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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ MAY 8, 2021 & MAY 22, 2021

Awash in DECEPTION

How science can help us avoid being duped by misinformation

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VOL. 199 | NO. 9

ScienceNews

Awash in Deception

SPECIAL REPORT

22 The Battle Against Fake News
Most people are concerned about the spread of false information, but few know how to spot it. *By Alexandra Witze*

29 Anatomy of Misinformation
Purveyors of deceitful messaging use a few key tricks that take advantage of the brain's desire to believe. *By Laura Sanders*

32 Vaccine Hesitancy Through the Ages
Opposition to COVID-19 vaccines is just the latest chapter in a long history of anti-vaccination protests. *By Tara Haelle*

36 Turning the Page on Climate Change Denial
As disinformation tactics evolve, researchers find ways to help people tell true from false on climate claims. *By Carolyn Gramling*

News

6 Wobbling muons could break with the standard model of physics

7 Neandertals and humans had regular liaisons in Europe

8 Even when "less is more," people tend to choose more, experiments show

East Asian people's DNA hints at an ancient coronavirus outbreak

9 Early *Homo* brains may have had great ape–like frontal lobes for a lot longer than suspected

10 The dinosaur-killing asteroid reshaped tropical rainforests

12 Lion yawns may serve as subtle social cues

Raindrops are all mostly the same size, no matter what planet they fall on

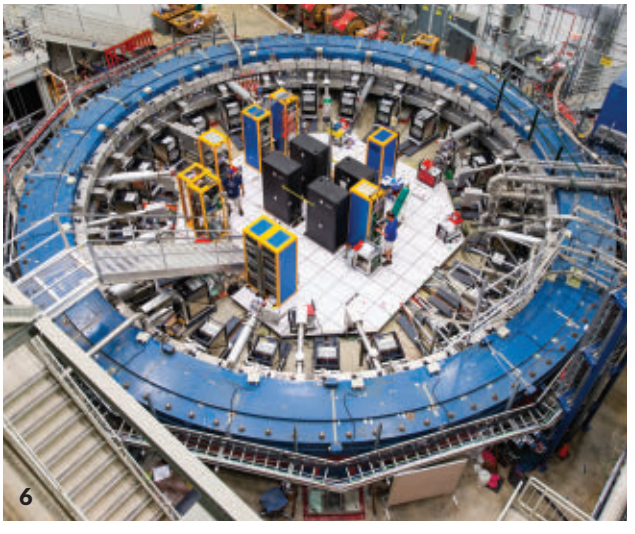
14 An underwater robot gets a glimpse of what's eating an Antarctic glacier

16 Earth's space dust collection grows by thousands of metric tons per year

A pterosaur with opposable thumbs makes its debut

18 An oxygen-starved galaxy hints at early universe conditions

20 Black and Hispanic people remain underrepresented in STEM, both at work and in school



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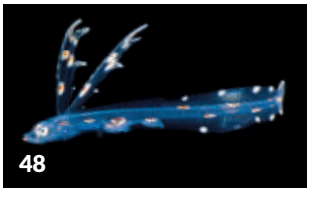

Departments

2 **EDITOR'S NOTE**

4 **NOTEBOOK**
A warming Arctic may be a lightning rod; face masks under the microscope

40 **REVIEWS & PREVIEWS**
Viral BS fights fake health news with a dose of storytelling

46 **FEEDBACK**

48 **SCIENCE VISUALIZED**
Larval fishes dazzle in new baby pictures

COVER Researchers hope to help people stand up against waves of social media misinformation on health and climate change. *Brian Stauffer*

When attacks on science threaten our survival

We're living through an extraordinary triumph of science — the deployment of new vaccines that promise to stop a pandemic that just a year ago looked unstoppable. But just as governments and health organizations around the world are racing to protect billions of people, malevolent agents of death and despair are working just as hard to persuade anyone they can that these life-saving vaccines are dangerous, ineffective or part of a global mind-control conspiracy.

As we report in this special issue, misinformation and deliberate disinformation about vaccines is rampant — and nothing new. The introduction of smallpox vaccination in the late 18th century sparked decades of opposition, even though inoculation was a game changer — the virus had been killing up to 30 percent of those infected. As freelance writer Tara Haelle reports, anti-vaccination groups argued that requiring vaccination violated personal liberty and interfered with parents' rights to "protect their children from disease" (Page 32). Those intent on delegitimizing vaccines today — from shots that protect against COVID-19 to measles and more — use the same arguments.

Most people are eager to get a COVID-19 vaccine and return to something approaching normal life; in the United States, over half of people ages 18 and older had gotten at least one shot by mid-April. But about 20 percent of U.S. adults say they remain unwilling to get vaccinated, and partisanship is a big factor: Forty-three percent of Republicans say they will shun vaccination compared with 5 percent of Democrats, according to a Monmouth University poll.

Leading conservative media outlets including Fox News have relentlessly promoted unproven COVID-19 cures and attacked scientists for doing what scientists do — saying when they don't yet know the answers, as in whether the Johnson & Johnson vaccine could be causing rare, serious blood clots. Scientists under attack include Anthony Fauci, a leader in both the Trump and Biden administrations' COVID-19 response teams. Uncertainty is uncomfortable, but it's intrinsic to the process of science.

The shift to social media as a primary source of news has turbocharged the spread of antiscience disinformation worldwide. But as contributing correspondent Alexandra Witze reports on Page 22, studying that flood of messages has also given researchers a much better understanding of why false information is so compelling. Recent work is beginning to reveal ways that the general public, scientists and social media platforms can identify falsehoods. Senior writer Laura Sanders maps out the anatomy of misinformation, with real-world examples of the tricks that hook us (Page 29). And earth and climate writer Carolyn Gramling talks with scientists about their work countering decades-long efforts to cast doubt on the realities of climate change (Page 36).

These are battles that won't be easily won, but they must be fought if we are to ensure the health and safety of our families, our communities and our planet. We're all susceptible to being manipulated by misinformation. But knowing how it works is the first step in beating back the tide. And, not surprisingly, science is here to help. — *Nancy Shute, Editor in Chief*

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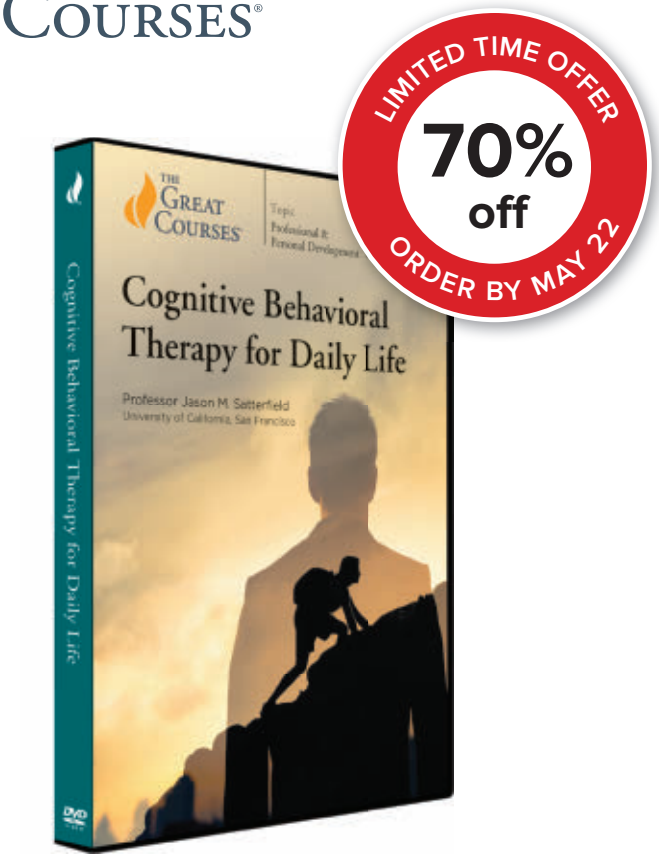

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Excerpt from the May 8, 1971 issue of *Science News*

50 YEARS AGO

Lunar quarantine dropped

Spacecraft and men from Earth can contaminate space ... with Earth-related material or organisms. But there is also a chance material returned from another celestial body could contain something harmful to the Earth.... Last week [NASA] announced it will [recommend] ... that "further lunar missions need not be subject to quarantine" [because] ... "there is no hazard to man, animal or plants" from anything brought back from the moon.

UPDATE: The last U.S. lunar mission to come back to Earth, Apollo 17, didn't have to quarantine upon return in 1972. But missions *to* the moon remained under strict protocols to prevent spacecraft from contaminating it. In 2020, NASA exempted most of the moon — minus areas of scientific interest and historic sites — from those rules (*SN: 11/23/19, p. 10*). For missions to other planets, though, strict anti-contamination measures still apply. NASA has called for research of possible risks as it aims to land humans on Mars in the 2030s.

Citizen science and bird migration data could help prevent bald eagles and other birds from colliding with wind turbines as more pop up across the United States.

SOAPBOX

How to keep birds safe as U.S. wind farms expand

Wind energy is surging in the United States. In 2020, wind turbines generated about 8 percent of the country's electricity, according to the U.S. Energy Information Administration. That's more than 80 times the share of electricity generated by wind in 2000. While the growth is a positive step toward curbing climate change, scientists say, it could be bad news for birds.

An estimated 140,000 to 500,000 birds die each year in wind turbine collisions in the United States. Those deaths

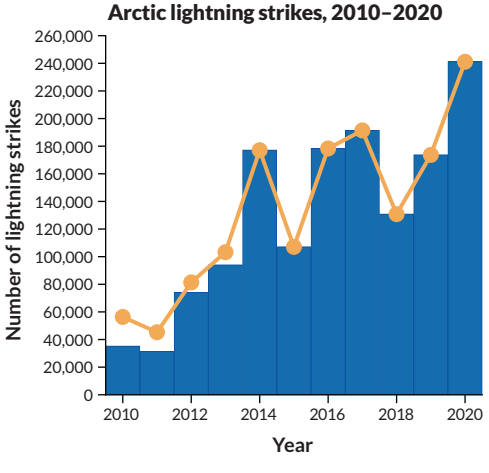
SCIENCE STATS

Climate change may spark more Arctic lightning

Lightning strikes in the Arctic have become much more frequent over the last decade, data from the World Wide Lightning Location Network suggest. That may be because the region, historically too cold to fuel many thunderstorms, is heating up, researchers report in the April 16 *Geophysical Research Letters*.

Atmospheric scientist Robert Holzworth of the University of Washington in Seattle and colleagues tallied lightning strikes above 65° N latitude in the Arctic during the stormiest months of June, July and August from 2010 to 2020 (see graph below). The number of strikes rose from about 35,000 in 2010 to about 240,000 in 2020. Part of the uptick may have resulted from the network expanding from 40 stations to more than 60 stations over the decade. So the team calculated the expected number of strikes if the network used the same number of sensors over time (orange line). "I would argue that we have really good evidence that the number of [strikes] ... has increased by, say, 300 percent," Holzworth says.

That increase happened as global summertime temperatures rose by 0.2 degrees Celsius, hinting that climate change may create favorable conditions for lightning in the Arctic and, perhaps, more wildfires. — *Maria Temming*



SOURCE: R.H. HOLZWORTH *ET AL/GEOPHYSICAL RESEARCH LETTERS* 2021

FROM TOP: DENNIS SCHROEDER/NREL (CC BY-NC-ND 2.0); E. OTWELL

could soar to 1.4 million per year if the U.S. Department of Energy achieves its goal of wind energy accounting for 20 percent of the country's electricity demand by 2030. To minimize harm to wildlife, some scientists advocate for using citizen science and bird migration data when deciding where to construct wind farms.

Citizen science is already filling vital information gaps. From 2007 to 2018, more than 180,000 birders uploaded observations about bald eagles to the eBird database. Conservation scientist Viviana Ruiz-Gutierrez and colleagues used that data treasure trove to estimate where in the United States the eagles would be most abundant throughout the year — and thus face the highest risk of colliding with wind turbines. Unlike traditional surveys, which cover limited time periods or locations, the citizen science data span the entire country and whole years, the team reports April 13 in the *Journal of Applied Ecology*.

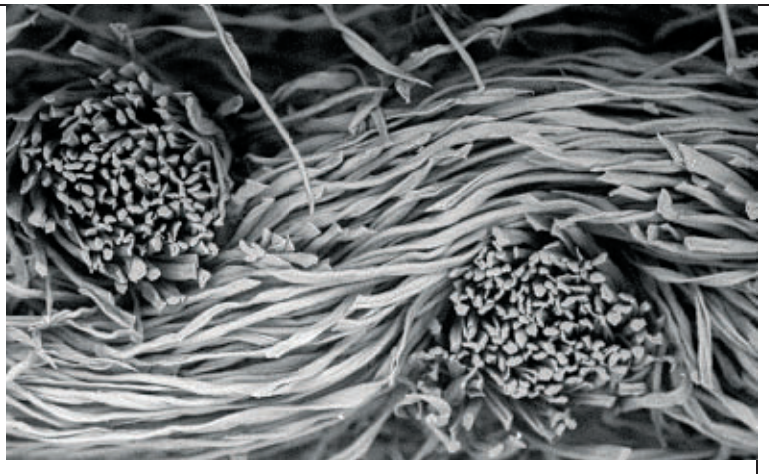
Conservation scientist Viviana Ruiz-Gutierrez argues that citizen science data should inform decisions about where to build wind turbines.

"What we're able to do is really harness strength that only citizen science has," says Ruiz-Gutierrez, of the Cornell Lab of Ornithology. The U.S. Fish and Wildlife Service has recommended using the team's bald eagle maps to identify low-risk collision areas where wind turbines could be built.

Wind turbines can also harm animals by altering habitats. Each year, the only naturally occurring population of endangered whooping cranes migrates over a handful of states that produce most of the country's wind energy. GPS tracking data for 57 cranes from 2010 through 2016 suggests that the birds were less likely to rest at stopover sites if turbines were within about five kilometers, researchers report April 7 in *Ecological Applications*.

As of early 2020, this equates to a loss of 5 percent of the birds' habitat, says wildlife biologist Aaron Pearse of the U.S. Geological Survey in Jamestown, N.D. Over the study period, the number of turbines in the migration corridor more than tripled, from 2,215 to 7,622. If the trend continues, then additional habitat loss could lead to further population decline, Pearse says.

Like citizen science data, migration tracking provides a clearer picture of bird activity over time, Ruiz-Gutierrez says. Such information could help wind energy developers keep birds and their homes safe. — *Jack J. Lee*



PICTURE THIS

Texture matters for face mask protection

Scientists are taking a microscopic approach to show how effective face masks are at slowing the spread of the coronavirus. Using a scanning electron microscope, researchers have examined dozens of materials. While N95 masks are most effective at blocking the virus, when it comes to cloth masks, cotton (microscopic cross section, above) outperforms synthetic fabrics like nylon. That's because cotton fibers, with wrinkles and complex shapes, trap more particles than smooth synthetics. Cotton also swells as it absorbs moist breath, making it harder for particles to get through, the team reports in the March 26 *ACS Applied Nano Materials*. — *Emiliano Rodríguez Mega*

Get a closeup view of more mask materials at **bit.ly/SN_FaceMask**

THE LIST

Invasive species cost a fortune

Cleaning up the wreckage left by invasive species over the last 50 years has come at a big price for the global economy: at least $1.28 trillion. Between 1970 and 2017, annual costs roughly doubled every six years, scientists report March 31 in *Nature*. By 2017, the annual bill totaled $162.7 billion. While insects account for many of the costliest species from this period (partial list below), cats, rats (one shown) and mice are troublemakers, too. Gaps in data — on plants, for example — likely skew the rankings, the team says. — *Jonathan Lambert*

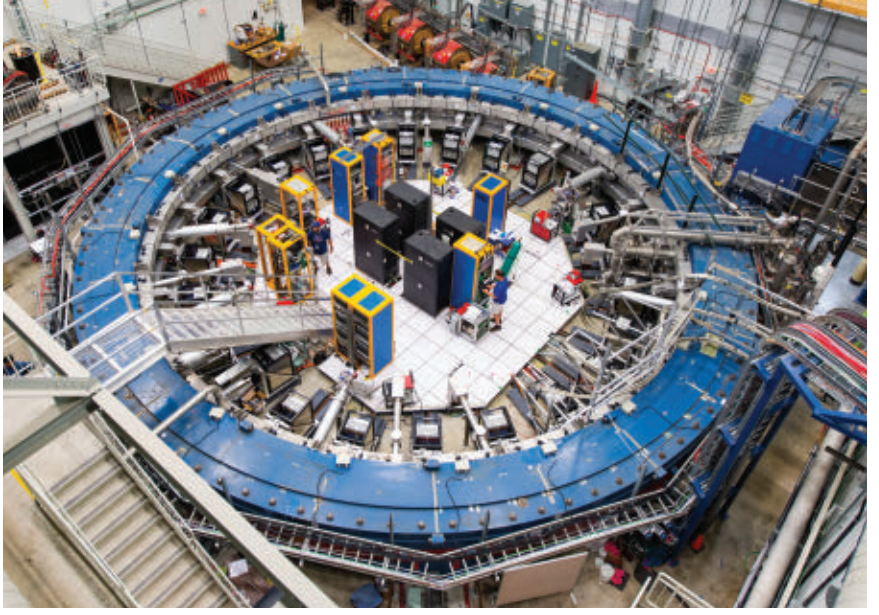
Top 5 costliest invasive species, 1970–2017

1. *Aedes* mosquitoes, $149 billion
2. Rats and mice, $67 billion
3. Domestic cats, $52 billion
4. Formosan termites, $19 billion
5. Fire ants, $17 billion

ATOM & COSMOS

Muons may signal new physics

Experimental measurement could shake up standard model



The Muon g–2 experiment studies how muons wobble as they circulate at nearly the speed of light in a giant, doughnut-shaped magnet (shown). New results disagree with the standard model of particle physics, hinting at the possible existence of new particles.

BY EMILY CONOVER

A mysterious magnetic property of subatomic particles called muons hints that new fundamental particles may be lurking undiscovered.

In a painstakingly precise experiment, muons' gyrations within a magnetic field seemed to defy predictions of the standard model of particle physics, which describes known fundamental particles and forces. The result strengthens earlier evidence that muons, the heavy kin of electrons, behave unexpectedly.

"It's a very big deal," says theoretical physicist Bhupal Dev of Washington University in St. Louis. "This could be the long-awaited sign of new physics that we've all hoped for."

Muons' misbehavior could point to the existence of unknown types of particles that alter muons' magnetic properties. Muons behave like tiny magnets, each with a north and south pole. The strength of that magnet is tweaked by transient quantum particles that constantly flit into and out of existence, adjusting the muon's magnetism by an amount known as the muon magnetic anomaly. Physicists can predict the value of the magnetic anomaly by considering the contributions of all known particles. If any fundamental particles are in hiding, their additional effects on the magnetic anomaly could give them away.

Physicists flung billions of muons around the doughnut-shaped magnet of the Muon g–2 experiment at Fermilab in Batavia, Ill., to suss out the particles' magnetic subtleties (*SN: 9/29/18, p. 18*). Inside that magnet, the orientation of the muons' magnetic poles wobbled, or precessed. Notably, the precession rate diverged slightly from the standard model expectation, physicists report in the April 9 *Physical Review Letters*.

The researchers worked under self-imposed secrecy, hiding the final number as they analyzed the data, to avoid bias. When the answer finally was revealed, "I was having goose bumps," says physicist Meghna Bhattacharya of the University of Mississippi in Oxford. The researchers found a muon magnetic anomaly of 0.00116592040, accurate to within 46 millionths of a percent. The theoretical prediction pegs the number at 0.00116591810. That discrepancy "hints toward new physics," Bhattacharya says.

A previous measurement from an experiment at Brookhaven National Laboratory in Upton, N.Y., also disagreed with theoretical predictions (*SN: 2/17/01, p. 102*). When the new result is combined with the earlier discrepancy, the measurement diverges from the prediction by a statistical measure of 4.2 sigma — tantalizingly close to the 5-sigma benchmark for claiming a discovery.

"We have to wait for more data from the Fermilab experiment to really be convinced that this is a real discovery," says theoretical physicist Carlos Wagner of the University of Chicago.

According to quantum physics, muons constantly emit and absorb particles in a frenzy, which makes theoretical calculations of the magnetic anomaly extremely complex. An international team of more than 170 physicists finalized the theoretical prediction in December 2020 in *Physics Reports*.

Though many physicists believe that this prediction is unlikely to budge, debate lingers. Using a computational technique called lattice QCD for a particularly thorny part of the calculation gives an estimate that falls closer to the experimental value, physicist Zoltan Fodor of Penn State and colleagues report April 7 in *Nature*. If the calculation is correct, "it could change how we see the experiment," Fodor says, perhaps making it easier to explain the experimental results with the standard model.

As theoretical physicists continue refining predictions, experimental estimates will improve too. Muon g–2 physicists have so far analyzed only a fraction of their data. And physicist Tsutomu Mibe of the KEK High Energy Accelerator Research Organization in Japan and colleagues are planning an experiment using a different technique to begin in 2025.

If the discrepancy between experiment and prediction holds up, scientists will need to find an explanation beyond the standard model. The new measurement will intensify investigations, says Muon g–2 physicist Jason Crnkovic of the University of Mississippi. "It's going to generate a lot of conversations." ■

REIDAR HAHN/FERMILAB

Neandertals and humans mated often

The two groups regularly interbred about 45,000 years ago

BY BRUCE BOWER

When some of the earliest human migrants to Europe encountered Neandertals already living there around 45,000 years ago, hookups flourished.

Analyses of DNA found in human fossils from around that time — the oldest known human remains in Europe — suggest that interbreeding between *Homo sapiens* and Neandertals occurred more commonly than has often been assumed, two new studies suggest.

Genetic evidence in those reports indicates for the first time that distinct human populations reached Europe shortly after 50,000 years ago. Neandertals — who were on the fast track to extinction — interbred with all the groups detected so far, ensuring that some of their genes live on today in our DNA.

Remains of three *H. sapiens* males unearthed in Bulgaria's Bacho Kiro Cave yielded nuclear DNA containing Neandertal contributions of about 3 to 4 percent, evolutionary geneticist Mateja Hajdinjak of the Francis Crick Institute in London and colleagues report in the April 8 *Nature*. The ancient DNA came from a tooth and two bone fragments radiocarbon dated to between around 43,000 and 46,000 years ago. Stone tools typical of late Stone Age humans were found in the same sediment as the fossils.

"All of the Bacho Kiro individuals had recent Neandertal ancestors, as few as five to seven generations back in their family trees," Hajdinjak says.

Further evidence of ancient interbreeding comes from a nearly complete human skull discovered in 1950 in a cave in what's now the Czech Republic. About 3 percent of the DNA from that fossil, identified as a female, comes from Neandertals, evolutionary geneticist Kay Prüfer of the Max Planck Institute for the Science of Human History in Jena, Germany, and colleagues report April 7 in *Nature Ecology & Evolution*.

The *H. sapiens* fossils in Bulgaria and the Czech Republic aren't the first ones found with bits of Neandertal DNA in their genetic instruction manuals, but they most likely are the oldest. Several lines of genetic evidence suggest the Czech Republic woman lived around 45,000 years ago. For instance, long Neandertal DNA segments break into shorter segments over generations. Comparing the lengths of the Czech Republic woman's Neandertal DNA segments with those of a previously reported Siberian man who lived 45,000 years ago suggests the woman lived a few hundred to a few thousand years before him (*SN: 11/29/14, p. 8*). Previous studies of the man's DNA indicated that interbreeding outside of Europe began as early as 60,000 years ago. A Romanian man who lived roughly 40,000 years ago also possessed long stretches of Neandertal DNA, indicating he was four to six generations removed from a Neandertal relative (*SN: 6/13/15, p. 11*).

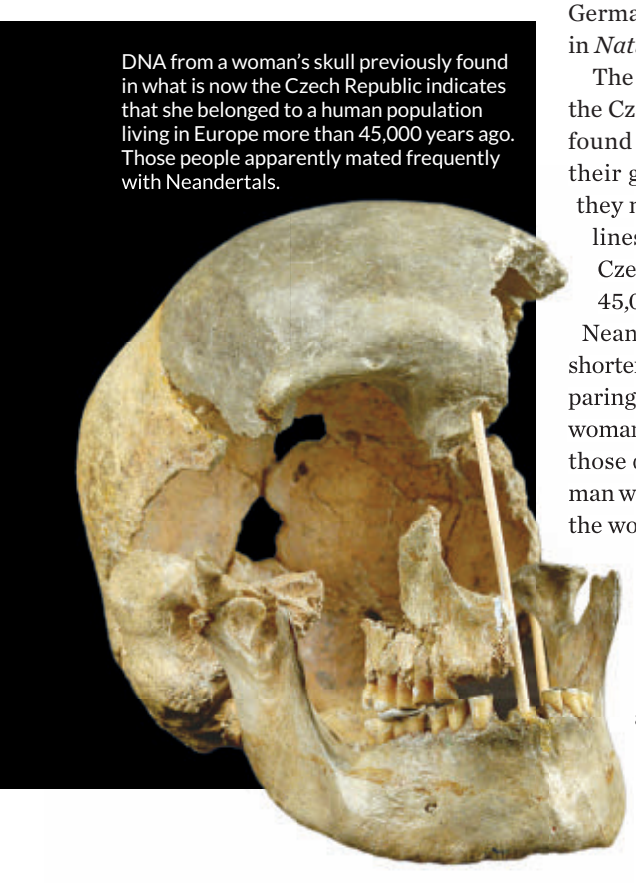
Neandertals went extinct around 40,000 years ago, though their genetic remnants remain — today, non-African people carry, on average, nearly 2 percent Neandertal DNA. Present-day Africans possess a smaller Neandertal genetic legacy (*SN: 2/29/20, p. 6*).

Taken together, the new studies suggest that some early human entrants to Europe had a long-lasting impact on our DNA while others hit genetic dead ends. Bacho Kiro humans represent a newly identified population of ancient Europeans with genetic ties to present-day East Asians and Native Americans, but not western Eurasians, Hajdinjak's group says. The Czech Republic woman, like the ancient Romanian and Siberian men, may have contributed no DNA to *H. sapiens* groups that lived after around 40,000 years ago.

"It is remarkable that the Bacho Kiro finds could represent a population that was spreading 45,000 years ago at least from Bulgaria to China," says evolutionary geneticist Carles Lalueza-Fox of the Institute of Evolutionary Biology in Barcelona, who peer-reviewed both studies.

If *H. sapiens* and Neandertals regularly interbred as the latter population neared its demise, then relatively large numbers of incoming humans accumulated a surprising amount of DNA from smaller Neandertal populations, Lalueza-Fox suspects. After 40,000 years ago, additional migrations into Europe by people with little or no Neandertal ancestry would have diluted Neandertal DNA from the human gene pool, he says.

Those humans made distinctive stone and bone tools and served as ancestors of present-day Europeans, Hajdinjak suggests. At Bacho Kiro Cave, for instance, newly recovered DNA from a roughly 35,000-year-old *H. sapiens* bone fragment displays a different makeup than that of the cave's earlier human inhabitants. This individual contributed genes mainly to later populations in Europe and western Asia, Hajdinjak says. ■



MAREK JANTAČ

DNA from a woman's skull previously found in what is now the Czech Republic indicates that she belonged to a human population living in Europe more than 45,000 years ago. Those people apparently mated frequently with Neandertals.

HUMANS & SOCIETY

Subtraction does not come naturally

People's notion that more is better may explain modern excesses

BY SUJATA GUPTA

Picture a bridge made of Legos. One side has three support pieces, the other two. How would you stabilize the bridge?

Most people would add a piece so that there are three supports on each side, a new study suggests. But why not remove a piece so that each side has two supports instead? It turns out that getting people to subtract — whether a Lego block, ingredients in a recipe or words in an essay — requires reminders and rewards, researchers report in the April 8 *Nature*.

This default to addition isn't limited to assembling blocks, cooking and writing. Thinking in pluses instead of minuses could contribute to modern-day excesses such as cluttered homes, institutional red tape and even an overburdened planet, says behavioral scientist Benjamin Converse of the University of Virginia in Charlottesville. "We're missing an entire class of solutions."

He and his colleagues first observed the behavior when they asked 1,585 study participants to tackle eight puzzles and problems that could be solved by adding or removing some things. One puzzle required shading or erasing squares on a grid to make a pattern symmetrical. In another, individuals could optimize an experience by adding or subtracting items from a travel itinerary.

Across all experiments, most participants chose addition over subtraction. Out of 94 participants who completed the grid task, 73 added squares, 18 subtracted squares and another three simply reworked the original number of squares.

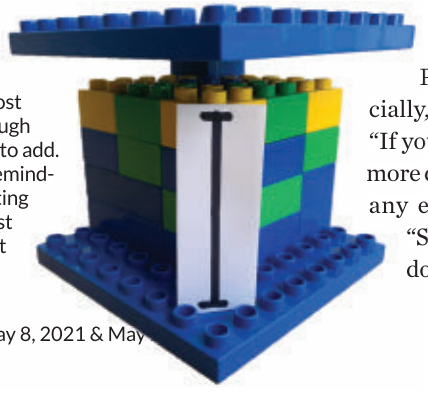
The scientists hypothesized that participants added because they failed to think about subtraction. Through a series of controlled experiments, the team nudged people toward the minus sign.

In one experiment, the team offered 197 people a dollar to stabilize a Lego structure on which a figurine was standing in front of a pillar. Atop that pillar, a single block supported a flat roof. Researchers asked the participants to stabilize the roof to avoid squashing the figurine. About half the participants were told that each block added costs 10 cents. Even with that penalty, only 40 out of 98 participants removed the block and rested the roof on the pillar. When the team told another group of participants that adding blocks costs 10 cents each but removing blocks is free, 60 out of 99 participants removed the block.

Practice helped participants call to mind that elusive minus sign, the team found. A variation on the grid experiment in which subtraction yielded the superior solution showed that three practice runs prompted more participants to subtract during the actual task than those who solved the task without practice.

However, bombarding participants with unrelated information decreased their likelihood of subtracting. People add even more when they experience information overload, experiments showed.

People intuit that subtraction comes less naturally than addition. Hence the adoption of adages such as "less is more." But curbing excess will take more than nudges and a clear mind, says Hal Arkes, a judgment and decision-making researcher at Ohio State University. Political leaders, especially, abhor cutting the fat. "If you add more people and more dollars, you won't make any enemies," Arkes says. "Subtraction has serious downsides." ■



In an experiment, people had to secure a Lego roof over a figurine (paper slip). Most added blocks, even though each block cost money to add. Only when scientists reminded people that subtracting blocks was free did most remove a block and rest the roof on a pillar.

GENES & CELLS

Ancient epidemic left lasting marks

Modern East Asian people's DNA shows signs of a viral fight

BY BRUCE BOWER

An ancient coronavirus, or a closely related pathogen, triggered an epidemic among ancestors of present-day East Asian people roughly 25,000 years ago, a new study indicates.

Analysis of DNA from more than 2,000 modern-day people shows that genetic changes in response to that persistent epidemic accumulated over the next 20,000 years or so, evolutionary geneticist David Enard of the University of Arizona in Tucson reported April 8 at a virtual meeting of the American Association of Physical Anthropologists. The finding raises the possibility that some East Asian people today have inherited biological adaptations to coronaviruses or related viruses.

The discovery opens a path to explore what role genes linked to ancient viral epidemics may play in shaping how modern outbreaks unfold. Genes with ancient viral histories might also someday provide clues in searches for antiviral drugs.

Enard's group consulted a public DNA database of 2,504 individuals from five continents and 26 ethnic populations, including Chinese Dai, Vietnamese Kinh and African Yoruba people. The team focused on 420 proteins known to interact with coronaviruses, including 332 that interact with the virus that causes COVID-19. These interactions may range from boosting immune responses to helping a virus hijack a cell.

Substantially increased production of all 420 proteins, a sign of past exposures to coronavirus-like epidemics, appeared only in East Asian people. Enard's group traced the origins of the viral responses of 42 of those proteins back to roughly 25,000 years ago.

Analysis of the genes known to help make those proteins found that specific gene variants became more common in

G.S. ADAMS ET AL./*NATURE* 2021

the population around 25,000 years ago before leveling off in frequency by around 5,000 years ago. That pattern is consistent with a vigorous genetic response to a virus that waned over time, either as East Asian people adapted to the virus or as the virus lost its ability to cause disease, Enard said. Of the 42 gene variants, 21 either enhance or deter the effects of a wide array of viruses, suggesting an unknown virus that exploited similar proteins as coronaviruses could have started the ancient epidemic, he said.

These findings "show that East Asians have been exposed to coronavirus-like epidemics for a long time and are more [genetically] adapted to epidemics of these viruses," says evolutionary geneticist Lluis Quintana-Murci of the Pasteur Institute in Paris. It's possible that DNA adjustments to coronavirus epidemics over thousands of years may contribute to lower COVID-19 infection and death rates reported in some East Asian nations versus in Europe and the United States, Quintana-Murci speculates. But many factors, including mandatory on-site work and lack of health care access, drive COVID-19 infections, he says. And strict lockdowns and widespread mask wearing may have deterred infections in some East Asian nations.

Large-scale genetic studies in modern East Asian people and of ancient human DNA spanning the last 25,000 years are needed to explore how the gene variants may contribute to COVID-19 or other infections. Those variants may also present opportunities to develop treatments, Enard said. So far, just four of the genes are targets of 11 drugs being used or investigated for treating COVID-19, he said. ■

HUMANS & SOCIETY

Humanlike brains had a late start

Modern frontal lobes began shaping up by 1.7 million years ago

BY CHARLES Q. CHOI

Even after members of the genus *Homo* took their first steps out of Africa, they still may have possessed brains more like those of great apes than humans today, a new study suggests.

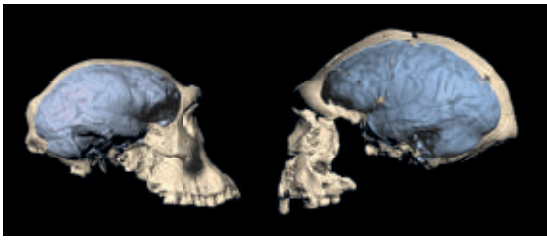
For decades, scientists had thought modern human–like organization of brain structures evolved soon after the lineage *Homo* arose roughly 2.8 million years ago (*SN: 4/4/15, p. 8*). But an analysis of fossilized skulls that retain imprints of the brains they once held now suggests such brain development occurred much later. Modern human–like brains may have emerged in an evolutionary sprint starting about 1.7 million years ago, paleoanthropologist Marcia Ponce de León and colleagues report in the April 9 *Science*.

To learn more about how the human brain evolved, the team analyzed replicas of the brain's convoluted outer surface. Those replicas were re-created from the oldest fossils from the Dmanisi archaeological site in Georgia known to preserve the inner surfaces of early *Homo* skulls, dated to around 1.85 million to 1.77 million years ago. Researchers compared the replicas with those re-created from bones unearthed in Africa and Southeast Asia that range in age from roughly 2 million to 70,000 years old.

The scientists focused on the frontal lobes, brain areas linked with complex mental tasks such as toolmaking and language. Early *Homo* from Dmanisi and Africa retained a great ape–like organization 1.8 million years ago, "a million or so years later than previously thought," says paleoanthropologist Philipp Gunz of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, who was not involved in the study.

The findings reveal that hominids may have possessed relatively primitive brains even after they first left Africa some 2.1 million years ago (*SN: 8/4/18, p. 7*). *Homo sapiens* started migrating from the continent about 210,000 years ago (*SN: 8/3/19, p. 6*). Still, it is essential to not underestimate the mental capabilities of those earliest hominid migrants, says Ponce de León, of the University of Zurich. "These people ventured out of Africa, produced a variety of tools, exploited animal resources and cared for elderly people, as we know from the site of Dmanisi," she says.

Ponce de León's team discovered that modern human–like brain organization appeared in Africa between about 1.7 million and 1.5 million years ago. The scientists also found that hominids with modern human–like brains appeared in Southeast Asia shortly after 1.5 million years ago, hinting at another dispersal from Africa separate from the first migration, the team says. It's unclear whether this second wave merged with or replaced earlier groups.



Early hominid brains may have evolved from a more apelike version (left in this digital reconstruction) to a more modern human–like one (right) between 1.7 million and 1.5 million years ago, an analysis of fossilized skulls suggests.

Future research into what evolutionary pressures might have driven the emergence of modern human–like brain organization could reveal how it relates to the evolution of language and symbolic thought, says paleoanthropologist and coauthor Christoph Zollikofer, also of the University of Zurich.

Reconstructing ancient brains from skulls remains largely controversial, cautions paleoanthropologist Bernard Wood of George Washington University in Washington, D.C., who was not involved in the study. Deducing how the insides of fossil braincases reflected bumps and grooves on the brain's surface, or what the effects of such organization might have had on brain function, can prove challenging, "This is just the beginning of discussions about what this means," Wood says. ■

M.S. PONCE DE LEÓN AND C.P.E. ZOLLIKOFER/UNIV. OF ZURICH

LIFE & EVOLUTION

Amazon is rooted in asteroid impact

Dino-killing bolide revamped region's tropical rainforests

BY CAROLYN GRAMLING

The day before a giant asteroid hit Earth 66 million years ago, a very different kind of rainforest thrived in what is now Colombia. Ferns unfurled and flowering shrubs bathed in sunlight shining through large gaps in a canopy made of towering conifers.

Then the bolide hit and everything changed. The impact set off a massive extinction event that wiped out more than 75 percent of life on Earth and transformed the Amazon's sun-dappled, open-canopied tropical rainforests into today's dark, dense, lush, dripping forests, researchers report in the April 2 *Science*.

The team analyzed tens of thousands of fossils of pollen, spores and leaves, collected from 39 sites across Colombia, that were dated to between 70 million and 56 million years ago. The scientists assessed forest plant diversity, dominant species and insect-plant interactions, and tracked how these factors shifted. Plant diversity declined by 45 percent in the immediate aftermath of the asteroid strike, the team found, and it took 6 million years before the rich diversity of the tropical rainforests rebounded. Even then, the forests were never the same.

"A single historical accident changed the ecological and evolutionary trajectory of tropical rainforests," says Carlos Jaramillo, who studies ancient pollen at the Smithsonian Tropical Research Institute in Panama City. "The forests that we have today are really the by-product of what happened 66 million years ago."

Just before the extinction event, the tropical forests were a roughly 50-50 mix of angiosperms, or flowering trees and shrubs, and gymnosperms such as conifers and ferns. Afterward, angiosperms took over, making up about 90 percent of the plant species in the forest.

The reasons why aren't wholly clear. At the end of the Cretaceous Period 66 million years ago, the region's climate was similar to how it is today: hot and humid. But other factors were likely at work. Huge plant-eating sauropods would have helped maintain the open gaps, letting light in, Jaramillo says. Once the asteroid hit, those dinosaurs were out of the picture (*SN: 2/4/17, p. 22*). Extinction of certain plant families from the impact may also have played a role.

A third likely factor was a shift in the chemical composition of forest soil. Frequent rainfall leached Cretaceous soils of many nutrients, which would have favored gymnosperms, Jaramillo says. Ash falling to the ground in the wake of the asteroid impact may have fertilized the soils with phosphorus, the team suggests. With more food available, angiosperms outcompeted the gymnosperms, swiftly growing and blocking sunlight.

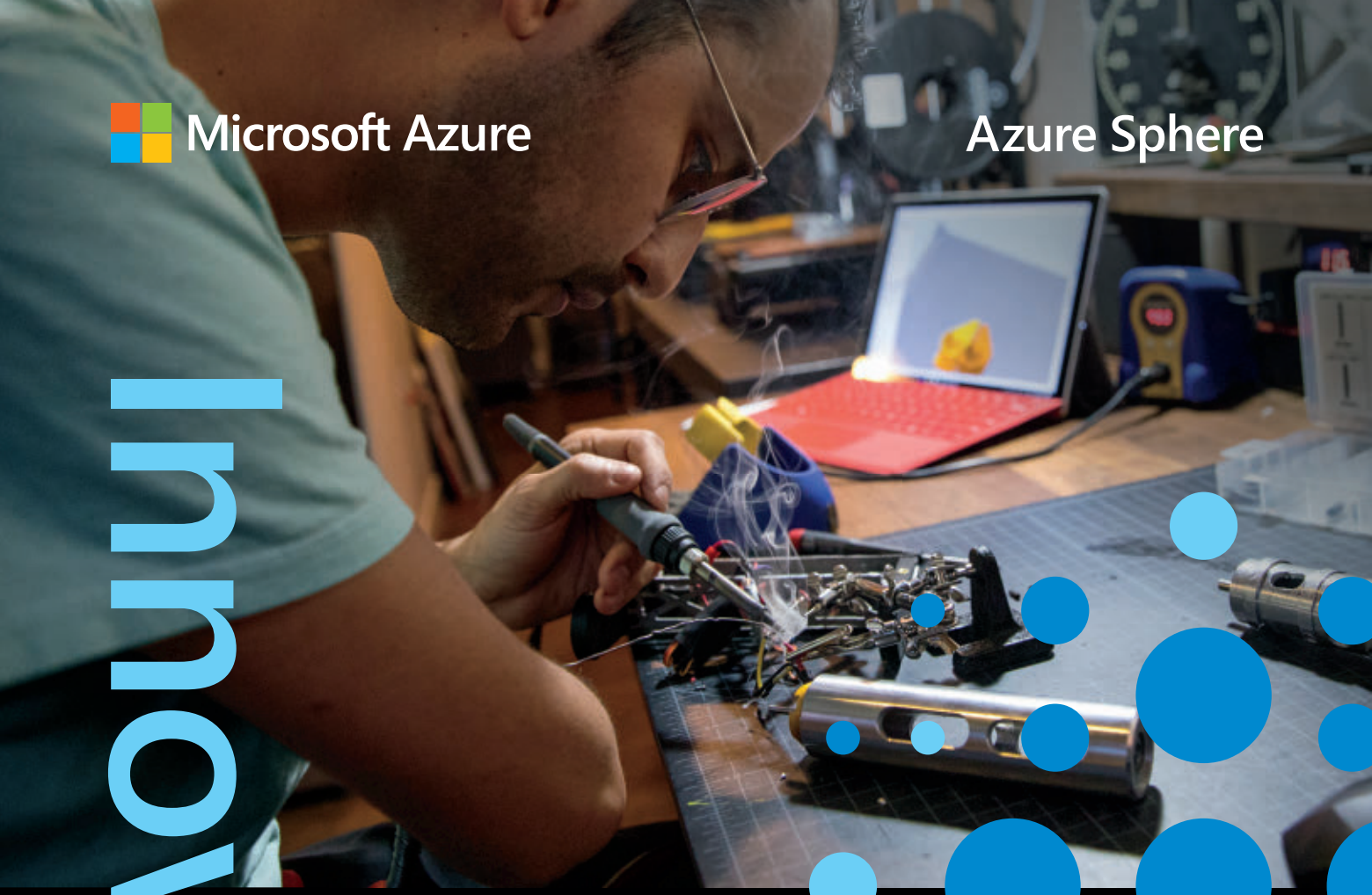
Overall forest diversity took much longer to recover as new species began to evolve to occupy new ecological niches. This was also true of the many insect species that had once feasted on the plants, leaf fossils indicate. Insects that can make a meal from many different types of plants were largely unaffected, says paleoecologist Conrad Labandeira of the Smithsonian National Museum of Natural History in Washington, D.C. Insects "that got really creamed were things like leaf miners and piercers and suckers," which are more dependent on particular plant types, Labandeira says.

The findings provide the first comprehensive picture of what happened in tropical ecosystems right after the extinction event, says paleoecologist Elena Stiles of the University of Washington in Seattle, who was not involved in the study. Most work on the very end of the Cretaceous and the start of the Paleogene Period comes from North America (*SN: 4/27/19, p. 10*) or from much farther south, such as in Patagonia, Stiles says. "In the tropics, there is no place where we have the boundary [between periods] preserved," she says, and the fossil record is very fragmented.

Also striking is the possibility that the findings may help explain South America's rich biodiversity. Researchers have speculated that the continent's climate or its long isolation from other continents may be responsible. "This mass extinction event could have been one of the mechanisms that shaped it to be this unique region," Stiles says. ■

M.R. CARVALHO *ET AL*/*SCIENCE* 2021

Fossils of leaves (shown) from across Colombia reveal how tropical rainforests in the Western Hemisphere shifted from a mix of conifers, ferns and flowering trees (bottom row) to forests dominated by flowering trees (top two rows) after a mass extinction event 66 million years ago.



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LIFE & EVOLUTION

Yawning lions move in sync

Contagious behavior may help a pride coordinate activities

BY JAKE BUEHLER

Watch a group of lions yawn, and it may seem like nothing more than big, lazy cats acting sleepy, but new research suggests that these yawns may be subtly communicating important social cues. Yawning not only is contagious among lions, but it also appears to help the predators synchronize their movements, researchers report in the April *Animal Behaviour*.

The discovery was partially made by chance, says Elisabetta Palagi, an ethologist at the University of Pisa in Italy. While studying play behavior in spotted hyenas in South Africa, Palagi and colleagues often had the opportunity to watch lions at the same time. She noticed that lions yawn frequently, concentrating the yawns in short time periods.

Yawning is ubiquitous among vertebrates, possibly boosting blood flow to the skull, cooling the brain and aiding alertness. In many species — like humans, monkeys and even parakeets — yawners can infect onlookers with their yawn contagion, leading onlookers to yawn shortly afterward. And some species appear to have co-opted the behavior for purposes conducive to group living.

Curious if the lions' prodigious yawning was socially linked, Palagi's team recorded videos of 19 lions at the Greater Makalali Private Game Reserve in South Africa over about four months in 2019. The team analyzed when the cats yawned and any behaviors around those times.

Lions that saw another member of the pride yawn were about 139 times as likely to yawn within the next three minutes, the team found. And lions that caught a yawn from another lion were 11 times as likely to mirror the movements of the original yawner than those that hadn't. This motor synchrony involved lions getting up and walking around or lying down.

A lion's yawn may be a subtle social cue that helps the big cat's pride move together.

In lions, contagious yawning might be important for maintaining social cohesion, Palagi says. Yawns that help lions harmonize group movements could help get the pride on the same page — crucial for cooperative hunting and cub rearing.

Other researchers have suggested that yawning helps coordinate group behavior in other species, says Andrew Gallup, a biopsychologist at State University of New York Polytechnic Institute in Utica. "But this is the first study ... that's actually attempted to quantify that," Gallup says. Contagious yawning, he says, may prove common for some highly social species. ■

ATOM & COSMOS

Physics helps alien rain stay in shape

Drops stay a similar size regardless of makeup or planet of origin

BY LISA GROSSMAN

Whether they're made of methane on Saturn's moon Titan or iron on the exoplanet WASP 76b, alien raindrops behave similarly across the Milky Way. They are always close to the same size, regardless of the liquid they're made of or the atmosphere they fall in, according to the first generalized physical model of alien rain.

"You can get raindrops out of lots of things," says planetary scientist Kaitlyn Loftus of Harvard University. In the April *Journal of Geophysical Research: Planets*, Loftus and Harvard planetary scientist Robin Wordsworth published equations for what happens to a falling raindrop after it has left a cloud. Previous studies have looked at rain in specific cases, like the water cycle on Earth or methane rain on Titan. But this is the first study to consider rain made from any liquid.

"They are proposing something that can be applied to any planet," says astronomer Tristan Guillot of the Observatory of the Côte d'Azur in Nice, France. "This is something that's needed, really, to understand what's going on" in the atmospheres of other worlds.

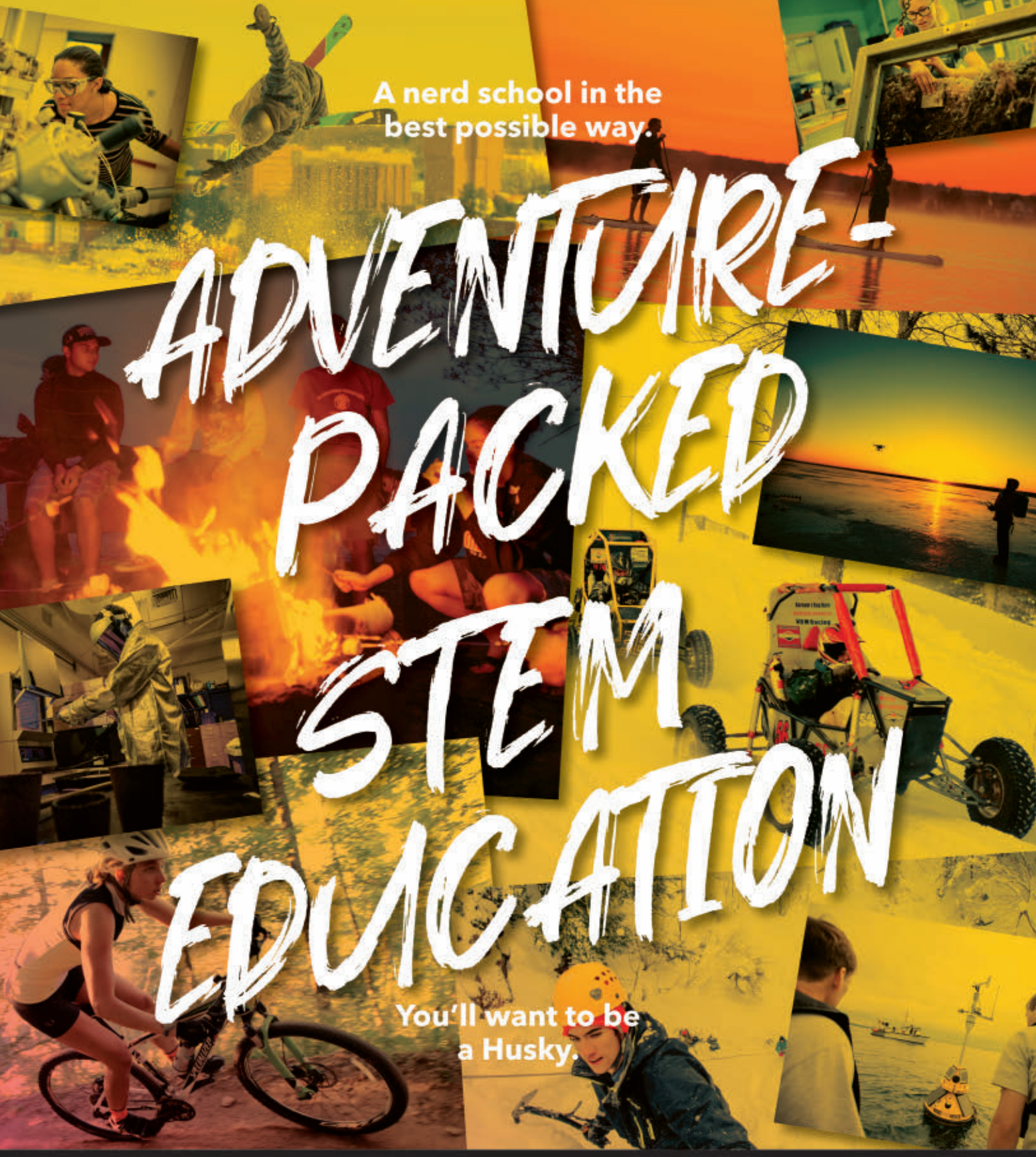
Raindrops help transport chemical elements and energy around the atmosphere, and are governed by a few simple physical laws. Falling droplets of liquid tend to default to similar shapes, regardless of the liquid's properties. The rate at which that droplet evaporates is set by its surface area.

Loftus and Wordsworth considered different forms of rain, including water on early Earth, ancient Mars and a gaseous exoplanet called K2 18b that may host clouds of water vapor. The pair also considered Titan's methane rain, Jupiter's ammonia "mushballs" and exoplanet WASP 76b's iron rain (*SN: 4/11/20, p. 4*). "All these different condensables behave similarly, [because] they're governed by similar equations," Loftus says.

Worlds with higher gravity tend to produce smaller raindrops, the duo found. Still, all the raindrops studied are within a narrow size range, from about a tenth of a millimeter to a few millimeters in radius. Much bigger, and raindrops break apart as they fall. Much smaller, and they quickly evaporate. The scientists next want to investigate solid precipitation like hail.

The work is a first step toward understanding precipitation in general, says astronomer Björn Benneke of the University of Montreal. "That's what we are all striving for: to develop a kind of global understanding of how atmospheres and planets work, and not just be completely Earth-centric," he says. ■

MANOJ SHAH/STONE/GETTY IMAGES PLUS



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EARTH & ENVIRONMENT

Glacier trek reveals warm water risks

A robot shows how water erodes Antarctica's Thwaites ice shelf

BY CAROLYN GRAMLING

An autonomous underwater vehicle's trek below the ice is giving scientists their first direct evidence for how and where warm ocean waters are threatening the stability of Antarctica's vulnerable Thwaites Glacier. These new data will ultimately help scientists more accurately project the fate of the glacier — how quickly it is melting and retreating inland, and how far it might be from complete collapse, the team reports April 9 in *Science Advances*.

"We know there's a sick patient out there, and it's not able to tell us where it hurts," says Eric Rignot, a glaciologist at the University of California, Irvine who was not involved in the study. "So this is the first diagnosis."

Scientists have eyed the Florida-sized Thwaites Glacier with mounting concern for two decades. Satellite images reveal it has been retreating at an alarming rate of 0.3 to 0.8 kilometers per year on average since 2001. The glacier's full collapse could ultimately add more than half a meter to global sea levels and destabilize other glaciers in West Antarctica. But estimates of how quickly the glacier is retreating, based on computer simulations, vary widely from place to place on the glacier, Rignot and colleagues reported in *Science Advances* in 2019. Such uncertainty is one of the biggest difficulties when it comes to projecting sea level rise (*SN: 2/29/20, p. 18*).

Relatively warm ocean waters sneaking beneath floating ice shelves is a primary culprit for the rapid retreat of Thwaites and other Antarctic glaciers. This water eats away at ice anchored to the seafloor that keeps glaciers from sliding into the sea.

Scientists have used satellite data to roughly map out what lies beneath the Thwaites ice shelf. Three deep channels carved into the seafloor connect the ocean to a vast water-filled cavity 120 kilometers across. But without direct measurements of the water's chemistry and paths to Thwaites' underbelly, it's been impossible to know where the threatening water is coming from, how warm it is and where it's attacking the ice, says physical oceanographer Anna Wåhlin of the University of Gothenburg in Sweden.

In February and March 2019, Wåhlin and colleagues sent an autonomous underwater vehicle, or AUV, to traverse two of the deep channels. Gliding 50 meters above the seafloor, the AUV collected the first direct measurements of the water's temperature, salinity and oxygen levels. From those measurements, the team traced the origins of water parcels mixing beneath Thwaites.

Ocean data collected by this red autonomous underwater vehicle from beneath the Thwaites ice shelf in Antarctica are helping scientists identify sources of warm water eroding the ice.

FILIP STEDT

Based on its chemical makeup, some of the warm water came from neighboring Pine Island Bay. "We were very surprised" because that area wasn't thought to be a major player in the future of Thwaites, Wåhlin says. The water mass from Pine Island Bay was near the bottom of the cavity, about 1,050 meters deep, and was both less salty than the surrounding seawater and several degrees Celsius warmer than the freezing point. That unstable situation is likely to create turbulence and increase the potential for erosion of the ice, Wåhlin says.

The find also suggests that what happens in Pine Island Bay doesn't necessarily stay in Pine Island Bay — and that the fate of Thwaites may be closely intertwined with that of the Pine Island Glacier, which also is rapidly melting, Wåhlin says. Together, the two glaciers account for most of the ice and water that Antarctica is shedding. While Thwaites is still pinned to the seafloor in some places, slowing the glacier's slide into the sea, the Pine Island ice shelf's underpinnings are long gone, she says.

In March, scientists described three tipping points for the Pine Island Glacier, thresholds it might cross as climate changes that would lead to rapid, irreversible retreat. The final threshold, prompted by a rise in ocean temperatures of about 1.2 degrees C, would drive the glacier to complete collapse, the team found.

Wåhlin and others are planning an expedition for January 2022 that will use two AUVs to explore much farther into the cavity beneath Thwaites. Ideally, the AUVs will reach the grounding line where the base of the glacier rests on land.

Observing how water masses interact with the glacier's grounding line will be crucial to understanding the glacier's future, Rignot says. "That's the place where melting makes the most difference to the glacier's stability." ■

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ATOM & COSMOS

Earth gains tons of extraterrestrial dust

An estimated 5,200 metric tons settles on the surface each year

BY SID PERKINS

As our planet orbits the sun, it swoops through clouds of extraterrestrial dust — and several thousand metric tons of that material actually reaches Earth's surface every year, new research suggests.

During three summers in Antarctica over the last two decades, researchers collected more than 2,000 micrometeorites from four snow pits. Extrapolating from this meager sample to the rest of the world, tiny pebbles from space account for a whopping 5,200 metric tons of weight gain each year, researchers report in the April 15 *Earth and Planetary Science Letters*.

Much of Antarctica is the perfect repository for micrometeorites because there's no liquid water to dissolve or otherwise destroy them, says cosmochemist Jean Duprat of Sorbonne University in Paris. Nevertheless, collecting the samples was no easy chore.

First, Duprat and colleagues had to dig down two meters or more to reach layers of uncontaminated snow deposited between 1920 and 1980, before researchers first arrived at an inland site dubbed Dome C. Then they used ultraclean tools to collect thousands of kilograms of snow, melt it and sieve the tiny treasures from the frigid water.

In all, the team found 808 micrometeorites that had partially melted as they blazed through Earth's atmosphere and another 1,280 pristine micrometeorites. The particles ranged in size from 30 to 350 micrometers across and all together weigh a fraction of a gram. But all the micrometeorites were found within just over 100 square meters, a mere fraction of Earth's surface. Assuming that particles of space dust are just as likely to fall in Antarctica as anywhere else let the team estimate how much dust falls over the entire planet.

The team's findings "are a wonderful complement to previous studies," says Susan Taylor, a geologist at the Cold Regions Research and Engineering Laboratory in Hanover, N.H. That's because Duprat and colleagues found a lot of the small stuff that would have dissolved elsewhere, she notes.

About 80 percent of the micrometeorites originate from comets that spend much of their orbits closer to the sun than Jupiter, the researchers estimate. Much of the rest probably derive from collisions of objects in the asteroid belt. All together, these tiny particles deliver somewhere between 20 and 100 metric tons of carbon to Earth each year, the team suggests. This sort of space dust could have been an important source of carbon-rich compounds early in Earth's history (*SN: 12/5/20, p. 4*). ■

CHUANG ZHAO

LIFE & EVOLUTION

Pterosaur thumbed through trees

Future *Jurassic Park* films could feature one weird new beast in the menagerie: a pterosaur nicknamed Monkeydactyl for its opposable thumbs.

This flying reptile may be the earliest known animal that could touch the insides of its thumbs to the insides of its other fingers, researchers report online April 12 in *Current Biology*. Such dexterity probably allowed Monkeydactyl to climb trees about 160 million years ago, perhaps to feed on insects and other prey (illustrated at left). The latter half of the creature's official name, *Kunpengopterus antipollicatus*, comes from ancient Greek words for "opposite" and "thumb."

The fossilized remains, unearthed in northeastern China in 2019, are embedded in rock. So the team used micro-CT scanning to create a 3-D rendering. "We're able to look at the fossil from any angle and make sure that the bones are in their right [original] place," says paleontologist Rodrigo Pêgas of the Federal University of ABC in São Bernardo do Campo, Brazil. The scans helped confirm that each hand had a well-preserved opposable thumb. "Almost all of the modern animals that have opposable thumbs use them to climb trees," Pêgas says. That evidence, along with Monkeydactyl's flexible joints, suggests the species was well-suited to clambering through tree branches. — *Maria Temming*

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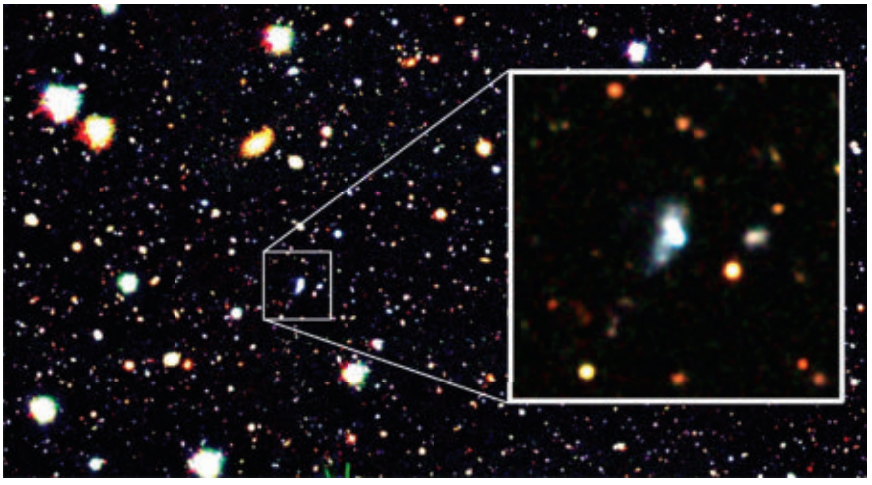
ATOM & COSMOS

Star shrapnel may litter rare galaxy

Explosions of giant stars could explain odd element ratios

BY KEN CROSWELL



The dwarf galaxy HSC J1631+4426 (centered in inset) boasts the lowest oxygen-to-hydrogen ratio known. Such oxygen-poor galaxies hint at what conditions were like in the early universe.

T. KOJIMA ET AL/*ASTROPHYSICAL JOURNAL* 2020, NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN

The most oxygen-poor star-forming galaxy ever found hints that the first galaxies to arise after the universe's birth glittered with supermassive stars that left behind big black holes.

Such galaxies are rare now because almost as soon as a galaxy initiates star formation, massive stars produce huge amounts of oxygen — the most abundant element in the cosmos after hydrogen and helium. Astronomers prize the few oxygen-poor galaxies found close to home because they offer a glimpse of what conditions were like in the very early universe, before stars had made much oxygen.

The newfound galaxy's oxygen-to-hydrogen ratio — a standard measure of relative oxygen abundance in the cosmos — is well under 2 percent of the sun's, researchers report in a study to appear in the *Astrophysical Journal* and posted online March 22 at arXiv.org.

"It is quite difficult to pick up such a rare object," says astrophysicist Takashi Kojima, who made the discovery with colleagues while he was at the University of Tokyo.

Named HSC J1631+4426, the record-breaking galaxy, found by using the Subaru Telescope in Hawaii, is 430 million light-years from Earth in the constellation Hercules. The galaxy is a dwarf, with far fewer stars to create oxygen than the Milky Way has. Those relatively few stars have given the runt just a pinch of oxygen: one atom for every 126,000 hydrogen atoms. That's only 1.2 to 1.6 percent of the oxygen level in the sun.

"Any new galaxy is good," says Trinh Thuan, an astronomer at the University of Virginia in Charlottesville. He helped find the previous record holder, J0811+4730, which is 620 million light-years away in the constellation Lynx. "We're counting the number of [very oxygen-poor galaxies] in the palm of our hand," Thuan says. The new galaxy's oxygen-to-hydrogen ratio is 83 percent that of J0811+4730.

In HSC J1631+4426, Kojima's team also found odd abundances of another chemical element: iron. While the overall amount of iron in the galaxy is low, "the iron-to-oxygen abundance ratio is surprisingly high," he says.

The same pattern appears in the oxygen-poor galaxy in Lynx. In contrast, ancient stars in the Milky Way usually have little iron relative to oxygen. That's because newborn stars get most of their iron from the explosions of long-lived stars. Those explosions had not occurred by the time the Milky Way's oldest stars formed. But in the two nearly pristine galaxies, the amount of iron relative to oxygen is as high as that of the sun, which acquired large amounts of both elements from previous generations of stars.

"This is a very unusual pattern, and it's not obvious how to explain that," says Volker Bromm, an astrophysicist at the University of Texas at Austin who was not involved with the discovery.

Just before Kojima earned his Ph.D. in 2020, he hit upon a possible explanation: High-mass stars in dense star clusters merged together to make stellar goliaths more than 300 times as massive as the sun. These superstars then exploded and showered their galactic homes with both iron and oxygen, leading to high iron-to-oxygen ratios in the two primitive galaxies as well as a source of what little oxygen exists there.

No stars this massive are known to exist in the modern Milky Way. But their possible presence in the two most oxygen-poor star-making galaxies suggests that primordial galaxies also had them, Kojima says.

When the superstars died, they should have left behind intermediate-mass black holes, which are more than 100 times as massive as the sun (*SN: 9/26/20, p. 7*). That's about 10 times as massive as typical black holes, which can form when bright stars die.

Kojima's team sees evidence for these big black holes in the newly discovered galaxy. Gas swirling around such large black holes should get so hot that it emits high-energy photons, or particles of light. These photons would tear electrons from helium atoms, turning them into positively charged ions. Sure enough, the newfound galaxy in Hercules emits a wavelength of blue light that comes from such helium ions.

The galaxy is "an exciting preview of things to come," Bromm says. In coming years, enormous new telescopes will find even more extreme galaxies, he says. "Then we will have a wonderfully complementary way to learn about the early universe." ■

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HUMANS & SOCIETY

STEM's racial gaps still strikingly large

Black and Hispanic scientists are underrepresented and paid less

BY MARIA TEMMING

Efforts to promote equity and inclusion in science, technology, engineering and math have a long way to go, a new report suggests.

Over the last year, widespread protests in response to the police killings of George Floyd, Breonna Taylor and other Black people have sparked calls for racial justice, including in STEM. Social media movements have drawn attention to discrimination faced by Black students and professionals, and the Strike for Black Lives challenged the scientific community to build a more just, antiracist research environment (*SN: 12/19/20 & 1/2/21, p. 26*).

Now, an analysis of federal education and employment data from recent years highlights how wide the racial and ethnic gaps in STEM representation are. "This has been an ongoing conversation in the science community" for decades, says Cary Funk, director of science and society research at the Pew Research Center in Washington, D.C.

Because the most recent data come from 2019, Pew's snapshot of STEM cannot reveal how recent calls for diversity, equity and inclusion may have moved the needle. But from 2017 to 2019, Black professionals were 11 percent of the overall U.S. workforce, but only 9 percent of STEM workers in the United States.

The representation gap was even larger for Hispanic professionals, who were 17 percent of the total U.S. workforce, but made up only 8 percent of people working in STEM.

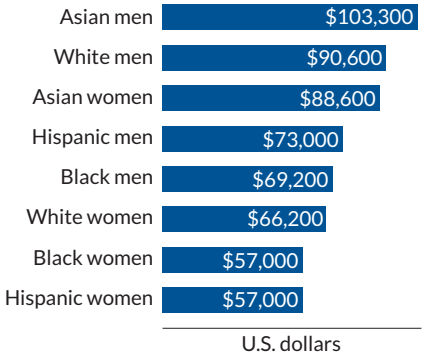
White and Asian professionals, meanwhile, remained overrepresented. Although white professionals made up 63 percent of the overall workforce, they accounted for 67 percent of STEM workers. Likewise, while Asian professionals constituted only 6 percent of all U.S. workers, they made up 13 percent of all STEM professionals.

Some STEM occupations, such as engineers and architects, skew particularly white. But even fields that include more professionals from underrepresented groups do not necessarily boast more supportive environments, notes Jessica Esquivel, a particle physicist at Fermilab in Batavia, Ill.

For instance, Black professionals are represented in health care jobs at the same level as they are in the overall workforce, according to the Pew report. But many white people with medical training continue to believe racist medical myths, such as the idea that Black people have thicker skin or feel less pain than white people, reports a 2016 study in *Proceedings of the National Academy of Sciences*. Such medical myths may not create a supportive learning environment for Black students who are pursuing STEM careers.

When it comes to compensation, racial and ethnic disparities have widened. Black STEM professionals typically earned about 78 percent of white workers' earnings from 2017 to 2019 — down from 81 percent in 2016. And typical pay for Hispanic professionals in STEM was 83 percent of white workers' earnings — down from 85 percent in 2016.

Median annual earnings of STEM workers by demographic, 2017–2019



SOURCE: PEW RESEARCH CENTER

Getting paid STEM workers' typical annual pay varies by gender, race and ethnicity. Black and Hispanic professionals earn less than their white and Asian colleagues.

Meanwhile, Asian STEM professionals' typical earnings rose from 125 percent of white workers' pay to 127 percent.

The authors of the Pew report see no major shifts in workplace representation in the near future. That's because racial and ethnic gaps in STEM education are similar to gaps in the workforce. Black and Hispanic students are less likely to earn undergraduate and advanced degrees in STEM than in other fields, the Pew report finds. For instance, Black students earned 7 percent of bachelor's degrees in STEM in 2018 (the most recent year with available data) — lower than their 10 percent share of all bachelor's degrees that year. Asian students, on the other hand, are overrepresented. They earned 7 percent of all bachelor's degrees in 2018, but about 10 percent of all STEM-related bachelor's degrees that year.

These findings are important but not surprising, says Cato Laurencin, a surgeon and engineer at the University of Connecticut in Farmington. "Why the numbers are where they are, I think, is maybe an even more important discussion."

The barriers to entering STEM "are very, very different with every group," says Laurencin, who chairs the National Academies of Sciences, Engineering and Medicine's Roundtable on Black Men and Black Women in Science, Engineering and Medicine. In particular, he says, "Blacks working their way through STEM education and STEM professions really face a gauntlet of adversity." That runs the gamut from fewer potential STEM role models in school to workplace discrimination.

Esquivel, a cofounder of the group Black in Physics, is optimistic about change. Over the last year, "we've realized the power of our voice, and I see us not going back because of that — because we've started grassroots movements, like Black in Physics, like all of the Black in X networks that popped off this past June," she says. "These early-career, student-led grassroots movements are keeping the people in power's feet to the fire, and just not backing down. That really does give me hope for the future." ■

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The battle against fake news

Scientists offer tools to stem the tide of misinformation

By Alexandra Witze

From lies about election fraud to QAnon conspiracy theories and anti-vaccine falsehoods, misinformation is racing through our democracy. And it is dangerous.

Awash in bad information, people have swallowed hydroxychloroquine hoping the drug will protect them against COVID-19 — even with no evidence that it helps (*SN Online: 8/2/20*). Others refuse to wear masks, contrary to the best public health advice available. In January, protestors disrupted a mass vaccination site in Los Angeles, blocking life-saving shots for hundreds of people. "COVID has opened everyone's eyes to the dangers of health misinformation," says cognitive scientist Briony Swire-Thompson of Northeastern University in Boston.

The pandemic has made clear that bad information can kill. And scientists are struggling to stem the tide of misinformation that threatens to drown society. The sheer volume of fake news, flooding across social media with little fact-checking to dam it, is taking an enormous toll on trust in basic institutions. In a December poll of 1,115 U.S. adults, by NPR and the research firm

BRIAN STAUFFER

Ipsos, 83 percent said they were concerned about the spread of false information. Yet fewer than half were able to identify as false a QAnon conspiracy theory about pedophilic Satan worshippers trying to control politics and the media.

Scientists have been learning more about why and how people fall for bad information — and what we can do about it. Certain characteristics of social media posts help misinformation spread, new findings show. Other research suggests bad claims can be counteracted by giving accurate information to consumers at just the right time, or by subtly but effectively nudging people to pay attention to the accuracy of what they're looking at. Such techniques involve small behavior changes that could add up to a significant bulwark against the onslaught of fake news.

In January, protests closed down a mass vaccination site at Dodger Stadium in Los Angeles.

IRFAN KHAN/*LOS ANGELES TIMES* VIA GETTY IMAGES

Wow factor

Misinformation is tough to fight, in part because it spreads for all sorts of reasons. Sometimes it's bad actors churning out fake-news content in a quest for internet clicks and advertising revenue, as with "troll farms" in Macedonia that generated hoax political stories during the 2016 U.S. presidential election. Other times, the recipients of misinformation are driving its spread.

Some people unwittingly share misinformation on social media and elsewhere simply because they find it surprising or interesting (see Page 29). Another factor is the method through which the misinformation is presented — whether through text, audio or video. Of these, video can be seen as the most credible, according to research by S. Shyam Sundar, an expert on the psychology of messaging at Penn State. He and colleagues decided to study this after a series of murders in India started in 2017 as people circulated via WhatsApp a video purported to be of child abduction. (It was, in reality, a distorted clip of a public awareness campaign video from Pakistan.)

Sundar recently showed 180 participants in India audio, text and video versions of three fake-news stories as WhatsApp messages, with research funding from WhatsApp. The video stories were assessed as the most credible and most likely to be shared by respondents with lower levels of knowledge on the topic of the story. "Seeing is believing," Sundar says.

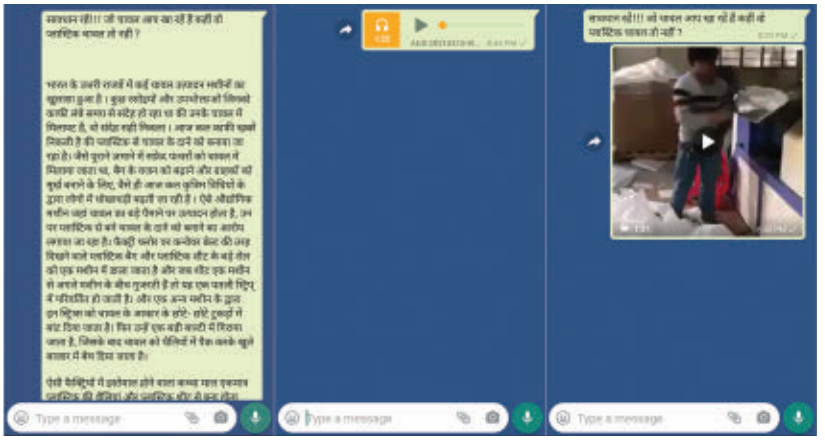
The findings, in press at the *Journal of Computer-Mediated Communication*, suggest several ways to fight fake news, he says. For instance, social media companies could prioritize responding to user complaints when the misinformation being spread includes video, above those that are text-only. And media-literacy efforts might focus on educating people that videos can be highly deceptive. "People should know they are more gullible to misinformation when they see something in video form," Sundar says. That's especially important with the rise of deepfake technologies that feature false but visually convincing videos (*SN: 9/15/18, p. 12*).

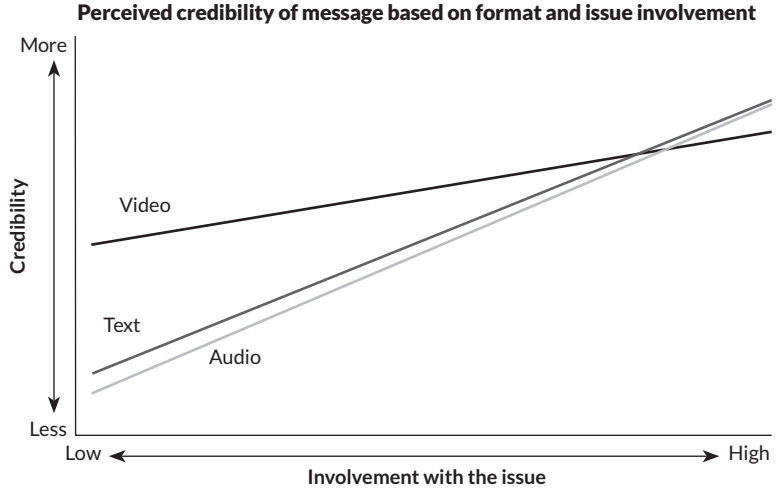
One of the most insidious problems with fake news is how easily it lodges itself in our brains and how hard it is to dislodge once it's there. We're constantly deluged with information, and our minds use cognitive shortcuts to figure out what to retain and what to let go, says Sara Yeo, a science-communication expert at the University of Utah in Salt Lake City. "Sometimes that information is aligned with the values that we hold, which makes us more likely to accept it," she says. That means people continually accept information that aligns with what they already believe, further insulating them in self-reinforcing bubbles.

Compounding the problem is that people can process the facts of a message properly while misunderstanding its gist because of the influence of their emotions and values, psychologist Valerie Reyna of Cornell University wrote in 2020 in *Proceedings of the National Academy of Sciences*.

Thanks to new insights like these, psychologists and cognitive scientists are developing tools people can use to battle misinformation before it arrives — or that prompts them to think more deeply about the information they are consuming.

One such approach is to "prebunk" beforehand rather than debunk after the fact. In 2017, Sander van der Linden, a social psychologist at the University of Cambridge, and colleagues found





Video sells WhatsApp users looked at three versions of a story that falsely claimed that rice was being made out of plastic — in text, audio or a video showing a man feeding plastic sheets into a machine (images above). Participants tended to rate the video version as more credible than the audio or text versions. The effect diminished for users who were highly involved with the topic of the false story, suggesting that video is a particularly compelling medium for those who may not be knowledgeable on the topic at hand. SOURCE: S.S. SUNDAR AND E. CHO/PENN STATE AND M. MOLINA/MICHIGAN STATE UNIV.

that presenting information about a petition that denied the reality of climate science following true information about climate change canceled any benefit of receiving the true information. Simply mentioning the misinformation undermined people's understanding of what was true.

That got van der Linden thinking: Would giving people other relevant information *before* giving them the misinformation be helpful? In the climate change example, this meant telling people ahead of time that "Charles Darwin" and "members of the Spice Girls" were among the false signatories to the petition. This advance knowledge helped people resist the bad information they were then exposed to and retain the message of the scientific consensus on climate change.

Here's a very 2021 metaphor: Think of misinformation as a virus, and prebunking as a weakened dose of that virus. Prebunking becomes a vaccine that allows people to build up antibodies to bad information. To broaden this beyond climate change, and to give people tools to recognize and battle misinformation more broadly, van der Linden and colleagues came up with a game, *Bad News*, to test the effectiveness of prebunking (see Page 36). The results were so promising that the team developed a COVID-19 version of the game, called *GO VIRAL!* Early results suggest that playing it helps people better recognize pandemic-related misinformation.

Take a breath

Sometimes it doesn't take very much of an intervention to make a difference. Sometimes it's just a matter of getting people to stop and think for a moment about what they're doing, says Gordon Pennycook, a social psychologist at the University of Regina in Canada.

In one 2019 study, Pennycook and David Rand, a cognitive scientist now at MIT, tested real news headlines and partisan fake headlines, such as "Pennsylvania federal court grants legal authority to REMOVE TRUMP after Russian meddling," with nearly 3,500 participants. The researchers also tested participants' analytical reasoning skills. People who scored higher on the analytical tests were less likely to identify fake news headlines as accurate, no matter their political affiliation. In other words, lazy thinking rather than political bias may drive people's susceptibility to fake news, Pennycook and Rand reported in *Cognition*.

When it comes to COVID-19, however, political polarization does spill over into people's behavior. In a working paper first posted online April 14, 2020, at PsyArXiv.org, Pennycook and colleagues describe findings that political polarization, especially in the United States with its contrasting media ecosystems, can overwhelm people's reasoning skills when it comes to taking protective actions, such as wearing masks.

Inattention plays a major role in the spread of misinformation, Pennycook argues. Fortunately, that suggests some simple ways to intervene, to "nudge" the concept of accuracy into people's minds, helping them resist misinformation. "It's basically critical thinking training, but in a very light form," he says. "We have to stop shutting off our brains so much."

With nearly 5,400 people who previously tweeted links to articles from two sites known

TOP: S.S. SUNDAR, M.D. MOLINA AND E. CHO; GRAPH: T. TIBBITTS

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How to debunk

Debunking bad information is challenging, especially if you're fighting with a cranky family member on Facebook. Here are some tips from misinformation researchers:

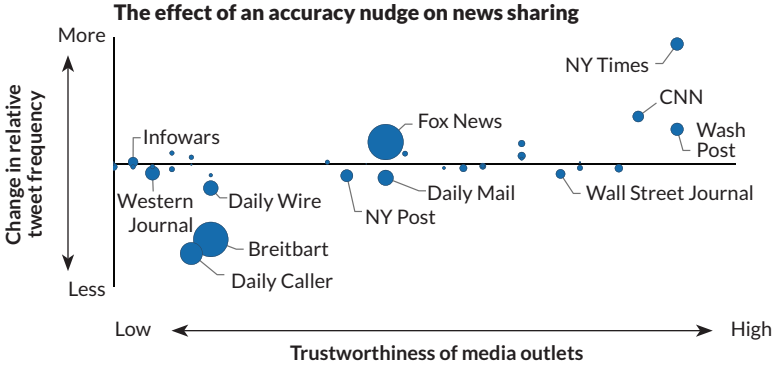
- Arm yourself with media-literacy skills, at sites such as the **News Literacy Project** (newslit.org), to better understand how to spot hoax videos and stories.
- Don't stigmatize people for holding inaccurate beliefs. **Show empathy and respect**, or you're more likely to alienate your audience than successfully share accurate information.
- Translate complicated but true ideas into **simple messages** that are easy to grasp. Videos, graphics and other visual aids can help.
- When possible, once you provide a factual alternative to the misinformation, **explain the underlying fallacies** (such as cherry-picking information, a common tactic of climate change deniers).
- Mobilize when you see misinformation being shared on social media as soon as possible. **If you see something, say something**.

SOURCE: *THE DEBUNKING HANDBOOK 2020*; NEWS LITERACY PROJECT

for posting misinformation — Breitbart and InfoWars — Pennycook, Rand and colleagues used innocuous-sounding Twitter accounts to send direct messages with a seemingly random question about the accuracy of a nonpolitical news headline. Then the scientists tracked how often the people shared links from sites of high-quality information versus those known for low-quality information, as rated by professional fact-checkers, for the next 24 hours.

On average, people shared higher-quality information after the intervention than before. It's a simple nudge with simple results, Pennycook acknowledges — but the work, reported online March 17 in *Nature*, suggests that very basic reminders about accuracy can have a subtle but noticeable effect.

Push in the right direction Nudging Twitter users to think about the accuracy of a nonpolitical headline resulted in users temporarily sharing more information from more trustworthy media outlets (blue dots toward the right) and less from less trustworthy outlets (blue dots toward the left). Dot size is proportional to the number of tweets that link to that website prior to the accuracy nudge. SOURCE: G. PENNYCOOK *ET AL*/*NATURE* 2021



For debunking, timing can be everything. Tagging headlines as "true" or "false" after presenting them helped people remember whether the information was accurate a week later, compared with tagging before or at the moment the information was presented, Nadia Brashier, a cognitive psychologist at Harvard University, reported with Pennycook, Rand and political scientist Adam Berinsky of MIT in February in *Proceedings of the National Academy of Sciences*.

Prebunking still has value, they note. But providing a quick and simple fact-check after someone reads a headline can be helpful, particularly on social media platforms where people often mindlessly scroll through posts.

Social media companies have taken some steps to fight misinformation spread on their platforms, with mixed results. Twitter's crowdsourced fact-checking program, Birdwatch, launched as a beta test in January, has already run into trouble with the poor quality of user-flagging. And Facebook has struggled to effectively combat misinformation about COVID-19 vaccines on its platform.

Misinformation researchers have recently called for social media companies to share more of their data so that scientists can better track the spread of online misinformation. Such research can be done without violating users' privacy, for instance by aggregating information or asking users to actively consent to research studies.

Much of the work to date on misinformation's spread has used public data from Twitter because it is easily searchable, but platforms such as Facebook have many more users and much more data. Some social media companies do collaborate with outside researchers to study the dynamics of fake news, but much more remains to be done to inoculate the public against false information.

"Ultimately," van der Linden says, "we're trying to answer the question: What percentage of the population needs to be vaccinated in order to have herd immunity against misinformation?" ■

Explore more

- Gordon Pennycook and David G. Rand. "The psychology of fake news." *Trends in Cognitive Sciences*. May 2021.
- Dietram A. Scheufele *et al*. "Misinformation about science in the public sphere." *Proceedings of the National Academy of Sciences*. April 13, 2021.

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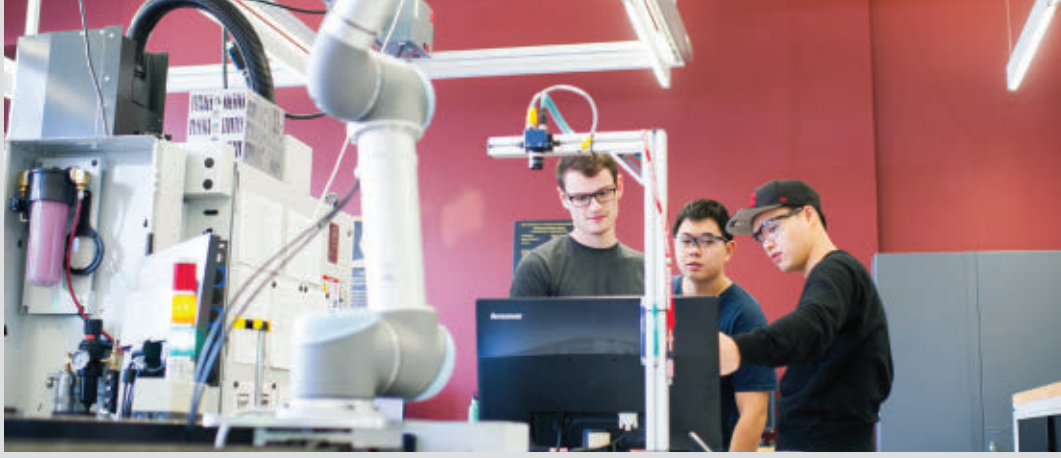

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Anatomy of misinformation

These tricks are more likely to make fake news flourish

By Laura Sanders

Bad information isn't new. Propagandists and scam artists have been selling their brand of proverbial snake oil for ages, all to bend people's thinking to their goals. What's different today is that the digital world flings information faster and farther than ever before.

Our brains can't always keep up.

That's because we often rely on quick estimates to figure out whether something is true. These shortcuts, called heuristics, are often based on very simple patterns (*SN: 9/20/14, p. 24*). For instance, most information we come across in our daily lives is true. So when forced to guess, we often err on the side of believing.

Other shortcuts exist that encourage information — true or false — to find its way into our minds, research on human psychology shows. We take notice of information that is new, that fires up our emotions, that supports what we already believe and that we hear over and over.

Most of the time, these shortcuts make us "super-efficient," quickly leading us to the right answer, says cognitive psychologist Elizabeth Marsh of Duke University. But in fast-moving digital landscapes, those shortcuts are "going to get us in trouble," she says.

How the various online platforms feed us information changes the game, as well. "We are not only contending with our own cognitive crutches as humans," says Jevin West, a computational social scientist at the University of Washington in Seattle who cowrote the 2020 book *Calling Bullshit: The Art of Skepticism in a Data-Driven World*. "We're also contending with a platform, and with algorithms and bots that know how to pierce into our cognitive frailties." The goal, he says, is "to glue our eyeballs to those platforms."

Here, scientists who study misinformation pull back the curtain on some false social media posts to show how bad information can creep into our minds.

Sharing what's new

People take special notice of fresh information. "Novelty has an advantage in the information economy in terms of spreading farther, faster, deeper," says information scientist Sinan Aral of MIT and author of the 2020 book *The Hype Machine: How Social Media Disrupts Our Elections, Our Economy, and Our Health — And How We Must Adapt*. Fresh intel can inform our beliefs, behaviors and predictions in powerful ways. In a study of Twitter behavior that spanned 10 years, Aral and his colleagues found more signs of surprise — an indicator that information was new — in people's responses to false news stories than to true ones.

Sharing new tidbits can also provide a status boost, as any internet influencer knows. "We gain in status when we share novel information," Aral says. "It makes us look like we're in the know."

New information becomes even more alluring in times of uncertainty, West says. That played out early in the COVID-19 pandemic, when researchers and physicians were scrambling to find life-saving treatments. Unproven methods — vitamins, garlic and hydroxychloroquine, among others — got lots of attention. "There were not a lot of answers on how to treat COVID early in the pandemic," he says.

Editor's note: The yellow highlighted text on these two pages show false statements found on social media or in the news. These examples, all misleading and untrue, show how misinformation can trick us.

MISINFORMATION

"...found out COVID19 can be cured by the mixture of salivary water extracted from plantain stem, pawpaw tree, scent leaf and Garlic."

This tweet provides unequivocal, confident certainty with "cure" and it appeals to people's beliefs [in natural remedies] with "pawpaw tree" and "garlic." The author understands well these tricks. The consumer will want to believe this, and ... be in the know by seeing it before their friends receive it as a share.
— Jevin West, University of Washington

Supports prior beliefs

Accepting information that's consistent with what we already know to be true can feel like a safe bet. We tend to give that sort of message less scrutiny. "It's more comfortable to find pieces of information that fit our narrative," West says. "And when we are confronted with information that breaks that narrative, that's incredibly uncomfortable."

But this reliance on our stored knowledge can lead us astray. People are wrong about a lot of facts, easily confuse facts and opinions and claim to know facts that are impossible, as Marsh and her colleague Nadia Brashier of Harvard University wrote in 2020 in *Annual Review of Psychology*. And with so much information streaming in, it's easy to find the material that fits with what you think you know. "To the extent that I want to believe X, I can go out there and find evidence for X," Marsh says. "If I were an anti-vaxxer, it wouldn't matter how many times you told me that vaccines are good, because it would be against my world identity," she says.

Baseball legend and civil rights advocate Hank Aaron died on January 22 at age 86. Some people soon noted that he'd received a COVID-19 vaccine 17 days earlier. Anti-vaccine groups used his death to blame vaccines, with no evidence that the vaccine was involved. "It's so opportunistic," says global health researcher Tim Mackey of the University of California, San Diego.

MISINFORMATION

"How long would HANK AARON have lived had he not been lied to about the safety of the experimental COVID19 Vaccine? What a tragedy. RIP Hank. You are truly a hero and a legend."

This one is very emotive. Most everyone knows Hank Aaron. [The post is] playing on [a] reaction of shock over his death (novel info) and then introducing misinformation that leads people to believe he died from the COVID-19 vaccine. The use of the [CBS Sports] link is compelling as it's from a trusted news source, even though the link says nothing about Aaron dying from the vaccine. It almost makes him an unknowing martyr for the anti-vax movement. Aaron said he wanted to encourage vaccine uptake among African American people. His untimely death is instead used strategically to target this population. ***— Tim Mackey, UC San Diego***

Tugs on emotions

Playing on emotions is the "dirtiest, easiest trick," West says.

Outrage, fear and disgust can capture a reader's attention. That's what turned up in Aral's analyses of over 126,000 instances of rumors spreading through tweets, reported in 2018 in *Science*. False rumors were more likely to inspire disgust than true information, the researchers found.

"False news is shocking, surprising, blood-boiling, anger-inducing," Aral says. "That shock and awe combines with novelty to really get false news spreading at a much faster rate than true news." The presence of emotional language increases the spread of social media messages by about 20 percent for each emotion-triggering word, researchers at New York University reported in *Proceedings of the National Academy of Sciences* in 2017.

Along with message content, readers' emotions matter, too. People who rely on emotions to assess a news story are more likely to be duped by fake news, misinformation scientist Cameron Martel of MIT and colleagues reported in 2020 in *Cognitive Research: Principles and Implications*.

MISINFORMATION

"U.N. health experts admit toxic vaccine ingredients are harming children worldwide."

[In studies], this headline was particularly evocative of both anger and anxiety, even relative to other false news headlines. I would guess that this has to do with the fact that the headline is tapping into both a common myth about (false) vaccine dangers, and focuses on potential harm to a vulnerable population (children).
— Cameron Martel, MIT

On repeat

Even the most outlandish idea begins to sound less wild the 10th time we hear it. That's been the case since long before the internet existed. In a 1945 study, people were more inclined to believe rumors about wartime rationing that they had heard before rather than unfamiliar ones.

Many recent studies have found similar effects for repetition, a phenomenon sometimes called the "illusory truth effect." Even when people know a statement is false, hearing it again and again gives it more weight, Marsh says. "Keep it simple. Say it over and over."

There's lots of repetition to be found on Twitter, where hashtags can draw many people into a conversation, Mackey says. On July 27, 2020, then-President Donald Trump tweeted a link to a video of a doctor making false claims that hydroxychloroquine can cure COVID-19. Similar tweets exploded soon after, jumping from an average of about 29,000 daily tweets to over a million just a day later, Mackey and his colleagues reported in the *Lancet Digital Health* in February. "It just takes one piece of misinformation for people to run with," Mackey says. ■

Explore more

- Nadia Brashier and Elizabeth Marsh. "Judging Truth." *Annual Review of Psychology*. January 2020.

MISINFORMATION

I will never trust a government on 'health mandates' who denies access to safe, decades-old drugs like #Hydroxychloroquine and #Ivermectin but coerces rushed vaccinations with legal immunity. It is nonsensical, unscientific behaviour from panicked politicians.

You have to ask yourself why frontline doctors who try to bring awareness for or try to use such medicines as #ivermectin & #hydroxychloroquine are being censored. If it saves lives under medical supervision it should be used. #savinglives #stopgroupthink

"If we had used it… would we have saved more lives?"
"Yes… without a doubt"
All you need to know about the handling of the #covid19 #pandemic in 21s. #ivermectin #HydroxyChloroquine

"I demand that Bill Gates and Dr. Fauci submit to urine tests to determine if they have received #Hydroxychloroquine treatment as a prophylactic against Covid-19. Retweet if you agree."

[The tweet about Gates and Fauci] was a pretty common theme. Repetition for this one is all about building an online campaign. Essentially propagation serves two roles: (1) getting [the fake message] out there that people who are against use of hydroxychloroquine are involved in a conspiracy to keep the treatment out of people's hands; and (2) a campaign [to] force these public figures to actually get tested. ***— Tim Mackey, UC San Diego***

A rally of the Anti-vaccination League of Canada filled the streets near City Hall in Toronto in 1919.

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VACCINE HESITANCY THROUGH THE AGES

Disease prevention with vaccines has had detractors since its earliest days

By Tara Haelle

As vaccines to protect people from COVID-19 started becoming available in late 2020, the rhetoric of anti-vaccine groups intensified. Efforts to keep vaccines out of arms reinforce misinformation about the safety and effectiveness of the vaccines and spread disinformation — deliberately misleading people for political, ideological or other reasons.

Vaccines have been met with suspicion and hostility for as long as they have existed. Current opposition to COVID-19 vaccines is just the latest chapter in this long story. The primary driver of vaccine hesitancy throughout history has not been money, selfishness or ignorance.

"Vaccine hesitancy has less to do with misunderstanding the science and more to do with general mistrust of scientific institutions and government," says Maya Goldenberg, a philosophy expert at the University of Guelph, Ontario, who studies the phenomenon. Historically, people harmed or oppressed by such institutions are the ones most likely to resist vaccines, adds Agnes Arnold-Forster, a medical historian at the University of Bristol in England.

A range of recurring and intersecting themes have fueled hesitancy globally and historically. These include anxiety about unnatural substances in the body, vaccines as government surveillance or weapons, and personal liberty violations. Other concerns relate to parental autonomy, faith-based objections, and worries about infertility, disability or disease. For example, some people oppose vaccines that were grown in cell culture lines that began from aborted fetal cells, or they mistakenly believe vaccines contain fetal cells. One of today's false beliefs — that COVID-19 vaccines contain a microchip — represents anxiety about both vaccine ingredients and vaccines as a surveillance tool.

"The reasons people have hesitated reflect the cultural anxieties of their time and place," Goldenberg says. People worried about toxins arising during environmentalism in the 1970s and people in countries steeped in civil war have perceived vaccines as government weapons.

Historical attempts to curb vaccine hesitancy often failed because they relied on authoritarian and coercive methods. "They were very blunt, very punitive and very ineffective," Arnold-Forster says. "They had very little impact on actual vaccine intake."

The most effective remedies center on building trust and open communication, with family doctors having the greatest influence on people's decision to vaccinate. Increased use of "trusted messengers" to share accurate and reassuring vaccine information with their communities builds on this.

18th Century
Smallpox vaccine sets the stage around the globe

In a way, anti-vaccination attitudes predate vaccination itself. Public vaccination began after English physician Edward Jenner learned that milkmaids were protected from smallpox after exposure to cowpox, a related virus in cows. In 1796, Jenner scientifically legitimized the procedure of injecting people with cowpox, which he termed *variolae vaccinae*, to prevent smallpox. However, variolation — which staved off serious smallpox infections by triggering mild infection through exposure to material from an infected person — dates back to at least the 1000s in Asia, Africa and other parts of the world. In some cases people inhaled the dried scabs of smallpox lesions or rubbed or injected pus from smallpox lesions into a healthy person's scratched skin.

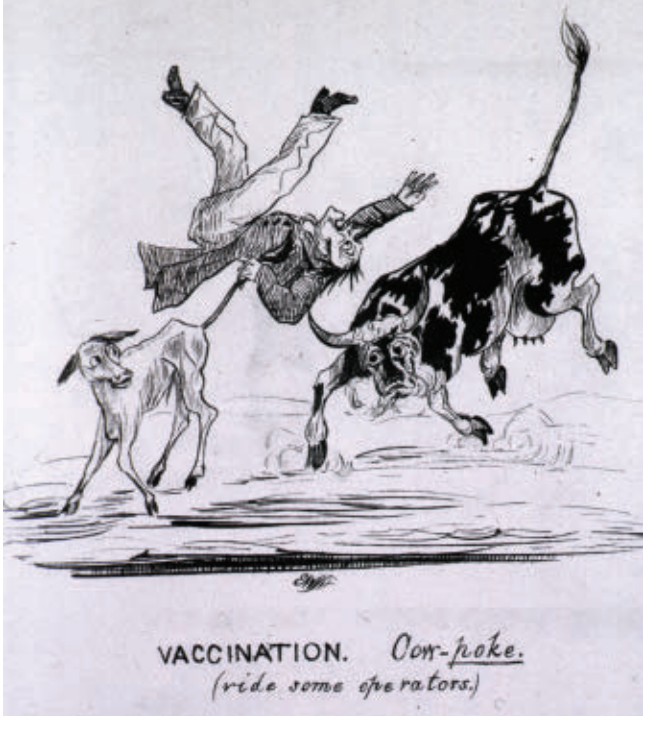
About 1 to 2 percent of people — including a son of Britain's King George III in 1783 — died from the procedure, far fewer than the up to 30 percent who died from smallpox. Benjamin Franklin rejected variolation, but later regretted it when smallpox killed his youngest son. Onesimus, an enslaved man in Boston, taught the procedure to Puritan minister Cotton Mather, who in turn urged doctors to inoculate the public during a 1721 smallpox outbreak. Many refused, and Mather faced hostility: A small bomb was thrown through his window. Reasons given for avoiding variolation — particularly that it was unnatural to interfere with a person's relationship with God — were the seeds of later anti-vaccination attitudes.

19th Century
The first vaccination laws kindle resistance

In 1809, Massachusetts passed the world's first known mandatory vaccination law, requiring the general population to receive the smallpox vaccine. Resistance began to grow as other states passed similar laws. Then the U.K. Vaccination Act of 1853 required parents to get infants vaccinated by 3 months old, or face fines or imprisonment. The law sparked violent riots and the formation of the Anti-Vaccination League of London. Vaccine resisters were often poor people suspicious of a forced medical intervention since, under normal circumstances, they rarely received any health care. Anti-vaccination groups argued that compulsory vaccination violated personal liberty, writing that the acts "trample upon the right of parents to protect their children from disease" and "invaded liberty by rendering good health a crime."

Anti-vaccination sentiment grew and spread across Europe until an 1885 demonstration of about 100,000 people in Leicester, England, prompted the British monarchy to appoint a commission to study the issue. The resulting 1896 report led to an 1898 act that removed penalties for parents who didn't believe vaccination was safe or effective. The act introduced the term "conscientious objectors," which later became more commonly associated with those who refuse military service on religious or moral grounds.

Across the Atlantic, most U.S. residents had embraced Jenner's cowpox protective, leading to a precipitous drop in smallpox outbreaks. But with fewer outbreaks, complacency set in and vaccination rates dropped. As smallpox outbreaks resurfaced in the 1870s, states began enforcing existing vaccination laws or passing new ones. British anti-vaccinationist William Tebb visited New York in 1879, which led to the founding of the Anti-Vaccination Society of America. The group's tactics will sound familiar: pamphlets, court battles and arguments in state legislatures that led to the repeal of mandatory vaccination laws in seven states. The 1905 Supreme Court decision Jacobson v. Massachusetts upheld a state's right to mandate vaccines; it remains precedent today.



This 1838 illustration seems to take a negative view of a vaccination method that used cowpox to immunize people against a similar, and deadly, human disease, smallpox.

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20th Century
A menu of vaccines draws praise and ire

1982: Documentary hypes vaccine injuries

The U.S. entered a golden age of vaccine development from the 1920s through the 1970s with the arrival of vaccines for diphtheria, pertussis, polio, measles, mumps and rubella. Opposition diminished as infection rates, particularly for polio, fell. Rosalynn Carter and Betty Bumpers, the wives of the governors of Georgia and Arkansas, respectively, began a vaccination campaign that grew into a national effort in the 1970s. The goal was to encourage every state to require children attending public school to receive most vaccines recommended by the U.S. Centers for Disease Control and Prevention.

A nationally aired 1982 news documentary called "DPT: Vaccine Roulette" changed everything. Lea Thompson, a reporter with WRC-TV in Washington, D.C., shared emotional stories of parents claiming their children had suffered seizures and brain damage from the diphtheria-pertussis-tetanus, or DPT, shot. Interviews with doctors lent the stories credence. Fever-caused seizures were a known side effect of DPT, and a 1974 study had reported neurological complications developing in 36 children within 24 hours of DPT vaccination. But the study did not follow the children long-term. Later research revealed neither the seizures nor the vaccine caused long-term brain damage.

But the damage to public trust was done. Coopting the DPT acronym, one parent, Barbara Loe Fisher, cofounded Dissatisfied Parents Together, which became the National Vaccine Information Center, the most influential anti-vaccine organization in the United States.

1998: Fraudulent study links vaccines to autism

The National Vaccine Information Center maintained a steady hum of anti-vaccination sentiment and activity through the 1980s and '90s. Then British gastroenterologist Andrew Wakefield published a report in the *Lancet* alleging that the measles-mumps-rubella, or MMR, vaccine caused autism spectrum disorder in 12 children. Wakefield falsified data, violated informed consent and secretly invested in development of a solo measles vaccine, but it took years to uncover his deceit (*SN Online: 2/3/10*). Fears about autism and vaccines had already exploded by the time the study was retracted 12 years after publication.

Almost immediately after publication of the study, U.K. vaccination rates began falling. But news of Wakefield's work didn't reach the United States until 2000, just as U.S. medical authorities were embroiled in a debate about the use of thimerosal, a mercury-containing preservative, in vaccines. In 1999, the U.S. Public Health Service recommended removing thimerosal from childhood vaccines as a precautionary measure to reduce infants' mercury exposure. Later research showed no safety concerns about its use.

The MMR vaccine never contained thimerosal, but fears about mercury-related brain damage merged with those about MMR and autism, creating a storm of anger and fear surrounding claims of vaccine harm.

Protesters at a February 2021 event in Sydney, Australia, came out against the idea of mandatory COVID-19 vaccinations, just days before vaccines became available to frontline health care workers.

BROOK MITCHELL/GETTY IMAGES

21st Century
Social media and slick documentaries

Despite the 2010 retraction of his study and the revocation of his license to practice medicine in the United Kingdom, Wakefield remains a leader in today's anti-vaccination movement. Joining him is Robert F. Kennedy, Jr., who gained prominence promoting unfounded allegations about thimerosal. Both men rode the wave of anti-vaccination networking on social media and the promotion of disinformation through slick documentaries like 2016's *Vaxxed: From Cover-Up to Catastrophe* (*SN Online: 4/1/16*).

In 2014, the United States saw its highest number of measles cases since the disease was eliminated from the country in 2000, culminating in a large outbreak that began at Disneyland that December. In response, California passed a law removing parents' ability to opt out of vaccinating their children based on personal beliefs and required that all children receive CDC-recommended vaccines to attend school (*SN Online: 7/2/19*). Extreme opposition to that law and subsequent ones helped fuel a resurgence in anti-vaccine advocacy along with an alarming measles outbreak in 2019 (*SN: 12/21/19 & 1/4/20, p. 24*).

The vast majority of people accept recommended vaccines and their role in stemming the spread of infectious diseases. Recent surveys suggest that 69 percent of U.S. adults say they have or will get a COVID-19 vaccine, an improvement over the 60 percent willing to do so in November. But responses to surveys don't necessarily predict behavior, Goldenberg says. ■

Explore more

- Talha Burki. "The online anti-vaccination movement in the age of COVID-19." The *Lancet Digital Health*. October 2020.
- "Smallpox: A great and terrible scourge." U.S. National Library of Medicine. bit.ly/NLMsmallpox

Tara Haelle is a freelance journalist based in Dallas.

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Turning the page on climate change denial

Researchers are testing ways to counter evolving disinformation tactics

By Carolyn Gramling

Over the last four decades, a highly organized, well-funded campaign powered by the fossil fuel industry has sought to discredit the science that links global climate change to human emissions of carbon dioxide and other greenhouse gases. These disinformation efforts have sown confusion over data, questioned the integrity of climate scientists and denied the scientific consensus on the role of humans.

Such disinformation efforts are outlined in internal documents from fossil fuel giants such as Shell and Exxon. As early as the 1980s, oil companies knew that burning fossil fuels was altering the climate, according to industry documents reviewed at a 2019 U.S. House of Representatives Committee on Oversight and Reform hearing. Yet these companies, aided by some scientists, set out to mislead the public, deny well-established science and forestall efforts to regulate emissions.

But the effects of climate change on extreme events such as wildfires, heat waves and hurricanes have become hard to downplay (*SN: 12/19/20 & SN: 1/2/21, p. 37*). Not coincidentally, climate disinformation tactics have shifted from outright denial to distraction and delay (*SN: 1/16/21, p. 28*).

As disinformation tactics evolve, researchers continue to test new ways to combat them. Debunking by fact-checking untrue statements is one way to combat climate disinformation. Another way, increasingly adopted by social media platforms, is to add warning labels flagging messages as possible disinformation, such as the labels Twitter and Facebook (which also owns Instagram) began adding in 2020 regarding the U.S. presidential election and the COVID-19 pandemic.

At the same time, Facebook was sharply criticized for a change to its fact-checking policies that critics say enables the spread of climate disinformation. In 2019, the social media giant decided to exempt posts that it determines to be opinion or satire from fact-checking, creating a potentially large disinformation loophole.

In response to mounting criticism, Facebook unveiled a pilot project in February for its users in the United Kingdom, with labels pointing out myths about climate change. The labels also point users to Facebook's climate science information center.

For this project, Facebook consulted several climate communication experts. Sander van der Linden, a social psychologist at the University of Cambridge, and cognitive scientist John Cook of George Mason University in Fairfax, Va., helped the company develop a new "myth-busting" unit that debunks common climate change myths — such as that scientists don't agree that global warming is happening.

Researchers John Cook and Sander van der Linden hope to inoculate people against climate change denial messages.

Cook and van der Linden have also been testing ways to get out in front of disinformation, an approach known as prebunking, or inoculation theory. By helping people recognize common rhetorical techniques used to spread climate disinformation — such as logical fallacies, relying on fake "experts" and cherry-picking only the data that support one view — the two hope to build resilience against these tactics.

This new line of defense may come with a bonus, van der Linden says. Training people in these techniques could build a more general resilience to disinformation, whether related to climate, vaccines or COVID-19.

Science News asked Cook and van der Linden about debunking conspiracies, collaborating with Facebook and how prebunking is (and isn't) like getting vaccinated. The conversations, held separately, have been edited for brevity and clarity.

We've seen both misinformation and disinformation used in the climate change denial discussion. What's the difference?

van der Linden: Misinformation is any information that's incorrect, whether due to error or fake news. Disinformation is deliberately intended to deceive. Then there's propaganda: disinformation with a political agenda. But in practice, it's difficult to disentangle them. Often, people use misinformation because it's the broadest category.

FROM LEFT: COURTESY OF J. COOK; DANIELLE DA SILVA PHOTOGRAPHY, COURTESY OF S. VAN DER LINDEN

Has there been a change in the nature of climate change denialism in the last few decades?

Cook: It is shifting. For example, we fed 21 years of [climate change] denial blog posts from the U.K. into a machine learning program. We found that the science denialism misinformation is gradually going down — and solution misinformation [targeting climate policy and renewable energy] is on the rise [as reported online in early March at SocArXiv.org].

As the science becomes more apparent, it becomes more untenable to attack it. We see spikes in policy misinformation just before the government brings in new science policy, such as a carbon pricing bill. And there was a huge spike before the [2015] Paris climate agreement. That's what we will see more of over time.

How do you hope Facebook's new climate change misinformation project will help?

Cook: We need tech solutions, like flagging and tagging misinformation, as well as social media platforms downplaying it, so [the misinformation] doesn't get put on as many people's feeds. We can't depend on social media. A look behind the curtain at Facebook showed me the challenge of getting corporations to adequately respond. There are a lot of internal tensions.

van der Linden: I've worked with WhatsApp and Google, and it's always the same story. They want to do the right thing, but don't follow through because it hurts engagement on the platform.

But going from not taking a stance on climate change to taking a stance, that's a huge win. What Facebook has done is a step forward. They listened to our designs and suggestions and comments on their [pilot] test.

We wanted more than a neutral [label directing people to Facebook's information page on climate change], but they wanted to test the neutral post first. That's all good. It'll be a few months at least for the testing in the U.K. phase to roll out, but we don't yet know how many other countries they will roll it out to and when. We all came on board with the idea that they're going to do more, and more aggressively. I'll be pleasantly surprised if it rolls out globally. That's my criteria for success.

Scientists have been countering climate change misinformation for years, through fact-checking and debunking. It's a bit like whack-a-mole. You advocate for "inoculating" people against the techniques that help misinformation spread through communities. How can that help?

van der Linden: Fact-checking and debunking is useful if you do it right. But there's the issue of ideology, of resistance to fact-checking when it's not in line with ideology. Wouldn't life be so much easier if we could prevent [disinformation] in the first place? That's the whole point of prebunking or inoculation. It's a multilayer defense system. If you can get there first, that's great. But that won't always be possible, so you still have real-time fact-checking. This multilayer firewall is going to be the most useful thing.

You've both developed online interactive tools, games really, to test the idea of inoculating people against disinformation tactics. Sander, you created an online interactive game called *Bad News*, in which players can invent conspiracies and act as fake news producers. A study of 15,000 participants reported in 2019 in *Palgrave Communications* showed that by playing at creating misinformation, people got better at recognizing it. But how long does this "inoculation" last?

van der Linden: That's an important difference in the viral analogy. Biological vaccines give more or less lifelong immunity, at least for some kinds of viruses. That's not the case for a psychological vaccine. It wears off over time.

In one study, we followed up with people [repeatedly] for about three months, during which time they didn't replay the game. We found no decay of the inoculation effect, which was quite surprising. The inoculation remained stable for about two months. In [a shorter study focused on] climate change misinformation, the inoculation effect also remained stable, for at least one week.

John, what about your game *Cranky Uncle*? At first, it focused on climate change denial, but you've expanded it to include other types of misinformation, on topics such as COVID-19, flat-earthism and vaccine misinformation. How well do techniques to inoculate against climate change denialism translate to other types of misinformation?

Cook: The techniques used in climate denial are seen in all forms of misinformation. Working on deconstructing [that] misinformation introduced me to parallel argumentation, which is basically using analogies to combat flawed logic. That's what late night comedians do: Make what is obviously a ridiculous argument. The other night, for example, Seth Meyers talked about how Texas blaming its [February] power outage on renewable energy was like New Jersey blaming its problems on Boston [clam chowder].

My main tip is to arm yourself with awareness of misleading techniques. Think of it like a virus spreading: You don't want to be a superspreader. Make sure that you're wearing a mask, for starters. And when you see misinformation, call it out. That observational correction — it matters. It makes a difference. ■

Explore more

- Stephan Lewandowsky and John Cook. The Conspiracy Theory Handbook. March 2020. bit.ly/CThandbook.
- T.G. Coan et al. "Computer-assisted detection and classification of misinformation about climate change." SocArXiv.org. March 9, 2021.

Viral BS
Seema Yasmin
JOHNS HOPKINS UNIV., $24.95

BOOKSHELF

A new book offers a cure for common medical myths

How does misinformation spread? What causes medical myths and pseudoscience to rapidly infect and fester in society? Seema Yasmin, an epidemiologist and author of a new book, *Viral BS*, has a diagnosis: the pervasive, persuasive power of storytelling. And, as Yasmin notes, "The more fantastical, the better."

Take the anecdote that opens the book: A woman in Texas demands an Ebola vaccine for her daughter as a deadly outbreak rages a continent away in Africa in 2014. When the pediatrician tells her there is no Ebola vaccine and that her daughter faces a much greater risk from the flu, for which he can give her a vaccine, the mother storms out: "Flu vaccine?! I don't believe in those things!"

Stories — like those this Texas woman may have heard, or maybe told herself — help us find order in a world bursting with uncertainty. But when these stories don't reflect reality, a public malady of tenacious and preposterous medical myths can take hold, Yasmin explains. Her book sets out to treat this malady with a dose of the virus itself: Storytelling and anecdotes that move beyond dry facts and figures to reveal pseudoscience's sticking power.

Storytelling and anecdotes that move beyond dry facts and figures can reveal pseudoscience's sticking power.

Yasmin sets up her credentials in the book's opener — physician, director of the Stanford Health Communication Initiative, former epidemiologist at the U.S. Centers for Disease Control and Prevention — to build trust among readers. But, true to form, it's her anecdotes of pseudoscience in her own upbringing that linger. Her India-born grandmother told her that the moon landing was a fake; as a child Yasmin would pray to the "unwalked upon moon" for clarity and vision. Yasmin and her cousins once secretly listened to Michael Jackson songs for signs of Satan worship — which an older cousin claimed were there. "Raised on conspiracy theories," she writes, "I understand why a patient might refuse medications, say chemtrails are poison, or shun vaccines, even as I bristle at the public health implications of these beliefs and behaviors."

Each chapter answers a question in a few pages of no-nonsense basics. The book tackles a slew of questions that have spread from the internet to dinner tables in recent years. These include: Is there lead in your lipstick? Do vaccines cause autism? Has the U.S. government banned research about gun violence (*SN: 5/14/16, p. 16*)? She analyzes the pseudoscientific answers that become hard to shake and reviews related research that presents the truth. The antidote is easy to swallow, thanks to Yasmin's approach.

For instance: Should you eat your baby's placenta? In chapter 2's breezy three pages, Yasmin points to celebrities such as Kim Kardashian who say eating their placentas helped them with postpartum recovery. Then Yasmin quickly moves to studies that have found no medical benefits. In fact, studies point to potential harm from the practice, since the organ can carry feces, inflammatory cells and bacteria (*SN Online: 7/28/17*).

She pulls no punches, referring to doctors who claim to be able to cure autism as "charlatans" who offer expensive, unproven and sometimes dangerous practices. Children have died, Yasmin writes, after being given Miracle Mineral Solution as an autism cure. The solution is actually industrial bleach. She rejects the overenthusiastic prescribing of vitamin D supplements for everything from obesity to cancer (*SN: 2/2/19, p. 16*), showing that the evidence of a benefit isn't there, at least not yet.

Some of the issues she addresses seem ludicrous on first glance, like "Can a pill make racists less racist?" Actress Roseanne Barr claimed that the drug Ambien made her post a racist tweet in 2018. Yasmin looks at the opposite notion, sparked by a 2012 study that linked heart disease medications to a reduction in racial bias. She explains how the drugs affect the body and how researchers tested for racial bias. Then she shifts to the dangers of trying to medicalize racism, which is not a medical phenomenon.

The book ends with a tear-out "bullshit detection kit," a list of 12 useful tips to keep in mind when weighing the credibility of a headline, research study or tweet. Questions to consider include: Who is funding the person or organization making the claim? Has a claim been verified by those not affiliated with the source? She explains how to run a reverse online search on an image to determine whether it was doctored and to learn its original source. This list will be particularly relevant to those navigating through all the misinformation swirling around COVID-19.

Readers will come away from this book with a deeper understanding of what research studies can and cannot say, and the effects that storytelling and celebrity have on whether someone internalizes a health claim. Some readers might prefer more background science for each question — for a book that aims to crush pseudoscience, a bibliography or at least footnotes would have been useful.

But perhaps this omission is part of Yasmin's broader point. For casual readers, references and statistics miss the mark. Instead, anecdotes in easy-to-swallow doses may be just the right amount of information and storytelling needed to stop the spread of viral BS. — *Cori Vanchieri*

CONVERSATIONS WITH MAYA

ROALD HOFFMANN
Frank H.T. Rhodes Professor of Humane Letters Emeritus, Cornell University

Maya Ajmera, President & CEO of the Society for Science and Publisher of *Science News*, chatted with Nobel Laureate Roald Hoffmann, an alumnus of the 1955 Science Talent Search, a program of the Society for Science. Hoffmann is the Frank H.T. Rhodes Professor of Humane Letters Emeritus at Cornell University. He is also an accomplished poet and playwright. We are thrilled to share an edited summary of their conversation.

Dr. Hoffmann, you have a very powerful story. Would you be willing to tell us a little bit about your childhood?

My life was divided by a marker, which was coming to America. The first 11 years of my life were spent both in surviving and then being a refugee.

The surviving was a geopolitical consequence of having been born in 1937 in southeast Poland, in a Jewish family just before World War II. The place where I was born was Austria-Hungary when my mother was born, then Poland when I was born, then it was conquered by the Nazis, and then became part of the Soviet Union. Today, it is part of independent Ukraine. Two and a half waves of ethnic cleansing along the way.

Over the years, this was not a very happy part of the world. Only about 200 Jews out of 4,000 in this town survived the war. Among them was my mother and I, but not my father and not my grandparents. The dimensions of the loss are typical of what happened to Jews in that part of the world. It took us five more years to come to America, with the same discriminatory quotas and immigration laws at play as those causing a barrier to immigrants today.

We had the hardest time to come to rejoin an aunt in America. We got here, eventually, as immigrants, and I'm not sure we came entirely legally." Once we got here, the second chapter of my life opened up. I went to public schools in New York City and studied in a wonderful science-oriented school, Stuyvesant High School, which to this day supplies many of your finalists in the Science Talent Search. Everything opened up in the world.

As a child living in Europe during the Holocaust, you have a pretty extraordinary story. I don't know if you'd be willing to share about that time. I believe you and your mother were hiding for a while.

Yes, it lasted 15 months. We were in an attic and then in a storeroom. Five of us, my mother and I among them. We were hidden by a courageous and good Ukrainian schoolteacher and his wife who had three small children. They did this at great risk to their life. I was a quiet child, but it was not an easy time. There were sometimes German soldiers and Ukrainian policemen in the house. It's a great credit to my mother, all the games she invented for me.

Do you remember a game she invented that still sticks out for you?

Yes. This was a schoolhouse with atlases stored in the attic. My mother taught me latitude and longitude, which you usually don't teach to 5- or 6-year-olds. To probe what I had learned, she then asked me to describe what latitude and longitude I would need to pass in order to travel from Poland to San Francisco, for example. She would give me hard tasks, asking me to go around the Strait of Magellan instead of through the Suez Canal.

Let's talk about being at Stuyvesant. What was that experience like for you? What was it like doing science research as a high school student and participating in the Science Talent Search?

Stuyvesant High School had always encouraged research

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experiences for its students, and there were absolutely great teachers in every subject. The only subject I didn't take advanced placement in was chemistry, which eventually became my profession! I found a professor at NYU who was doing experiments at Brookhaven National Laboratory on tracks left in a bubble chamber, which was a new device for measuring the outcome of nuclear reactions.

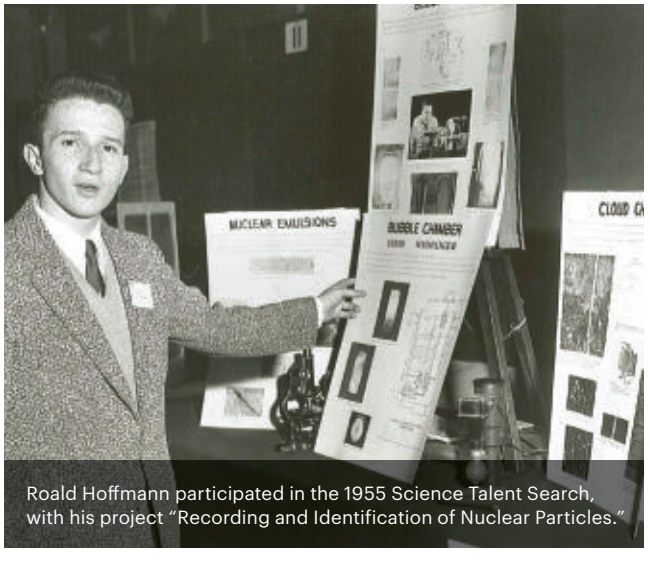
The project was an interesting experience, but it did not pull me into physics. It was quite wonderful, however, because it led to me being selected for the Westinghouse Science Talent Search, which included a trip to Washington where I had the opportunity to meet President Eisenhower.

Meeting President Eisenhower, five years after coming to America, had special meaning for me because he was the leader of the armies who had liberated Europe. It was from the Talent Search, eventually, that I got a summer job between high school and college at the National Bureau of Standards. That summer job led to a second summer there—these served as an introduction to real science.

Meanwhile, the world opened up in the arts and the humanities, thanks to a wonderful core curriculum in the liberal arts at Columbia. I'm a strong believer in the liberal arts education. One way to summarize my college career was that I worked up enough courage in college at Columbia to tell my parents I didn't want to become a doctor, but not enough to tell them I wanted to be an art historian.

What is it about chemistry that has inspired you and continues to inspire you?

I didn't decide on chemistry right away. In fact, I didn't make a commitment to chemistry until three-quarters of the way through my Ph.D. in chemistry. I took a year off after two years in graduate school to go to the Soviet Union. This was 1960, the Khrushchev period. Taking a junior year abroad while in graduate school was not done—Harvard thought I was crazy. My mother thought I would be drafted into the Soviet army.



Roald Hoffmann participated in the 1955 Science Talent Search, with his project "Recording and Identification of Nuclear Particles."

Now, you ask why chemistry. Somehow chemistry, in the end, was the right field for me. Chemistry is not based on certain knowledge. Sometimes our students complain that they have to memorize some things and then they're also asked to explain some other things, like the mechanism of an organic reaction.

That mixture of part logic and part facts that you are required to know, which you then have to connect with each other, is at the heart of chemistry. One comes to peace with partial knowledge. I love that—somehow it was in resonance with my psychology.

That kind of partial certainty, of having to deal with fuzzy logic, bothers some people. I tell them, if you want certainty, try mathematics. Studying molecules is different, much like dealing with people.

In addition to being a chemist, you publish essays, poetry and plays. Tell us about that—the process of being a poet.

Everything began in college for me. The interest in poetry came from a course with Mark Van Doren, a poet who wasn't allowed to teach how to write poetry. There were no writing courses in those days. If you wanted to learn how to write, you went to night school at Columbia.

I remember going across the street to Barnard College and seeing a production of Federico García Lorca's *Blood Wedding*. Somehow it touched me, wondering how an individual could come to feel that intensely. In time, I tried to write both poetry and plays. Maybe gaining confidence from doing chemistry gave me confidence to try these things.

I'm very glad I did write in time, for it put me in contact with the world of poets and playwrights. I could show you my logbook for submitting poems. Every poem of mine that has been eventually accepted in a magazine has been rejected 10 to 15 times before. Living in that world gives me a better feeling for what people who want to touch us spiritually have to deal with.

How does your childhood experience of surviving the Holocaust influence your view of humanity and the debates that are going on around social justice in the United States and around the world?

I tend to see good motives in the way people act. Perhaps that is not what people expect of someone who survived the Holocaust. The act of survival is sufficient. It is an affirmation of the human spirit that you can survive under extremely difficult conditions. There were a few people willing to risk their lives to help you, like that Ukrainian family I mentioned. That is a great affirmation of the positive nature of human beings. It takes just a few.

Here we are hiding from a virus. Seventy-six years ago, we were hiding from the Nazis. It's hard to find reasons for affirmation of the human spirit. But they were there, and I strongly believe that they are here. We will overcome.

REAL-WORLD RESEARCH

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Out of sight

A rare bird sighting doesn't lead to sightings of other rare bird species (painted bunting shown below), **Anushree Dave** reported in "Scientists debunk a popular birding claim" (*SN: 3/27/21, p. 4*). Reader and punster **Patrick J. O'Connor** wrote: "Birds of a rarity don't gather for parity."

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Cosmic crash

The Milky Way and Andromeda galaxies will merge in about 10 billion years, and the supermassive black holes at their centers will collide less than 17 million years later, ***Sid Perkins*** *reported in "Crash will follow 'Milkomeda' debut"* (SN: 3/27/21, p. 9). **Perkins** wrote that any civilization within about 3.25 million light-years of Earth that has gravitational wave–sensing technology similar to ours would be able to detect the collision. Some readers questioned why the crash would be detectable only to 3.25 million light-years when the gravitational wave observatories LIGO and Virgo can detect black hole mergers billions of light-years away (*SN: 1/30/21, p. 30*).

The reason has to do with the mass of the black holes, the story's editor **Chris Crockett** says. The black hole mergers discovered to date involved relatively lightweight black holes, and the smashups emitted gravitational waves that have frequencies within LIGO and Virgo's detection range of 10 to 10,000 hertz. But when supermassive black holes collide, they emit gravitational waves at much lower frequencies.

To observe such a crash today, researchers need pulsar timing arrays. This technology can detect low-frequency gravitational waves using variations in the steady radio blips of highly magnetized stars called pulsars. Pulsar timing arrays have yet to detect a supermassive black hole collision, but they are currently listening for the "background hum" of such events throughout the universe. The arrays could single out a smashup like the Andromeda–Milky Way out to about 3.25 million light-years away, **Crockett** says.

Bug off

Catnip wards off mosquitoes by triggering a chemical receptor that, in other animals, senses pain or itch, ***Erin Garcia de Jesús*** *reported in "How catnip repels pesky mosquitoes"* (SN: 3/27/21, p. 9). Reader **Rick Gillespie** wondered if catnip's active component, nepetalactone, also deters other insects such as fleas.

It would depend on the version of the receptor those species have, **Garcia de Jesús** says. TRPA1, the receptor that catnip triggers in mosquitoes, is common in many animals and typically responds to irritants such as cold, heat, wasabi and tear gas. But catnip doesn't spark the same reaction in all insects. "Some aphids, for instance, use nepetalactone as a pheromone, and green lacewings are attracted to it," she says. More studies are needed to learn how catnip affects other insects.

Leave it to beaver

Building simple structures made of sticks and stones in streams can entice beavers to build their own dams and keep water where it's needed to fight drought and wildfires, ***Brianna Randall*** *reported in "Reviving riverscapes"* (SN: 3/27/21, p. 22). Such beaver restoration tactics would not be as effective in streams that flow intermittently, **Randall** reported. Reader **Pam Nelson** asked why.

"Intermittent streams usually don't support beavers, since the rodents need ponded habitat year-round to survive, both for food sources and escape from predators," **Randall** says.

Beaver dam analogs could potentially work in such settings, but the stick structures usually work best when beavers are around to build on, repair and rearrange them as part of the natural process in healthy streams, she says.

ARTHUR MORRIS/CORBIS DOCUMENTARY/GETTY IMAGES

A Pacific pomfret (*Brama orcini*) was caught riding a jellyfish (shown above from three angles; at left is a preserved specimen). Some larval fishes take shelter in the tentacles of jellies, but hitching a ride is an odd twist on that behavior.

A preserved larval tripod fish (*Bathymicrops* sp.) is plain and pale (bottom). But while alive, larvae (top) sport flamboyant spiky fins and blue-hued bodies flecked with white and orange polka dots that may provide a flickering form of camouflage on the go.

Baby fish ready for their close-ups

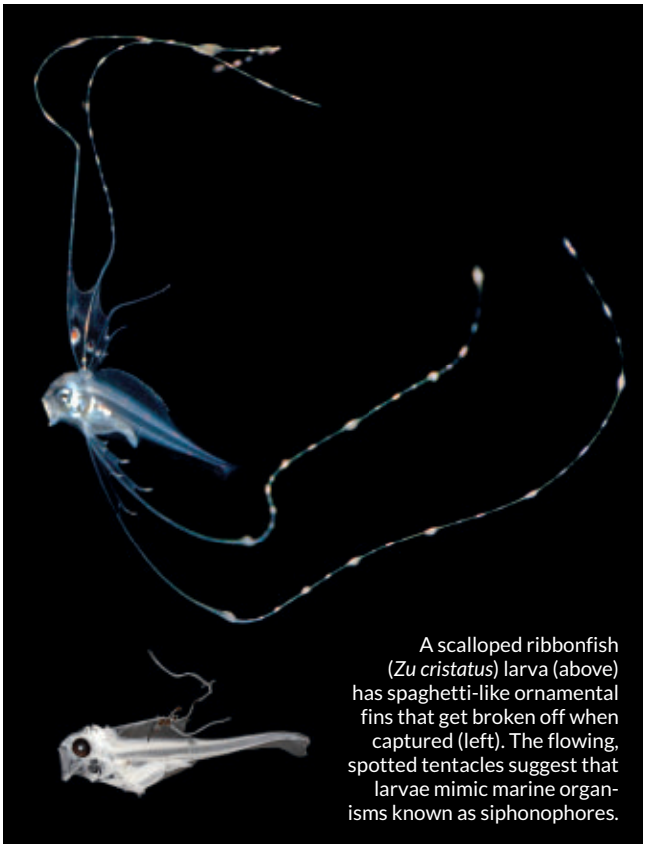
Newborn fishes are hard to study because they are tiny, semitransparent and get mashed when netted by research vessels. Now, a partnership between scientists and divers is letting researchers in on the secret lives of some fish larvae.

Underwater photos taken near Hawaii at night — when larvae rise toward the ocean surface — reveal colors, body structures and behaviors that can't be seen in preserved specimens. With lights in hand, divers snapped up-close photos of 26 larval fishes (three shown), then gingerly captured and shipped them and 50 others to scientists to be studied alongside their mug shots. DNA analyses let ichthyologists match the photos to known species, researchers report in the March issue of *Ichthyology & Herpetology*.

"Larvae that looked utterly drab as specimens have ... brilliantly colored markings and fantastic structures," says Ai Nonaka, a larval fish expert at the Smithsonian National Museum of Natural History in Washington, D.C.

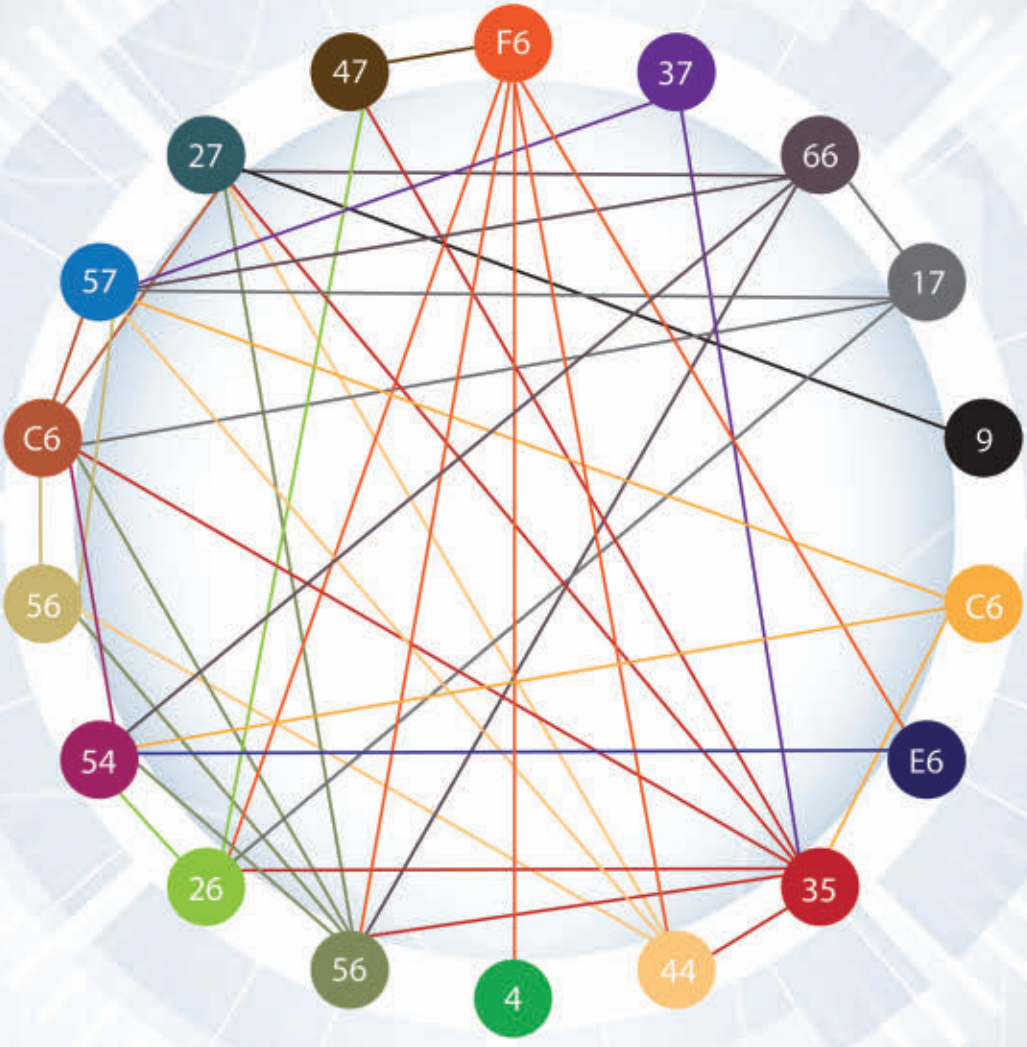
Larval fishes don't travel well. En route to the lab, they lose fins and other structures that evoke their behavior. And ethanol preservation to repel bacteria and fungi leaches out colors. But getting a complete picture of larvae is crucial to conservation planning.

"The chance to see these larvae in their environment was a wonderful advance in our scientific endeavors," says retired fisheries biologist Geoff Moser. — *Devin A. Reese*



A scalloped ribbonfish (*Zu cristatus*) larva (above) has spaghetti-like ornamental fins that get broken off when captured (left). The flowing, spotted tentacles suggest that larvae mimic marine organisms known as siphonophores.

PHOTOS OF LIVE FISHES: JEFF MILISEN; SPECIMENS: A. NONAKA/SMITHSONIAN NMNH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37
27
66
57
17
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9
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54
E6
26
35
56
4
44


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