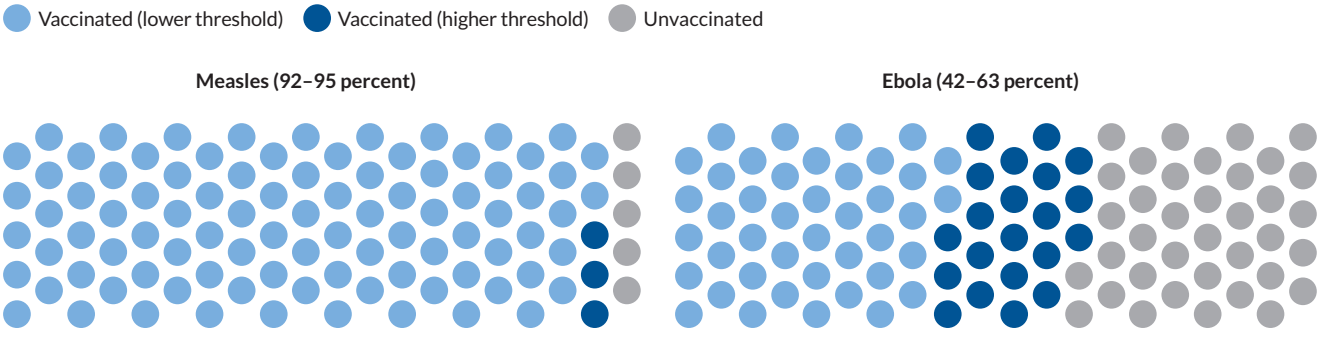
Three main variables go into calculating R_0: how long people stay contagious, how often they come into contact with others and the probability of infecting someone else. Every outbreak has its own R_0. That's why every disease has a range of R_0 estimates.

R_0 has its limitations, but measles' high number emphasizes why it's good that there's a vaccine for the potentially life-threatening disease. Before the vaccine was widely used starting in the 1960s, millions were infected each year, and hundreds died. — *Helen Thompson*



Why vaccines matter

R_0 can also be used to determine the fraction of the population that needs to be vaccinated to prevent a disease from spreading, known as herd immunity. Because measles is so contagious, 92 to 95 percent of a population needs to be vaccinated (below, left). Below that threshold, pockets of the unvaccinated create holes in that herd immunity, helping the virus spread, as the current U.S. measles outbreak shows. For Ebola, the threshold is lower. Estimates suggest that roughly 42 to 63 percent of a population needs to be vaccinated to achieve herd immunity (below, right).



GRAPHICS: T. TIBBITTS; SOURCES: P. FINE/*EPIDEMIOL. REV. 1993*; S. HAY *ET AL/PHILOS. T. R. SOC. B* 2013; G. CHOWELL AND H. NISHIURA/*BMC MED.* 2014; R. BEDNARCZYK, W. ORENSTEIN AND S. OMER/*AM. J. EPIDEMIOL.* 2016; K. GITTINGS AND K.L. MATSON/*VACCINE* 2016

GEOLOGIC ROAD TRIP OF THE MONTH

LASSEN VOLCANIC NATIONAL PARK

Eruptions and Boiling Springs

Lassen Peak is the southernmost volcano in the Cascade Range. The subduction of the Gorda Plate beneath the North American Plate continues to produce the heat that fuels the volcano and its hydrothermal areas. The Devastated Area in Lassen Volcanic National Park is a reminder of this active plate margin. A short loop trail that starts at the Devastated Area parking lot has a series of interpretative signs describing the eruptive events that occurred here from 1914 to 1921. In May of 1915, Lassen was visibly active, with more than 180 steam explosions blasting out of a 1,000-foot-wide crater. On the evening of May 14, incandescent blocks of lava bounced down the flanks of Lassen. On May 19, a mudflow produced by rapidly melting snow rushed 10 miles downslope. Finally, on May 22, an enormous eruption sent a column of volcanic ash 30,000 feet into the air, where it drifted as far as Winnemucca, Nevada, 200 miles to the east. The Devastated Area is littered with red and black boulders of dacite, a silica-rich volcanic rock that solidified from the lava erupted in 1915. The white speckles on the boulders are crystals of the mineral plagioclase. Hikers can get a spectacular view of the 1915 eruption area and surrounding volcanic landscape from the top of 10,457-foot Lassen Peak, but be forewarned: the trail climbs 2,000 feet in 2.5 miles.

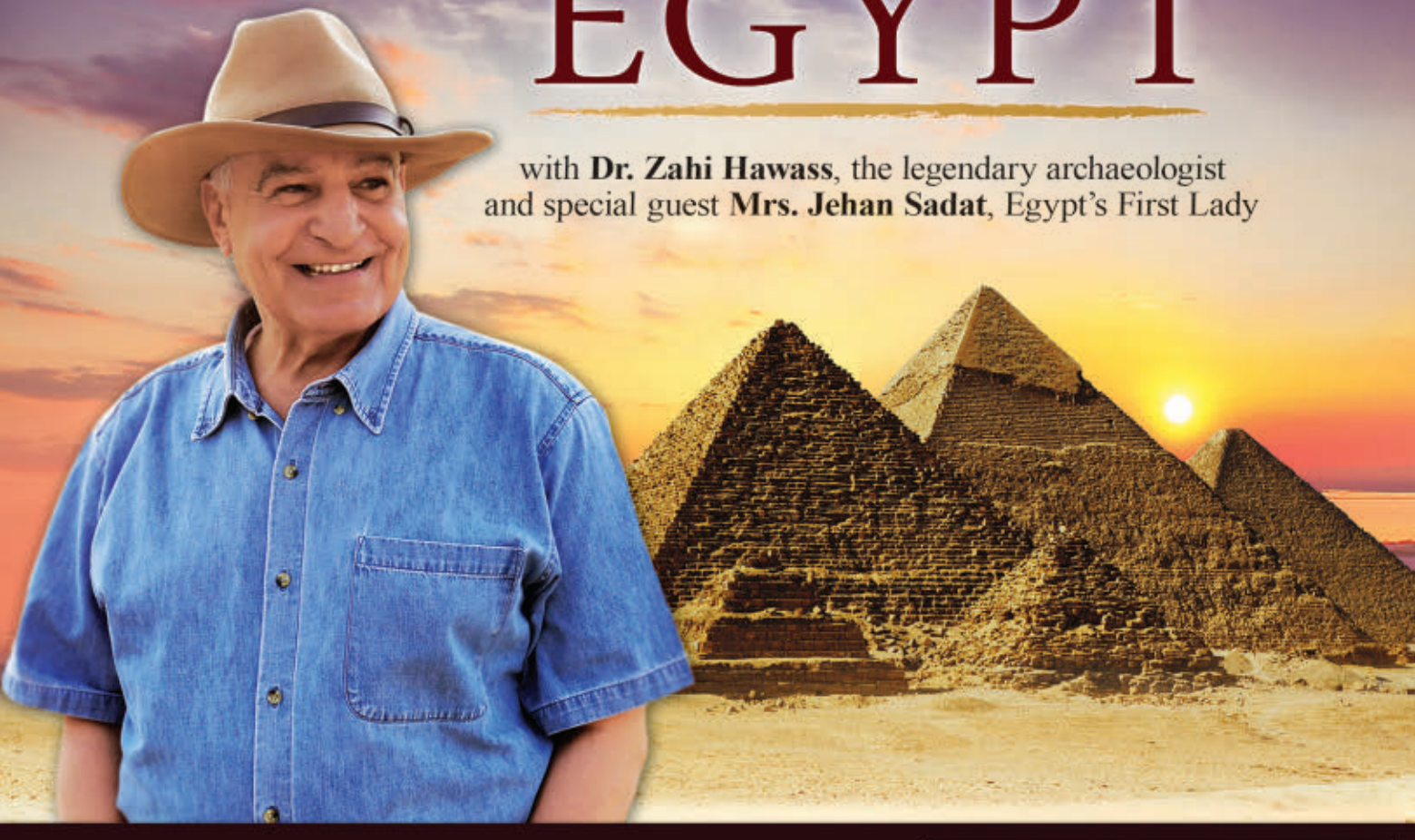
Bumpass Hell, a hydrothermal area in Lassen Volcanic National Park

Bumpass Hell, a 16-acre hydrothermal area in Lassen Volcanic National Park, was named for Kendall Vanhook Bumpass, a nineteenth-century explorer who promoted the area. As Bumpass led a group of visitors through the area, his leg plunged through the unstable ground into a boiling mud pool and was instantly scalded, giving the hydrothermal basin its name. Today, visiting Bumpass Hell is much safer—the National Park Service has constructed a sturdy boardwalk through the area, and visitors are warned to stay on it. The hydrothermal features, including fumaroles, mud pots, and boiling springs, are largely differentiated by their temperature and water content. Fumaroles, which are steam and volcanic gas vents, have the least water. More water and a bit of time produces a boiling mud pot, and even more water creates a boiling spring. The hydrothermal area is only a 1.5-mile hike from the parking lot on a moderate up-and-down trail, but visitors from sea level may find themselves breathing hard in the thin air at 8,000 feet elevation.

Devastated Area, the site of the 1915 Lassen Peak eruption.

THE ROYAL TOUR TO EGYPT

with **Dr. Zahi Hawass**, the legendary archaeologist
and special guest **Mrs. Jehan Sadat**, Egypt's First Lady



Multiple Tour Dates in 2019 & 2020

This is the most exciting tour to Egypt ever offered. Visit the Land of the Pharaohs with the most famous archaeologist in the world, Dr. Zahi Hawass. For over 20 years he has held the keys to all Egyptian antiquities. You will also meet our distinguished guests including Dr. Mostafa Waziri, Egypt's Head of Antiquities, and Mrs. Jehan Sadat, the former First Lady, in the residence of Egypt's late president Anwar Sadat. Thanks to *Archaeological Paths,* you will experience Egypt like no one else!

Dr. Zahi Hawass: *No one can tour Egypt like this – except for you when you come and join me. You will visit many unique sites that very few people can see. You will be treated like royalty! That is why we call it the Royal Tour.*

The tour includes private entrances to the entire Giza pyramid complex and to the Luxor temple outside of opening hours. Only with us will you stand between the paws of the Great Sphinx and gain exclusive access to sites closed to the public.

For more information visit:
www.royalegypt.com

ARCHAEOLOGICAL PATHS

contact@archaeologicalpaths.com
US phone: 917-719-1974