

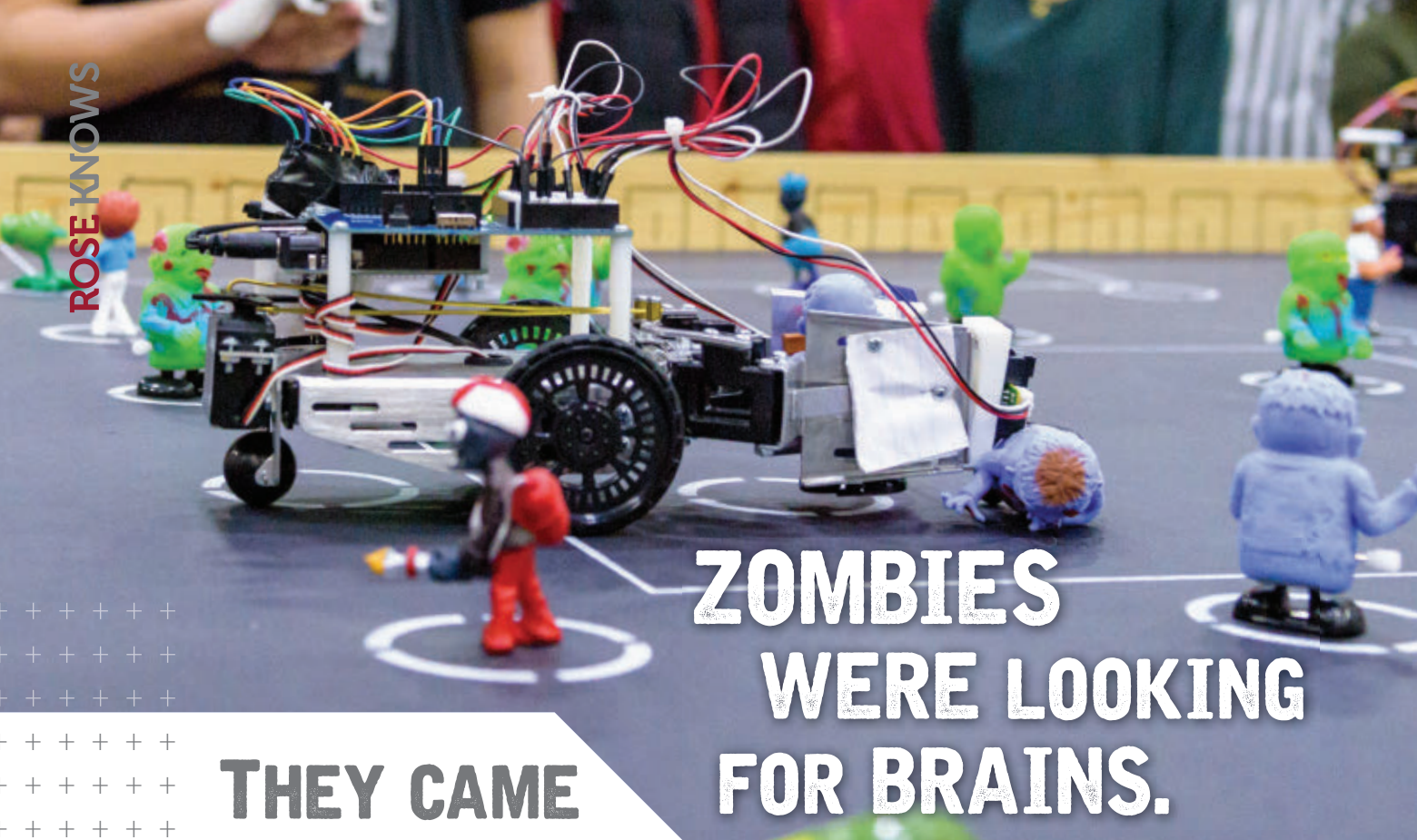
Invisibility Cloak Hides Objects in Water | New Drug for Resistant TB

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ SEPTEMBER 14, 2019

COSMIC UNCERTAINTY

Measurements of how fast the universe is expanding don't match up



ZOMBIES WERE LOOKING FOR BRAINS.

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THEY CAME TO THE RIGHT PLACE...AND THE WRONG ONE.

Okay, the undead weren't really at Rose, but it sure was fun building Arduino-controlled robots to stem the imaginary invasion. Dozens of first-year students compete in the robotics challenge every quarter. It's cool how just having fun helps you really start to understand what you're learning in class.

We're Rose. It's what we do. Sound like you?



Watch the robots stop the apocalypse.
rose-hulman.edu/zombies

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Rose Challenge

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A truck has a 15-gallon fuel tank, gets 30 miles per gallon, and takes a trip at 45 miles per hour. The fuel tank leaks gas at a constant rate. It starts a trip with a full tank and runs out of gas after 270 miles. Find the leak rate.

Visit rose-hulman.edu/RoseChallenge to submit your solution. If your solution is correct, you'll be entered for a chance to win a Rose-Hulman swag item!

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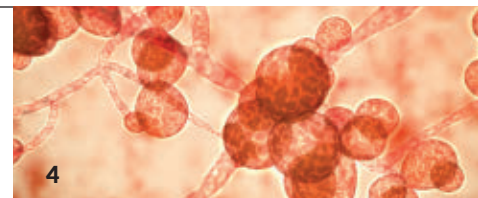
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Take a look at us now!

When *Science News* first went online in 1996, about one-fifth of Americans had access to the internet, and those who did spent very little time there. Dial-up modems were painfully slow. AOL was the largest internet service provider, and Amazon was a start-up online bookseller.

In those early days, journalists quickly realized how great the World Wide Web could be for researching subjects, connecting with sources and publishing. Julie Ann Miller, editor of *Science News* at the time, wrote in the magazine that it was too early to know if the Web would supplant newspapers and television (*SN: 12/21/96 & 12/28/96, p. 402*). But, she noted, “we are already benefiting from its ability to reduce the obstacles of distance and time to help us carry the news of science to an ever-widening audience.”

Are we ever. Today most people read *Science News* on their phones, and “reading” includes watching videos and engaging with interactive graphics that we could barely dream of offering 23 years ago. Digital publishing promises to keep evolving at an astonishing pace. To ensure that our online audiences have the best possible experience, we’ve rebuilt the *Science News* website to make it faster and easier to navigate, including browsing almost 100 years of science in our archives. And it’s beautiful. We’ve also upgraded our site for *Science News* in High Schools, which connects our journalism to teachers and students at almost 5,000 high schools. And the rebuild of our *Science News for Students* site, for readers ages 9 and up, is well under way. Take a look, and let us know what you think at feedback@sciencenews.org.

The new *Science News* site is built on WordPress, an open-source publishing platform that will make it easier for us to evolve with technology. I am grateful to our publisher Maya Ajmera and many others at our parent nonprofit Society for Science & the Public for supporting this effort, and to our digital team led by Kate Travis and our partners at Alley Interactive for making it happen.

Of course, one thing isn’t changing — our commitment to bringing you top-quality reporting on the latest in science, medicine and technology. However you connect with us, we aim to continue to make that experience more illuminating, thought-provoking and delightful. — *Nancy Shute, Editor in Chief*

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SOCIAL SCIENCES Sujata Gupta
STAFF WRITER Maria Temming
EDITORIAL ASSISTANT Kyle Plantz
SCIENCE WRITER/INTERN Carolyn Wilke
CONTRIBUTING CORRESPONDENTS
Laura Beil, Tom Siegfried, Alexandra Witz

DESIGN

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DESIGN DIRECTOR Erin Otwell
ASSISTANT ART DIRECTORS Chang Won Chang, Tracee Tibbitts

SCIENCE NEWS FOR STUDENTS

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WEB PRODUCER Lillian Steenblik Hwang

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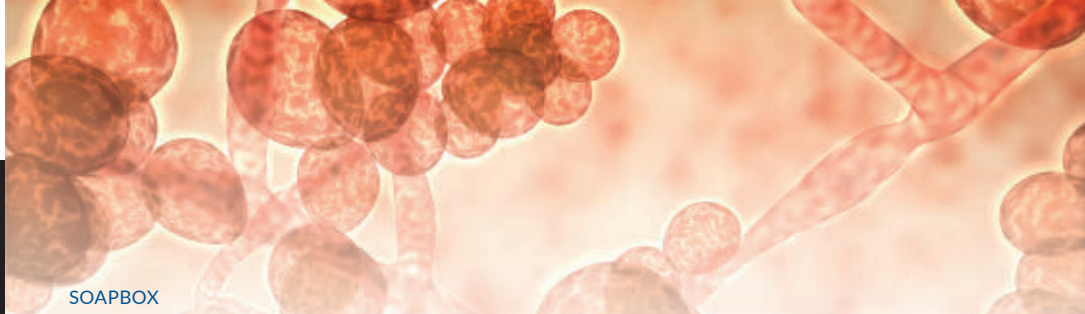
Excerpt from the September 13, 1969 issue of *Science News*

50 YEARS AGO

Polio could come back

Only eight cases of paralytic polio have been reported in the entire United States so far in 1969. But ... if infants and young children are not vaccinated as they come along, pockets of the disease could get larger.

UPDATE: The United States saw its last naturally occurring polio case in 1979. Though the paralyzing disease is now close to being eradicated worldwide, it still circulates in Afghanistan and Pakistan, where 66 new cases were recorded this year as of August 22. Meanwhile, dozens of new cases, mainly in Africa, were caused by vaccine strains that reverted to disease-causing versions. Newer vaccine versions yet to be deployed have a lower risk of causing disease, researchers reported in July in the *Lancet*. Vaccination campaigns are still needed everywhere, or the disease “will come roaring back,” says Oliver Rosenbauer, spokesman for the Global Polio Eradication Initiative. A resurgence could cause “as many as 200,000 new cases” globally a year.



SOAPBOX

Climate change may raise the risk of deadly fungal infections in humans. One species already is a threat

While fungal diseases have devastated many animal and plant species, humans and other mammals have mostly been spared. That’s probably because mammals have powerful immune systems and body temperatures too high for most fungi to multiply. Climate change could test those defenses by bringing new fungal threats to human health, a microbiologist warns.

From 2012 to 2015, harmful versions of the fungus *Candida auris* arose independently in Africa, Asia and South America. Because the strains are genetically distinct variants of the same species, their emergence across continents couldn’t have been caused by infected travelers, says Arturo Casadevall of the Johns Hopkins Bloomberg School of Public Health.

Instead, each continent’s *C. auris* may have become tolerant of humans’ average body temperature of about 37° Celsius by acclimating to warming in the environment caused by climate change, Casadevall and colleagues say. If the hypothesis is right,

C. auris “may be the first example of a new fungal disease emerging from climate change” and posing a risk to humans, the team reports in the July/August *mBio*.

Since the first national alert on *C. auris* infections in 2016, there have been 725 confirmed cases in 12 U.S. states as of June 30, with deadly outbreaks among patients in hospitals and other health care facilities. Such patients often have weakened immune systems. U.S. cases have involved strains genetically related to versions on other continents. Over 30 other countries also have reported cases. The fungus causes dangerous infections of the blood, brain, heart and other parts of the body. Infections have been fatal 30 to 60 percent of the time; some are resistant to available antifungal drugs, studies show.

C. auris wouldn’t have been a concern had it not developed the ability to multiply inside people. And to do that, Casadevall says, it had to become tolerant of higher temperatures.

Past work has shown a fungus can be coaxed to grow at warmer conditions in lab settings. As fungal species in the wild “adapt to a warmer climate, some of them will then have the capacity to breach our thermal defenses,” he says. Some fungi already wreak destruction on animals and plants, including frogs (*SN: 4/27/19, p. 5*), snakes and trees (*SN: 5/3/03, p. 282*). “A lot of our fellow creatures are being wiped out,” Casadevall says. While mammals have largely been “resistant to invasive fungal diseases,” bats have been hit hard by the fungus that causes white nose syndrome, in part because bat body temperatures drop during hibernation (*SN Online: 7/15/19*).

“The fungal kingdom is just so vast,” Casadevall says. If another fungus dangerous to humans can evolve to “defeat our thermal barrier, who knows what it will do to us?” — *Aimee Cunningham*

Fungal outbreak As of June 30, there have been 725 confirmed *Candida auris* infections in 12 U.S. states since monitoring began in 2016.

State	Number of cases
New York	355
Illinois	195
New Jersey	126
Florida	22
Massachusetts	8
Maryland	5
California	5
Texas	4
Oklahoma	2
Connecticut	1
Indiana	1
Virginia	1

SOURCE: CDC

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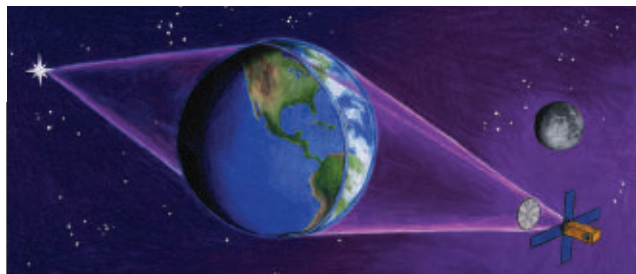
FOR DAILY USE

A single football season is enough to harm parts of players' brains

Aside from the head blows that cause concussions, smaller knocks in a game of football can cause trouble, too. Routine head bumps endured over just one season of college football practice and games were linked to abnormal tissue in players' brain stems, researchers report August 7 in *Science Advances*.

During the 2011, 2012 and 2013 football seasons, the researchers recruited players at the University of Rochester in New York for the study. Each player wore an accelerometer in his helmet to capture the forces at play during games and practices. Players also underwent pre- and postseason brain scans. A measure called fractional anisotropy helped the researchers gauge how well stretches of white matter tissue carried neural signals, a key job of healthy brain tissue.

The 38 players, each of whom took part in the study for one season, collectively took 19,128 hits. By a season's end, players on average had lower measures of fractional anisotropy in their right midbrains — a part of the brain stem — than at the season's start. These declines were more tightly linked to hits that twisted heads, as opposed to head-on hits. Those rotational forces might be particularly damaging to brain tissue, a finding that fits with results from earlier studies, the researchers say. It's unclear if the brain stem changes were permanent, or if they affected mental performance. — *Laura Sanders*



TEASER

A space telescope would use Earth's atmosphere as a lens

As telescopes get bigger — and pricier — one astronomer has a possible work-around: turn Earth's atmosphere into a telescope lens. When light from stars and other objects in the cosmos hits the atmosphere, the light rays bend and are concentrated so they focus on a region of space on the opposite side of Earth. A spacecraft in the right spot — say, orbiting 1.5 million kilometers from Earth — could catch those rays with onboard instruments (illustrated above), collecting more light from dim objects than ground-based telescopes can, says David Kipping of Columbia University. Ultrasensitive measurements by the terrascopes, as Kipping calls it, could reveal exoplanet features like mountains or clouds. A study on the concept will appear in *Publications of the Astronomical Society of the Pacific*. But some astronomers have noted the difficulty of blocking light from Earth, as well as possible image blurring due to light entering the atmosphere at different heights. — *Emily Conover*

SCIENCE STATS

One in 4 people lives in a place at high risk of running out of water

The world is facing a water crisis, with 17 countries, including India, Pakistan, Israel and Eritrea, using at least 80 percent of available water supplies on average each year, a new analysis finds. Those 17 countries are home to a quarter of the world's 7.7 billion people. Further urbanization and population rise could cause critical water shortages in many places, the researchers warn.

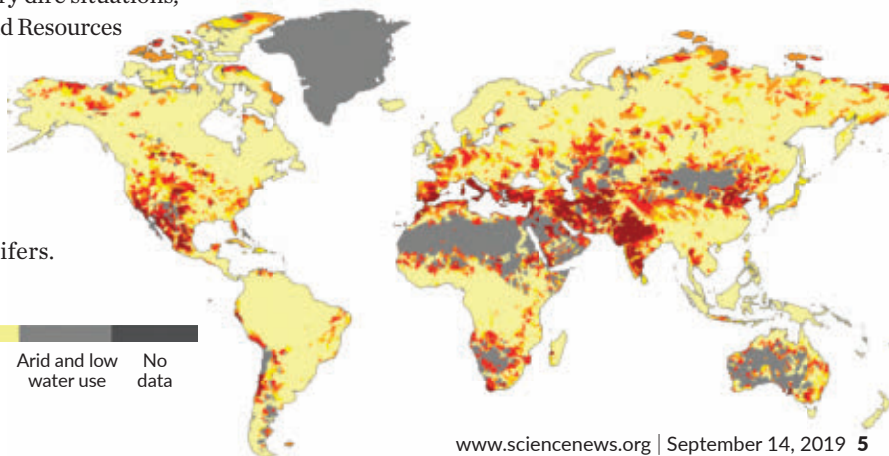
"As soon as a drought hits or something unexpected happens, major cities can find themselves in very dire situations," says data scientist Rutger Hofste of the World Resources Institute based in Washington, D.C., which released the findings August 6. To gauge this risk, or "water stress," the institute updated its online calculator with data from 1961 to 2014 on domestic, industrial and agricultural water use, as well as water supply data from surface sources and aquifers.

Previously, the tool, the Aqueduct Water Risk Atlas, assessed water demand based on a snapshot of 2010 data.

People "immediately link [water woes] to climate change," says Hofste, who is based in Amsterdam. But economic and population growth "are the biggest drivers." World water use has increased by 150 percent, from 1,888.7 cubic kilometers in 1961 to 4,720.8 cubic kilometers in 2014, the analysis found.

Twelve of the 17 countries facing "extremely high" risk are in the Middle East and North Africa. — *Carolyn Wilke*

Thirsty world Areas facing "extremely high" water stress use at least 80 percent of yearly supplies. "High" stress places use 40 to 80 percent, and "medium-high" to "low" stress places use less than 40 percent.



FROM TOP: JAMES TUTTLE/KEANE; WWW.WRI.ORG/AQUEDUCT

BODY & BRAIN

Chlamydia vaccine shows promise

Clinical trial offers hope in preventing common STD

BY AIMEE CUNNINGHAM

The first vaccine against chlamydia has passed its initial test in humans.

About three dozen healthy women were randomly assigned one of two versions of a chlamydia vaccine or a placebo in a clinical trial. Both vaccine versions were shown to be safe and produced an immune response not seen in the placebo group, scientists report online August 12 in the *Lancet Infectious Diseases*.

“These promising results provide encouragement,” says pediatric infectious disease specialist Toni Darville of the University of North Carolina School of Medicine in Chapel Hill, who coauthored a commentary accompanying the study. Chlamydia can lead to

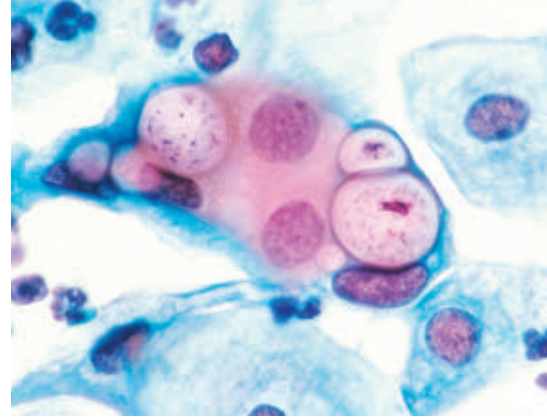
disabling, long-term complications for women, so a vaccine could have a big effect on public health, she says.

Chlamydia, caused by the bacterium *Chlamydia trachomatis*, is one of the most common sexually transmitted diseases, with about 131 million women and men ages 15 to 49 newly infected worldwide each year. But that’s likely an underestimate, as the disease can produce general symptoms that may not be recognized as chlamydia, such as genital discharge or pain, or no symptoms at all. Antibiotics can clear an infection. But left untreated, chlamydia can wreak reproductive havoc on women. An infection targets the cervix, and, for about 1 in 6 women, spreads to the uterus and fallopian tubes where it can cause pelvic inflammatory disease and infertility.

“The percentage of women who develop these long-term complications is relatively low,” Darville says. But the high number of infections overall, she says, means that “a significant number of women” go on to have chronic pelvic pain or infertility, or both.

Developing a vaccine is challenging because *C. trachomatis* bacteria live a complex life within the human body. The microbes make their way inside cells that

line the reproductive organs. Based on animal studies, researchers expect that a successful vaccine needs to provoke a strong immune response in two key ways: with antibodies that fight the bacteria outside of cells and with immune system proteins and cells, such as T cells, that help clear bacteria from infected cells.



A pap test sample seen under a microscope shows chlamydia-infected cells (center). An untreated infection can cause infertility.

line the reproductive organs. Based on animal studies, researchers expect that a successful vaccine needs to provoke a strong immune response in two key ways: with antibodies that fight the bacteria outside of cells and with immune system proteins and cells, such as T cells, that help clear bacteria from infected cells.

In the clinical trial, by immunologist Robin Shattock of Imperial College London and colleagues, both versions of the vaccine triggered an immune response via antibodies and T cells, but one formulation performed better than the other and will move forward to further testing. The next step will be to see if the vaccine prevents infection compared with a placebo and would involve volunteers at risk of infection, Shattock says. ■

BODY & BRAIN

New drug is approved for tuberculosis

Antibiotic, paired with two others, treats highly resistant cases

BY AIMEE CUNNINGHAM

An especially dangerous form of tuberculosis may have met its match.

The U.S. Food and Drug Administration announced August 14 that it had approved the antibiotic pretomanid to help tackle extensively drug-resistant tuberculosis. This form of the disease is resistant to at least four of the main TB drugs, and treatment often fails: Only about 34 percent of infected patients typically survive, according to the World Health Organization.

Becoming ill with this type of TB “can be a death sentence — until now,” says William Bishai, a TB researcher at the

Johns Hopkins University School of Medicine who was not involved in the drug’s development.

Current treatment for this type of TB requires taking as many as eight antibiotics orally, and sometimes by injection, for 18 months or more. By contrast, the new antibiotic is paired with two previously approved drugs, bedaquiline and linezolid, in a six-month course of pills. Ninety-five of 107 patients who had the highly resistant infection and took this drug regimen recovered, according to the TB Alliance, the nonprofit organization that developed pretomanid. The drug is only the third in more than 40 years to be

widely approved for TB, which is caused by *Mycobacterium tuberculosis* bacteria.

Tuberculosis sickened an estimated 10 million people in 2017. Around 458,000 cases were multidrug-resistant, unresponsive to the two most powerful TB drugs. Of those cases, about 8.5 percent, or roughly 39,000, were extensively drug-resistant, according to WHO.

Pretomanid has been tested only in patients with extensively resistant TB. More research is needed to determine whether the drug could be useful for the vast majority of patients who have TB that’s more receptive to treatment, says Bishai. Perhaps the standard regimen of multiple drugs taken for six months could be shortened by including the new antibiotic, he says. “We’re delighted to have this new drug pretomanid, but there’s a lot more to do.” ■

Big, bold bosses lead wasps to success

Colony size is linked to a queen's physical traits and personality

BY CAROLYN WILKE

A society's success can hinge on its head honcho. That's true even for social insects under the rule of a queen.

Paper wasp queens with big bodies, bold personalities or both tend to produce larger colonies than their smaller, shyer counterparts, a study in the September *Behavioral Ecology and Sociobiology* finds. These queenly characteristics can help to predict colony success, even a month before there's a colony to speak of, says Colin Wright, a behavioral ecologist at Penn State.

Polistes metricus queens blaze their own trails, often striking out alone to build a nest and raise young. After rearing a brood, a queen defends the nest from invaders while policing the behavior of workers and trying to prevent them from reproducing.

In 2016, Wright and colleagues collected 40 paper wasp queens and their nests within a couple of weeks of the females founding the nests. The

researchers gave the insects "personality" tests by poking the wasps in the face, up to 50 times in a session, to see if the insects would stay put or fly away.

"Some queens, you can prod them up to a hundred times, and they'll stand their ground," Wright says. Less tenacious queens fly away after one or two jabs.



For *Polistes metricus* paper wasps, whether a queen is big and has a bold personality can help predict if a colony thrives or not.

The researchers also measured the queens' heads to estimate body size, and then returned the wasps to their nests and the nests to the field. Over several months, the team monitored the populations of 27 colonies led by queens that didn't abandon their nests.

Larger queens may have physical advantages that allow them to lay more eggs or to forage or work on nests for longer each day than smaller counterparts, the researchers suggest. Being big or bold, or both, may also help queens be better fighters. In a study reported in 2009, evolutionary biologist Elizabeth Tibbetts of the University of Michigan in Ann Arbor, a coauthor of the new study, suggested that larger queens are less likely to have their nests usurped by a rival.

"The queen herself can have this legacy effect on the traits of the colony," says Amy Toth, a social insect biologist at Iowa State University in Ames who was not involved with the new research. "It's super clear with [these wasps], because you start with a single individual, and she creates a city, essentially." Populated by a queen's descendants, that city is an extension of the queen's genes and characteristics. ■

EARTH & ENVIRONMENT

El Niño planning may get harder

Climate change could limit forecasts of the worst events

BY MARIA TEMMING

Climate change may make it harder to predict the most severe of the El Niño and La Niña weather disturbances in the Pacific Ocean. That's because these events will become less connected with what happens halfway around the world in the Atlantic Ocean, researchers report August 21 in *Science Advances*.

At present, cooling in the waters of the equatorial Atlantic, called an Atlantic Niña, can lead to especially warm water in the equatorial Pacific, or El Niño. Meanwhile, warmer Atlantic

Niño waters tend to give rise to the cooler waters of La Niña in the Pacific. That call-and-response relationship, which involves air being swept into the atmosphere from over the Atlantic and settling down over the Pacific, can give forecasters an edge in anticipating destructive El Niño and La Niña events.

But as the atmosphere warms, that gas exchange is expected to become more sluggish, weakening the Atlantic's sway over the Pacific. Future El Niños and La Niñas may not follow the Atlantic events as reliably as in the past, new simulations show. That could make it harder to prepare for especially disruptive El Niños and La Niñas, which can incite flooding in some regions while drying up others, or make hurricanes stronger.

The computer simulations predict how the Atlantic-Pacific relationship

might change if greenhouse gas emissions continue to rise throughout the 21st century: Extreme El Niño and La Niña events are expected to happen more frequently, yet only about half will be foreshadowed by Atlantic events.

"It's going to be harder to predict the Pacific extreme El Niño and extreme La Niña," says study coauthor Wenju Cai, a climate scientist at the Commonwealth Scientific and Industrial Research Organization in Aspendale, Australia.

If future Atlantic Niños and Niñas aren't as useful predictors, "it's not going to be catastrophic," says climate scientist María Belén Rodríguez de Fonseca of the Complutense University of Madrid. The Atlantic is but one element among many factors, such as conditions in the Pacific and Indian oceans, that feed into forecasts for these meteorological juggernauts. ■

HUMANS & SOCIETY

Symbolism has deep roots in Asia

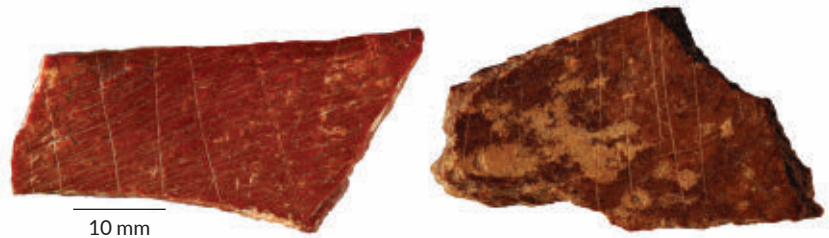
Denisovans might have etched bones over 100,000 years ago

BY BRUCE BOWER

Lines engraved 125,000 to 105,000 years ago on two animal bones found in northern China held some sort of meaning for their makers, researchers say.

These markings provide the oldest evidence of symbolic activity by humans or our close evolutionary relatives in East Asia, says a team led by archaeologists Zhanyang Li and Luc Doyon, both of Shandong University in Jinan, China. A mysterious Stone Age population called Denisovans, which had close genetic ties to Neandertals, may have carved sets of parallel lines into the bone fragments, the scientists suggest in the August *Antiquity*.

Denisovans inhabited East Asia at the same time that someone carved lines into the bones, found at a site called Lingjing. But either *Homo sapiens* or Neandertals,



Two bone fragments found in northern China with engraved lines, some marked with red pigment, are the oldest signs of symbolic behavior in East Asia, scientists report.

who also left behind creations with apparent symbolic meanings (*SN*: 3/17/18, p. 6), might have modified the bones.

“Nonetheless, the two objects from Lingjing suggest that symbolic capacities were within the realm of cognitive abilities of [*Homo*] species that lived before and during the evolution of *Homo sapiens* in Africa,” Doyon says.

Abstract markings on the Lingjing bones resemble engraved lines on roughly 100,000-year-old pigment chunks from South Africa, says Paul Pettitt, an archaeologist at Durham University in England. “As *Homo sapiens* was responsible for that early symbolism in Africa, and Neandertals were responsible for such in Europe, it is a fascinating possibility that these [Chinese] examples were created by another *Homo* species,” Pettitt says.

Until now, a roughly 40,000-year-old stone with a set of parallel and intersecting engraved lines, found at another northern Chinese site, represented the oldest evidence of symbolic behavior in East Asia. An engraved geometric design on a roughly half-million-year-old seashell found in Indonesia stands as the oldest example of symbolic behavior anywhere in the world (*SN*: 12/27/14, p. 6). Researchers suspect *Homo erectus* carved that pattern.

Almost one-quarter of 227 animal bone fragments excavated at Lingjing between 2005 and 2015 display stone-tool incisions typical of butchery, the researchers say. But that sample included two exceptions. A partial rib from an unidentified large, adult mammal had seven nearly parallel lines cut

ATOM & COSMOS

Crash may have broken Jupiter’s core

Simulations suggest why the gas giant’s interior is so diffuse

BY MARIA TEMMING

A planetary smashup billions of years ago may be to blame for Jupiter’s weirdly puffy core.

Recent measurements of Jupiter’s gravitational field indicate that, rather than a dense pit of rock and ice, Jupiter’s core is a haze of elements possibly spanning half the planet’s radius (*SN*: 6/24/17, p. 14). That observation, made by NASA’s Juno spacecraft that started orbiting Jupiter in 2016, defies current planet-formation theories. Those models suggest that Jupiter formed from a dense kernel that accumulated a thick envelope of gas.

New computer simulations show that a collision between Jupiter and a big planetary body could have shattered Jupiter’s compact core into the scattered

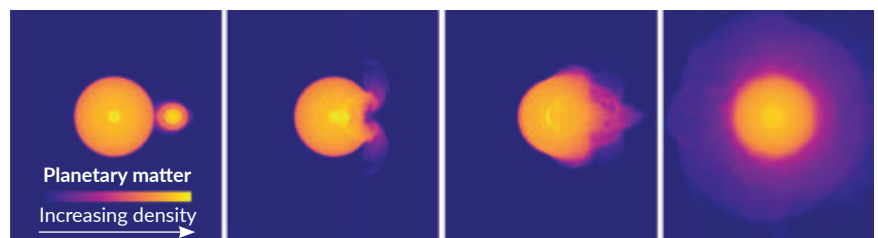
collection of heavy elements — those heavier than helium — seen today. Understanding the origins of Jupiter’s structure may give insight into the processes that shape other gas giants, scientists say in the Aug. 15 *Nature*.

“This impact may have happened when

the solar system was very, very young, and in a chaotic phase when there were lots of objects roaming around,” says Andrea Isella, an astronomer at Rice University in Houston. As the biggest planetary body in its neighborhood, Jupiter was liable to gravitationally attract other objects wandering the solar system, he says.

In the simulations, Isella and colleagues found that a planetary body of about 10 Earth masses could have broken apart and merged with Jupiter’s dense

Heavy hitter Billions of years ago, Jupiter may have collided with a rogue planetary body equal to about 10 Earth masses. The computer simulation below shows the impact and aftermath. The impact could have fractured the gas giant’s original compact core and mixed the heavy elements there into Jupiter’s gaseous envelope to create the diluted core seen today.



into it. Microscopic analysis indicated that the lines were made with a sharp point that was run across the bone's surface after the bone suffered some damage from weathering. Special care was taken to create each of the first five lines with a single pass of the engraving tool. Red residue in four engraved lines indicated that a pigment had been smeared on the pattern, possibly to increase its visibility.

A second rib fragment from a large mammal has 10 roughly parallel lines that had been sliced with a sharp stone point, probably in a single session, the scientists say. Engraving of these lines also occurred after the bone had been damaged by long exposure to the air. No pigment residue appears on this specimen.

The researchers estimated the ages of the engraved bones by calculating the time since the sediment in which they were found was last exposed to sunlight.

Whoever cut the lines also fashioned animal bones into tools. Bone and antler artifacts found in the same sediment as the engraved ribs were likely used to retouch and sharpen used stone tools, Doyon and colleagues reported in 2018. ■

core, causing that jumble of material to mix into Jupiter's inner gaseous envelope. Within hours, the merger would have transformed the original core, only about 15 percent of the planet's radius, into a dilute core that extended to nearly half the radius. Simulations also show that this core could have persisted for more than 4 billion years to the present.

The idea that a giant impact reshaped Jupiter's internal structure is plausible, says Juno mission leader Scott Bolton of the Southwest Research Institute in San Antonio, who wasn't involved in the study. But other scenarios — such as heavy elements mixing with gas during Jupiter's formation, or an internal churning process dredging up core material — may also explain the diffuse core. Simulations of those competing scenarios may help tease out which is most likely, Bolton says, noting that figuring out how Jupiter formed and evolved is “a work in progress.” ■

S. TIMMERMAN

EARTH & ENVIRONMENT

Primordial rock hides in Earth's mantle

Deep diamonds reveal reservoir of ancient, pristine material

BY MARIA TEMMING

A surprisingly hardy reservoir of rock left over from just after Earth's formation still lurks deep inside the planet, according to an analysis of diamonds.

Fluid trapped inside these diamonds, forged hundreds of kilometers underground in the mantle, bears the chemical signatures of rock that has remained relatively undisturbed for billions of years. This rock may be nearly as ancient as Earth itself — making it some of the planet's oldest preserved material, scientists report in the Aug. 16 *Science*. Understanding the characteristics and preservation of such pristine rock may yield insights into Earth's formation and evolution.

Chemical analyses of basalt, a type of volcanic rock, have hinted that the mantle contains extremely old material. But scientists weren't sure whether such a relic could withstand the continual mixing of mantle material. Evidence from volcanic rock is hard to trust on its own: Molten rock tends to get contaminated as it pushes up through the crust, and it's difficult to pinpoint where specific bits originated, says geochemist Suzette Timmerman of the Australian National University in Canberra.

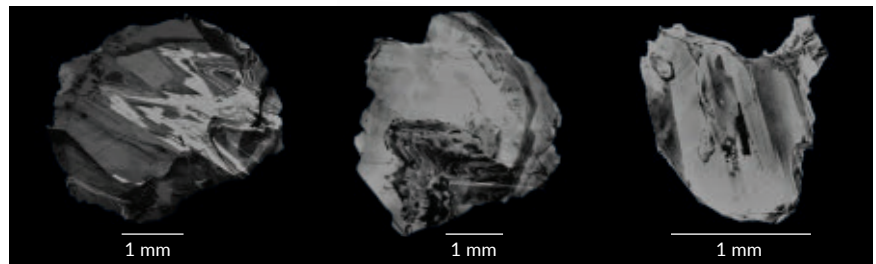
For a better glimpse into the interior, Timmerman and colleagues scrutinized 24 superdeep diamonds from Brazil that were found to have formed 410 to 660 kilometers underground. As the diamonds crystallized, they swallowed up microscopic pouches of fluid from the surroundings. When a superdeep

diamond rises to the surface, its sturdy crystal structure shields these inclusions from contamination, Timmerman says. “It's exactly preserving the chemical composition at those really deep depths.”

Using mass spectrometry, the team cataloged different isotopes, or variants, of elements in the inclusions and focused on the abundance of two helium isotopes, helium-3 and helium-4. Earth has not generated any new helium-3 since its formation, and any helium-3 that reaches the surface escapes into space, says geologist Andrew Thomson of University College London, who was not involved in the study. So material that is relatively rich in helium-3 compared with helium-4 must have formed early in Earth's existence and been isolated for a very long time.

In the inclusions richest in helium-3, the ratio of helium-3 to helium-4 was about 1-to-14,300. That's about 50 times higher than the ratio seen in air. The ratio suggests that the inclusions date back to about when Earth formed, some 4.5 billion years ago. Based on the depths of diamond crystallization, the pristine reservoir is probably at least 410 kilometers deep. Determining the exact location may help explain how the reservoir formed and stayed undisturbed, Thomson says.

The overall chemistry of the reservoir is a mystery, “but it must be quite dense in order to avoid mixing with the rest of the mantle,” Timmerman says. Another lingering question is whether the reservoir is one giant mass or multiple smaller pockets of age-old material. ■



Fluids enclosed in microscopic cavities in diamonds found in Brazil (like the ones shown in these electron microscope images) hint at the presence of primordial rock deep within Earth's mantle.

BODY & BRAIN

Alzheimer's harms brain's wake areas

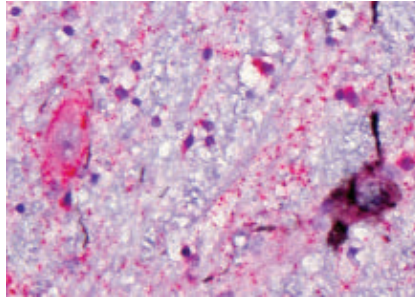
Study hints at why the disease comes with daytime sleepiness

BY LAURA SANDERS

Alzheimer's disease destroys command centers in the brain that keep people awake. That finding could explain why the disease often brings daytime drowsiness.

Sleep problems can precede Alzheimer's, sometimes by decades. But the new result, described online August 12 in *Alzheimer's & Dementia*, suggests that disordered sleeping isn't just a harbinger of Alzheimer's. Instead, sleep trouble is "part of the disease," says Lea Grinberg, a neuropathologist at the University of California, San Francisco.

Grinberg and colleagues focused on the brain stem and a structure perched above it called the hypothalamus. These



In the brain stem, a nerve cell (red, left) releases a chemical messenger involved in wakefulness. Nearby is a damaged nerve cell (purple, right) packed with tau, a protein tied to Alzheimer's.

parts of the nervous system help keep people awake and attentive during the day. The brain stem and its neighbors have been largely overlooked in studies of dementia, Grinberg says. The researchers searched for evidence of tau, a protein that can form tangles inside nerve cells, in 13 postmortem brains of people who had died with Alzheimer's disease.

Three small regions of the hypothalamus and brain stem were packed with tau.

Two of the areas had lost over 70 percent of their nerve cells, or neurons. That destruction could be part of the reason why people with Alzheimer's often feel tired during the day, even if they slept the night before.

The findings may refocus dementia research on parts of the brain that help control sleep and wake. "We can't continue to ignore the brain stem if we think about these dementias and how they progress," says Bryce Mander, a neuroscientist at the University of California, Irvine. A clearer understanding of how, when and where Alzheimer's first attacks the brain might lead to better ways to identify the disease early and even stop the damage.

The current study included samples only from people who had late-stage Alzheimer's. Grinberg is beginning a larger study of people at multiple stages of Alzheimer's in the hopes of spotting exactly when the neurons in these wake-promoting pockets start to deteriorate. ■

BODY & BRAIN

Midlife hypertension tied to dementia

High blood pressure in middle age can lead to problems later

BY AIMEE CUNNINGHAM

Controlling high blood pressure during middle age may help stave off dementia later in life.

In a long-term study of thousands of people, having hypertension throughout one's mid-40s to mid-60s was associated with an increased risk of dementia later in life, compared with those who had normal blood pressure, researchers report in the Aug. 13 *JAMA*.

Among people who had hypertension throughout midlife, there were 3.28 cases of dementia per 100 people per year, says Keenan Walker, a neuropsychologist at Johns Hopkins University School of Medicine. Among those with normal blood pressure during middle age, there were 1.84 cases per 100 people per year.

The results suggest "another major reason for aggressive public health campaigns to screen [for] and treat

hypertension earlier in life," says Shyam Prabhakaran, a vascular neurologist at the University of Chicago who wrote a commentary accompanying the study.

The study also indicated that if a person first has hypertension during middle age, either high or low blood pressure in late life increases the risk of dementia. "How late-life blood pressure influences the brain seems to be dependent on midlife blood pressure," Walker says. Previous studies had been inconsistent on whether high or low blood pressure late in life is a risk factor for dementia.

The estimated number of U.S. adults with hypertension increased recently, from about 75 million to 116 million, largely due to new guidelines that expanded the range of hypertension (*SN: 12/9/17, p. 13*). Close to 6 million people in the United States have Alzheimer's disease, the most common type of dementia.

The study began in 1987 and involved a total of 4,761 participants from four U.S. states. People had their blood pressure taken five times over 24 years, followed by neurological and psychological testing in the last decade of the study.

Hypertension was defined as having a systolic pressure above 140 millimeters of mercury, with a diastolic pressure above 90. This was the standard hypertension definition when the study began. Now, a reading of at least 130 over 80 is considered high. In the study, readings below 90 over 60 were considered low.

Hypertension can damage blood vessels, making them stiffer. Past research suggested that when vessels in the brain are damaged the organ doesn't function as well, possibly because it receives less oxygen and nutrients. Then later, if blood pressure is too low, the reduced blood flow may starve the brain further.

But, Walker says, "if you can reduce the amount of vascular dysfunction" by controlling blood pressure with medication, exercise or diet, it may be possible to delay or even prevent later dementia. ■

Primate brains evolved bit by bit

Odor and vision regions changed independently, fossil hints

BY BRUCE BOWER

A 20-million-year-old monkey skull that fits in the palm of an adult human hand may contain remnants of piecemeal brain evolution in ancient primates.

Neural landmarks preserved on the skull fit a scenario in which specific primate brain regions expanded or contracted while other regions remained unchanged, a study finds. In a clue to that evolutionary process, researchers

A 20-million-year-old skull from an extinct monkey, *Chilecebus carrascoensis*, contains evidence that different parts of primate brains evolved independently of each other.



say, a small part of the monkey's brain devoted to odor perception was not counterbalanced by an enlarged visual system, as is typical of primates today.

Primate visual systems expanded in size and complexity over millions of years without requiring substantial changes elsewhere in the brain, argue paleontologist Xijun Ni of the Chinese Academy of Sciences in Beijing and colleagues. And comparisons of the skull — from an extinct South American species called *Chilecebus carrascoensis* — with fossils of African primates from 30 million years ago or more indicate that major brain structures evolved at different rates in different primate lineages, as did increases in brain size relative to body size, the team reports August 21 in *Science Advances*.

These findings are in contrast to the idea that primate brains progressively got bigger overall as time passed.

Paleontologist John Flynn of the American Museum of Natural History in New York City and colleagues used high-resolution scanning and a digital 3-D cast

of the inner surface of the skull's braincase to reveal impressions made by a set of neural folds.

Those creases denoted a separation of tissue into areas with specific duties, such as smell and vision. Measurements of the eye sockets and an opening at the back of those cavities for the optic nerve let the team estimate the size of the primate's visual system. The placement of key folds on the brain's surface enabled scientists to estimate the size of the odor-perception region.

The study indicates that a large variety of neural folding patterns seen in New World monkeys today — which exceed the variety of such patterns in the brains of modern African and Asian monkeys — have deep evolutionary roots, says biological anthropologist Brenda Benefit. But neural features of ancient New World primates “are not necessarily relevant to Old World monkey and ape brain evolution,” says Benefit, of New Mexico State University in Las Cruces.

Even though fossil comparisons in the new study indicate that the brains of Old World and New World monkeys evolved along different evolutionary pathways, both groups eventually evolved similar increases in brain size and complexity, Ni says. ■

ATOM & COSMOS

Nearby asteroid looks too tidy

Scientists puzzle over why Ryugu appears to lack dust

BY LISA GROSSMAN

Ryugu is a neat freak. The surface of the near-Earth asteroid is surprisingly free of dust, observations from the German and French MASCOT lander show.

The asteroid, which may have formed from the breakup of a larger body about 700 million years ago, has no atmosphere to protect it from interplanetary dust. These dust particles pummel exposed space rocks at high speed, breaking down their surfaces into thin layers of dust and

dirt, like what's found on the moon.

But when it reached Ryugu in October 2018, the MASCOT lander took high-resolution photos that show no sign of any dust-sized particles, researchers report in the Aug. 23 *Science*.

Ryugu may be hiding its dust in larger, porous rocks or deep in its interior, planetary scientist Ralf Jaumann of the German Aerospace Center in Berlin and colleagues say. Shaking due to a meteorite impact may have shuffled the particles into porous surface rocks or down through small surface cracks to the asteroid's center, the way small nuts end up at the bottom of a cup of trail mix.

Or Ryugu could spray dust into space when sunlight heats patches of trapped ice and releases volatile gases. A similar asteroid, Benu, seems to do that, accord-

ing to NASA's OSIRIS-REx spacecraft (*SN: 4/13/19, p. 10*). But Jaumann thinks that explanation is less likely for Ryugu. Data from the Japanese Hayabusa2 craft, which has been orbiting Ryugu since June 2018 and brought MASCOT along, hint that Ryugu has less water than Benu.

There's another possible explanation for Benu's dust sprays, says OSIRIS-REx principal investigator Dante Lauretta of the University of Arizona in Tucson. Frequent temperature changes on Benu's surface as parts of the asteroid rotate in and out of sunlight could make the asteroid's larger rocks fracture like a snapped cracker, tossing crumbs into space. If something similar happens on Ryugu, then it “should also be ejecting particles,” Lauretta says. Hayabusa2 may just not be in the right position to see the crumbs. ■

EARTH & ENVIRONMENT

Intense wildfires send smoke soaring

Pyrocumulonimbus clouds can damage the ozone layer

BY MEGAN SEVER

For the first time, scientists have seen how towering clouds that rise from intense wildfires launch smoke high into the atmosphere, where it can linger for months and mess with the ozone layer.

Cooler air closer to Earth's surface normally keeps smoke from rising too high. But as dozens of fires raged in western Canada and the U.S. Pacific Northwest in the summer of 2017, the blazes created pyrocumulonimbus, or pyroCb,

clouds. These storm clouds produced a giant plume of smoke that lofted 12 to 23 kilometers up into the stratosphere, scientists report in the Aug. 9 *Science*. Solar radiation heating soot within the smoke helped the smoke reach those heights.

Using satellites, weather balloons and ground-based remote sensing, the team tracked the smoke plume over the Northern Hemisphere. Smoke persisted in the stratosphere for about eight months, says Pengfei Yu, a climate scientist at

Jinan University in Guangzhou, China.

This “mother of all pyroCbs” offered the first direct observation of a process called “self-lofting,” says Alan Robock, a climate scientist at Rutgers University in New Brunswick, N.J.

The observations align with what simulations predicted would happen if large amounts of smoke from a nuclear war were injected into the stratosphere, Yu, Robock and colleagues report. “Nature did the experiment for us,” Robock says, confirming the “nuclear winter” scenario, in which smoke from a burning city would have far-reaching and long-lasting climatic consequences, including blocking out sunlight.

Importantly, the observations show that “smoke in the stratosphere hangs around a long time,” says Loretta Mickley, a Harvard University atmospheric chemist. The longer the smoke stays in the stratosphere, the more time that organics and black carbon, or soot, in the smoke have to absorb sunlight or reflect it back into space. When major volcanic eruptions in past centuries have caused solar reflection, she says, the dimming effect has led to crop failures and famines.

It's unlikely that wildfires could loft enough smoke to cause hemispheric



Strong wildfires create pyrocumulonimbus clouds, like this one from a 2004 fire in Arizona, that can rise high enough to affect the ozone layer.

MATTER & ENERGY

Invisibility cloaks take to the water

Materials reduced drag or wave motion on items in fluids

BY EMILY CONOVER

Invisibility cloaks are making a splash. Or preventing splashes, perhaps.

The science fiction idea of an invisibility cloak is a Harry Potter-style device that renders objects invisible to the eye. But in addition to hiding objects from light, physicists have been branching out to mask objects' effects on sound and other waves (*SN: 5/18/13, p. 8*).

Now, two research teams have come up with different ways of directing waves and currents around an object in a fluid,

effectively hiding the object's presence by cloaking its effect on the surrounding water. The techniques also reduce drag or the rocking effect of waves on the cloaked object, the teams report in two studies in the Aug. 16 *Physical Review Letters*.

Whether for light, sound or water, cloaks steer waves so they travel around an object rather than scattering off it, which would disrupt the waves' paths and reveal the object's presence. A cloak forces waves to take a detour around the object and return to the same configuration they would be in if the object weren't there. But “actually making these things is tricky,” says physicist John Pendry of Imperial College London, who was not involved with the studies.

To cloak a miniature boat from the swells inside a wave tank, one team built a structure that steers waves away from

the tank's center. Along each side of the long, narrow tank, the researchers laid iron beams that gradually sloped upward to a flat region, and then back down. That changes the water's depth at the edges of the tank in a way that adjusts incoming waves' speed and direction. In experiments, a toy boat in the tank's center sat mostly motionless as waves rolled in. A series of such beams could be constructed in a port to stop boats from bobbing wildly while being loaded with cargo, the researchers suggest.

The structure appears simple, says engineer Zhenyu Wang of Zhejiang University in Hangzhou, China. But “when you understand the theory, you do not need to use a very complex method.”

Along with physicist Huanyang Chen, Wang and colleagues hope to test the setup in a real harbor. Chen, of Xiamen

dimming, but the smoke can damage the ozone layer, which protects Earth from the sun's ultraviolet radiation.

First, as ozone-poor smoke rises into the stratosphere, it pushes out ozone-rich air, causing a temporary loss of ozone in that area, Yu says. Yu's team measured ozone losses of up to 50 percent over parts of Canada during the 2017 fires. Second, over time, chemical reactions with water vapor transported into the stratosphere by smoke can release molecules that damage ozone.

How significant such ozone losses are "is a big question mark right now," but is being actively studied, says study coauthor Michael Fromm, a meteorologist at the Naval Research Laboratory in Washington, D.C. PyroCbs occur some three to six dozen times a year globally, Fromm says. But the fire clouds range in size, with the biggest and most intense ones requiring "a perfect storm" of hot, dry, windy conditions along with clusters of very hot fires in close proximity to reach the stratosphere, he says.

Given that climate change is increasing fire frequency and intensity in some places (*SN*: 12/22/18 & 1/5/19, p. 18), it is possible more of these fire clouds will reach the stratosphere, Fromm says. ■

University in China, jokes that the setup would yield another benefit: "With the help of the structure, it's easy for us to have coffee on a boat" — with no spillage.

In the other study, scientists shielded a small object in a flowing stream of water using a specially designed material made up of more than 500 tiny pillars, each 50 micrometers wide, that encircle the object. The interaction of the water with the pillars makes the water behave as if it is more viscous and alters its flow. As a result, water downstream flows as if no obstacle had been in its path.

And the material decreases the drag force on the object, simulations show. "The force cannot penetrate into the inner cloaked region," says study coauthor and MIT materials scientist Juhyuk Park. Reducing drag in this way could lead to more fuel-efficient vehicles, Park says. ■

MATTER & ENERGY

Chemists create a new form of carbon

Ring-shaped molecule joins other odd variations of the element

BY EMILY CONOVER

An elusive wreath of carbon has made its long-awaited debut.

Scientists have created a molecule called cyclocarbon and imaged its structure, describing the ring of 18 carbon atoms online August 15 in *Science*. The work unveils a new face of one of chemistry's most celebrated elements.

"It's not every day that you make a new form of carbon," says chemist Rik Tykwinski of the University of Alberta in Edmonton, Canada, who was not involved with the research. The result had eluded chemists for so long that Tykwinski had placed a bet about whether cyclocarbon would be created and imaged. "I basically won a bottle of Scotch from a friend," he says.

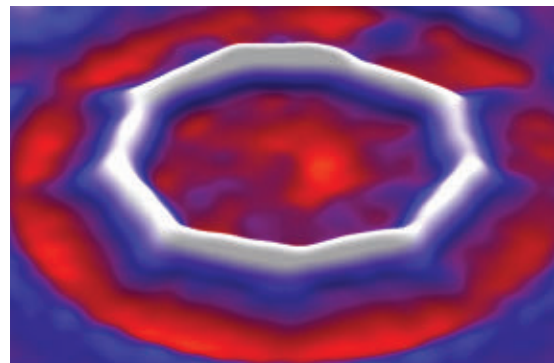
Cyclocarbon joins other forms of the versatile element, including diamond, graphite, thin sheets called graphene, tiny spheres known as buckyballs and miniature cylinders called carbon nanotubes.

Chemists thought it should be possible to create the molecule. But nobody knew what its properties would be, says physicist Katharina Kaiser of IBM Research in Zurich. "It's really amazing that we found it, and it's absolutely great that we could characterize it."

Kaiser and colleagues started with a cyclocarbon oxide molecule, which consists of carbon atoms arranged in a loop with additional carbon monoxide groups attached to the atoms. Removing the carbon monoxide to create the new form of carbon was no easy task; those groups help stabilize the molecule. Using an atomic force microscope, the team plucked off extraneous carbon monoxide by applying voltages to the molecule.

The procedure yielded a bare ring of carbon, which the team imaged with the microscope. Cyclocarbon reacts easily with other substances, so to isolate it, the team created the new carbon molecule on an inert surface of table salt.

Previous research had found hints of



A new form of carbon consists of 18 atoms arranged in a ring (illustrated here). Bonds between atoms are alternately longer and shorter, giving the ring nine sides.

cyclocarbon molecules in a gas. But it wasn't possible to image the molecule and confirm its structure. In particular, it was unclear if the bonds between each atom would alternate between longer and shorter lengths, known as single and triple bonds, or whether all the bonds would be the same length, or double bonds. The new study reveals that the carbon atoms are held together by alternating single and triple bonds.

That conclusion could help scientists refine the complex computer calculations used to predict the structures of unknown molecules. "There's still a big question whether many of these... calculations give the right answer, so it's very important to confirm by experiment," says UCLA chemist Yves Rubin, who was not involved with the study.

Previous new forms of carbon were met with great excitement. The discovery in the 1980s of buckyballs and their family of molecules, fullerenes, garnered a Nobel Prize (*SN*: 10/19/96, p. 247). Likewise, the 2004 discovery of graphene was honored with a Nobel and followed by investigations of potential applications in electronics, for example.

But because cyclocarbon isn't stable, it can't be bottled up for further study. So for now, it's not clear how wide-ranging the new molecule's impact will be. ■

BODY & BRAIN

Electrodes show a glimpse of memories emerging in the brain

Seconds before a memory pops up, certain nerve cells jolt into collective action. The discovery of this signal, described in the Aug. 16 *Science*, sheds light on the mysterious brain processes that store and recall information.

Electrodes implanted in the brains of epilepsy patients picked up neural signals in the hippocampus, a key memory center, while the patients were shown images of familiar people and places, including former President Barack Obama and the Eiffel Tower. As people took in this information, electrodes detected a kind of brain activity called sharp-wave ripples, created by the coordinated activity of many nerve cells in the hippocampus.

Later blindfolded, the patients were asked to remember the pictures. One to two seconds before participants described each picture, researchers noticed an uptick in sharp-wave ripples, echoing the ripples detected when the subjects had first seen the images.

That echo suggests that these ripples are important for learning information and for recalling it later, neurobiologist Yitzhak Norman of the Weizmann Institute of Science in Rehovot, Israel, and colleagues say. — *Laura Sanders*

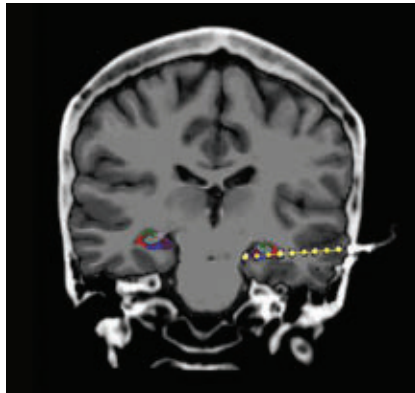
GENES & CELLS

Why people with celiac disease suffer so soon after eating gluten

Researchers may finally know why people with celiac disease get sick within hours of eating gluten. Some immune cells dump stomach-churning levels of immune chemicals called cytokines into the blood soon after encountering gluten, scientists report August 7 in *Science Advances*.

Scientists knew that in celiac disease some of these immune cells, called CD4+ T cells, react to gluten proteins in wheat, barley and rye, leading to damage of the small intestine. But normally, T cells don't rev up until a day or two after exposure to a trigger.

Researchers injected gluten peptides under the skin of volunteers who have celiac disease, or gave them a drink mixed



A second or two before a person described a memory of a picture in a new study, electrodes (locations in yellow) caught ripples of brain activity in the hippocampus (colored areas).

with wheat flour. Starting about two hours later, levels of a cytokine called interleukin-2 and other chemicals released by CD4+ T cells began to climb. Volunteers felt nauseous, and some vomited, as the cytokine levels increased.

Knowing that certain T cells, and cytokines in particular, cause celiac symptoms may lead to therapies that can block gluten-reacting T cells, says Robert Anderson, chief scientist of ImmusanT Inc. in Cambridge, Mass., a company that makes vaccines to protect against autoimmune diseases. — *Tina Hesman Saey*

ATOM & COSMOS

Researchers quintuple the tally of repeating fast radio bursts

Astronomers have found eight new fast radio bursts that repeatedly flash on and off. That haul brings the number of known repeating fast radio bursts, or FRBs, to 10, scientists report August 9 at arXiv.org.

Astrophysicist Cherry Ng of the University of Toronto and colleagues spotted the FRBs using the Canadian Hydrogen Intensity Mapping Experiment, or CHIME, in British Columbia.

The new finds could help astronomers figure out the sources of these repeating flashes of radio energy. Radio waves from the first known repeating FRB, reported in 2016, were scrambled and tossed around by charged particles on the way to Earth, suggesting that the FRB's source was in a dense, turbulent environment, such as a supernova remnant or a neutron

star orbiting a black hole (*SN: 2/3/18, p. 6*). But the energy from some of the new bursts seems to have had a less tumultuous journey. Perhaps these repeating FRBs hail from a calmer environment.

Each burst of a repeating FRB lasts longer than each of the 60 or so known FRBs that don't repeat, about 10 milliseconds per repeat burst versus one millisecond for a nonrepeater. That finding may support the idea that the two FRB types have different sources, though Ng says it's too soon to be sure. — *Lisa Grossman*

ATOM & COSMOS

Astronomers detect what may be a black hole eating a neutron star

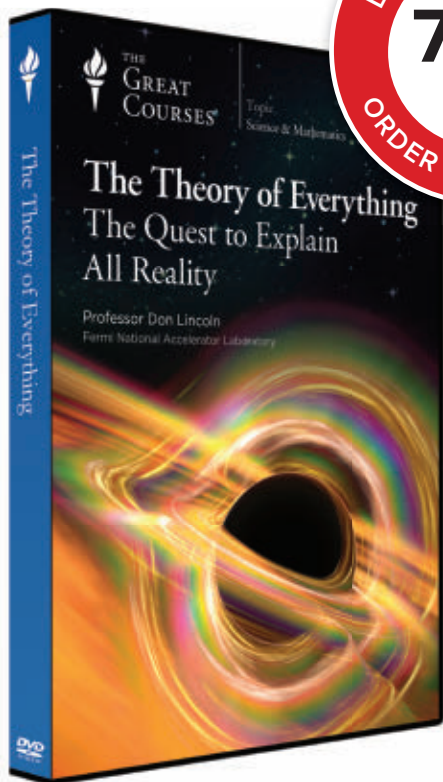
Shudders in the cosmos have revealed what's likely the sad end of a neutron star — getting swallowed by a black hole.

If confirmed, it would be the first solid detection of this source of gravitational waves, revealing a type of cataclysm never before spotted. Researchers from the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, and the Virgo observatory reported the detection August 14 in a public astronomical database.

Scientists are still analyzing the data to verify what created the gravitational waves, tiny vibrations in spacetime caused by massive, accelerating objects.

LIGO and Virgo have picked up gravitational waves from pairs of merging black holes and from colliding neutron stars, which are extremely dense collapsed stars (*SN: 1/19/19, p. 10*). In April, scientists saw hints of a rendezvous between a black hole and a neutron star, but the signal was weak and perhaps a false alarm.

This new discovery offers much more solid evidence. The detection was so clear that it's very unlikely to be a false alarm. Researchers estimate that the run-in between the objects occurred about 900 million light-years away and somewhere within an area about 23 square degrees across the sky. (For comparison, the moon is about half a degree across.) Astronomers have aimed telescopes at that region to look for light that may have been emitted in the merger but have not yet found any. — *Emily Conover*



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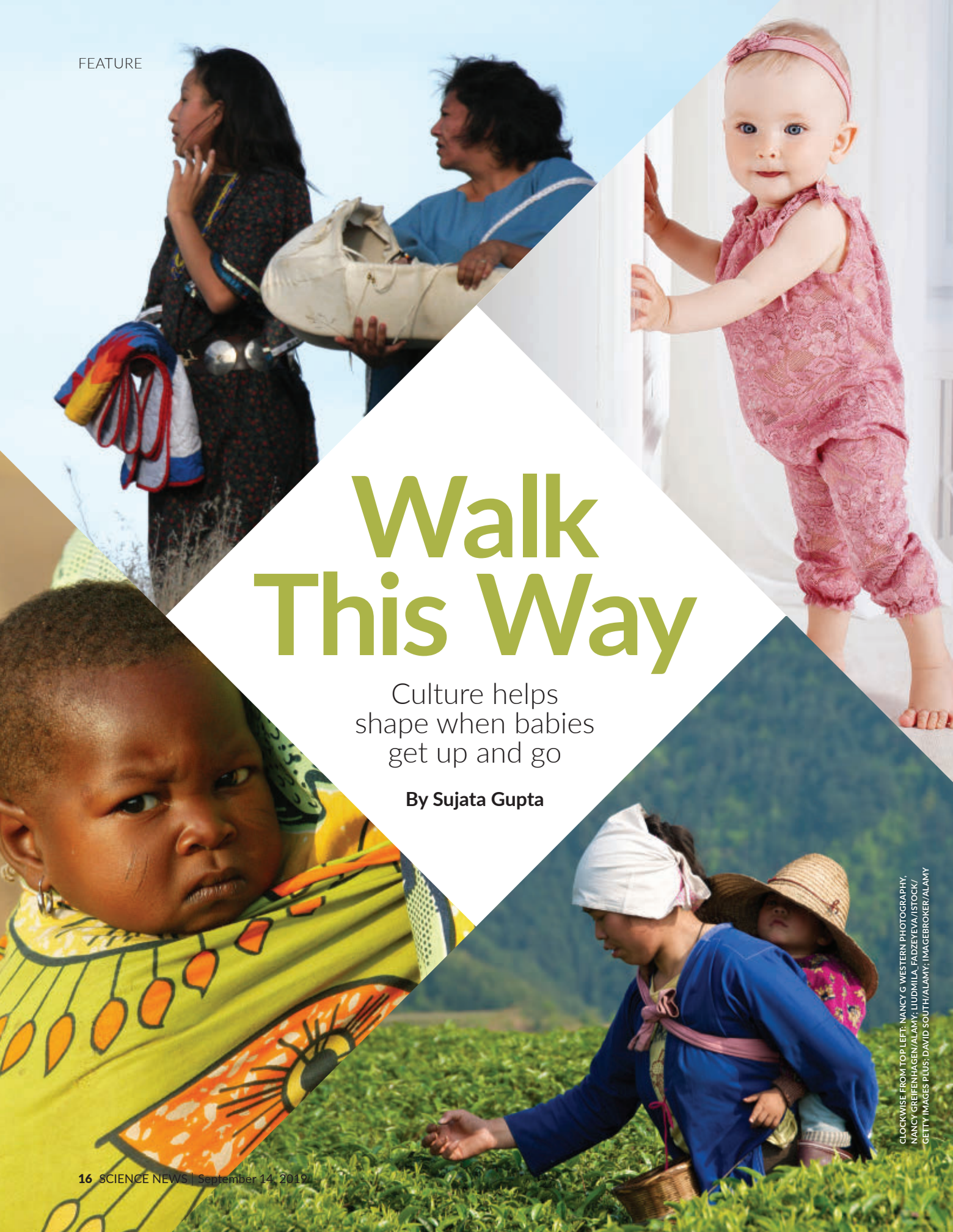
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Walk This Way

Culture helps shape when babies get up and go

By Sujata Gupta



CLOCKWISE FROM TOP LEFT: NANCY G. WESTERN PHOTOGRAPHY, NANCY GREFFENHAGEN/ALAMY; LIUDMILA FADZEYEVA/ISTOCK/GETTY IMAGES PLUS; DAVID SOUTH/ALAMY; IMAGEBROKER/ALAMY

For generations, farther back than anyone can remember, the women in Rano Dodojonova's family have placed their babies in "gahvoras," cradles that are part diaper, part restraining device. Dodojonova, a research assistant who lives in Tajikistan, was cradled for the first two or three years of her life. She cradled her three children in the same way.

Ubiquitous throughout Central Asia, the wooden gahvora is often a gift for newlyweds. The mother positions her baby on his back with his bottom firmly over a hole. Underneath is a bucket to capture whatever comes out. She then binds the baby with several long swaths of fabric so that only the baby's head can move. Next, she connects a funnel, specially designed for either boys or girls, to send urine out to that same bucket under the cradle. Finally, she drapes heavy fabric over the handle atop the gahvora to protect the child from bright light and insects.

Babies stay in that womblike apparatus for hours on end, with use decreasing as the child ages. When babies fuss, mothers often shush them by vigorously rocking the cradle back and forth or leaning over the side to breastfeed. Besides keeping babies dry and warm, gahvoras provide a sense of safety, Dodojonova says. "It is very nice for children because they are bound and cannot move." Eventually, they are running and jumping like children everywhere.

To the uninitiated, this child-rearing approach may sound odd, or even shocking. Yet cultures should be viewed within their own context, says psychologist Catherine Tamis-LeMonda of New York University. "We engage in practices that fit our needs, our own everyday lives."

Though Central Asia is home to 73 million people, Western researchers such as Tamis-LeMonda have only recently begun to document the gahvora's use and possible impact on how children grow.

Ignoring cultural variation of this sort leaves a big blind spot in the science of child development. Western researchers and medical staff define "normal" development — in this case, how and when babies acquire motor skills such as sitting, crawling and walking — based on a century of research on mostly white, Western babies.

Now a few motor development experts are pushing back with a new line of thinking that traces back to the 1950s, when evidence for huge variations in how and when babies acquire motor skills began to emerge in a piecemeal way. At that time, anthropologists and cultural psychologists working in far-flung locales started documenting



how babies in different cultures move about.

In recent decades, that research has become more systematic. Scientists are comparing the motor skills of babies in various cultures and creating controlled experiments to see if training can speed up the development of certain skills.

And motor skills don't arise in isolation. When a baby begins to sit, crawl or walk, she gains a new view on the world, which alters her perception. It also influences how babies and caregivers communicate. A baby who has learned to walk, for instance, will often carry objects to her mother, who frequently responds with words or ways of speaking that are new to the baby. So researchers are also studying how culture influences other areas of development linked to motor skills.

This research is "not just about walking," says Lana Karasik, a developmental psychologist at the City University of New York's College of Staten Island. "It's about what walking gives babies."

As this work continues among broader populations, it's becoming clear that across continents and cultures, children with the ability to do so will learn to walk. For some babies, that tentative first step may occur at 8 months old; for others, age 2 or 3 is a perfectly good time to start exploring.

The rule book

Many parents in Western cultures are familiar with infant motor development charts. Three-month-olds might be shown lifting their heads, 6-month-olds are sitting and 12-month-olds are walking. The implication is that babies learn to get around on a relatively fixed timeline, regardless of environment or experience.

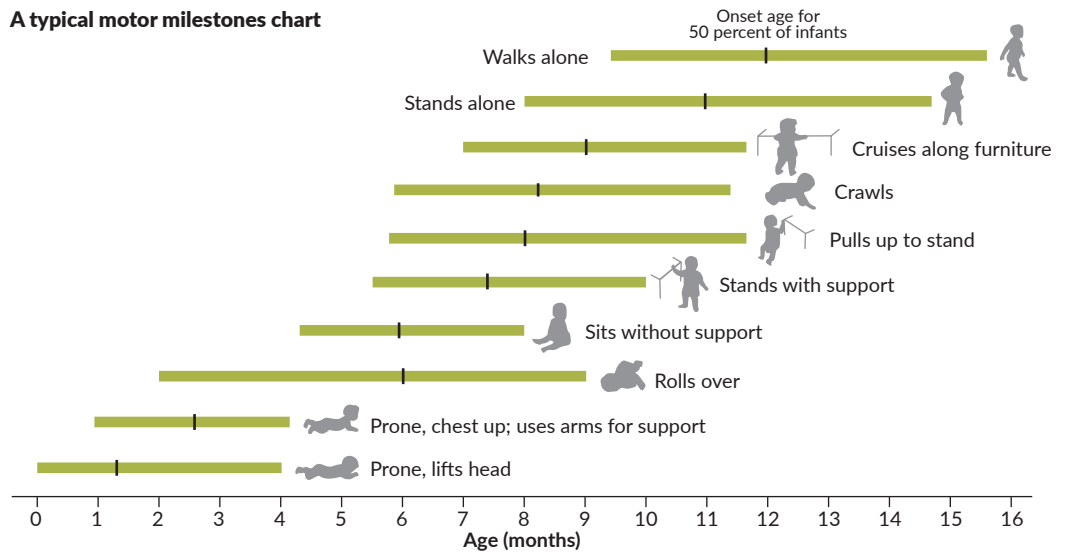
Such charts trace their origins to the early 1900s, when developmental psychologist Arnold Gesell of Yale University began filming babies

Babies and toddlers throughout Central Asia spend long stretches restrained inside cradles known as gahvoras (one shown in Tajikistan). Researchers are studying Tajik children to understand the interplay between this cultural practice and motor development.

Culture void

Motor development charts, like this one based on data from WHO and Canadian researchers, imply that infants learn to move and eventually walk when their bodies are physically ready and that such skills emerge in order. Yet such charts do not account for infants raised in cultures that actively encourage or discourage the development of certain motor skills. SOURCE: HANDBOOK OF INFANT DEVELOPMENT, IN PRESS

A typical motor milestones chart



from behind a one-way mirror. Based on 12,000 recordings, Gesell outlined in 1928 a developmental schedule for babies from 3 to 30 months old.

Meanwhile, psychologist Nancy Bayley began a study tracking development in more than 60 white babies born to relatively affluent families in Berkeley, Calif., in the late 1920s. That decades-long project, known as the Berkeley Growth Study, prompted Bayley to develop a way for a nonfamily member to assess a child’s development, including motor skills. She rolled out the Bayley Scales of Infant Development in 1969. Researchers and clinicians still widely use those scales, now in their fourth iteration.

Gesell, Bayley and others thought that babies began to move when their bodies matured enough to do so, and that motor skills emerged along a linear path, with sitting coming before crawling and crawling before walking. But that thinking hinged on a small set of U.S. babies.

In the early 2000s, the World Health Organization sought to broaden research on motor development to include the rest of the world. WHO researchers measured motor skill acquisition from 4 months to age 2 among 816 babies from five countries: Ghana, India, Norway, Oman and the United States. The analysis, appearing in 2006 in *Acta Paediatrica*, outlined windows of development during which certain motor skills should arise. Failure to achieve those skills within given windows — 8 to 18 months for walking independently, for instance — was considered “evidence of abnormal growth.”

Unfortunately, the WHO relied on Bayley’s motor scale, which meant the study used white U.S. babies as the standard of comparison. Also, the research lacked babies from cultures where

scientists have documented accelerated or uneven patterns of motor development, including the many cultures of Central Asia.

When “norms” based on a narrow sample of babies get built into a model and then that model is applied to a different, but still narrow, sample of babies, the whole system falls apart, says Karen Adolph, a psychologist at NYU. “Do you really want to say a third of the world is delayed and another third of the world is accelerated and our part of the world is normal?”

The need to look beyond the United States was driven home for Adolph several years ago, when she heard from a woman at Procter & Gamble who had been tasked with selling diapers throughout Central Asia. Sales, the woman said, were abysmal. It seemed the gahvora was to blame.

Adolph relayed the story to her graduate student Lana Karasik, who was studying motor development across cultures. Karasik replied that her husband’s family is from the region. “I know that practice,” she said. So several months later, in early 2014 and in collaboration with UNICEF and Save the Children, Karasik, Adolph and Tamis-LeMonda launched a study of motor development in babies in Tajikistan.

Culture clash

As Gesell and Bayley were building their models of motor development, other researchers had begun to document deviations from those standards. Charles Super, a developmental psychologist at the University of Connecticut in Storrs, recalls reading a paper from a researcher studying Ugandan infants in the 1950s. Ugandan babies walked much earlier than babies in the West. The

researcher wrongly interpreted that difference as an inferiority, suggesting that fast development would mean intellectual stunting, Super recalls. “I didn’t like that argument.”

In the 1970s, Super moved to Kenya to be with his wife, an anthropologist who was doing fieldwork there. He took the opportunity to investigate motor development among babies born in a farming community known as Kokwet. Between 1972 and 1975, he documented when those babies acquired new motor skills using the Bayley scale and interviewed mothers about their child-rearing practices.

Kokwet babies sat, stood and walked about a month earlier than Western infants, Super reported in 1976 in *Developmental Medicine & Child Neurology*. But the babies were slower to master other skills, such as lifting their heads, rolling over and crawling.

Super observed that mothers wore their babies on their backs while laboring in the fields. He suspected that vigorous motion gave the babies the sort of constant exercise needed to help develop strength and agility. The mothers also told Super they actively trained their children to walk through exercises like air stepping.

“The parents had a theory: If you don’t teach your children to walk, they won’t walk,” Super says. At the same time, however, mothers sought to keep their babies from crawling given myriad dangers on the ground, such as open fire pits and snakes. The training combined with the restrictions probably explains the development patterns that Super observed that were outside of normal ranges. His findings agreed with observations made elsewhere.

For instance, anthropologist Alma Gottlieb’s research on the Beng people in Ivory Coast from the late 1970s to the early 1990s showed that Beng babies sit earlier than Western babies but are actively discouraged from walking before age 1. The Beng believe that early walking can cause a grandparent’s early death, says Gottlieb, a visiting scholar at Brown University in Providence, R.I. And keeping the babies close and happy discourages the little ones from returning to a previous life.

When German psychologist Heidi Keller used Bayley’s rubric on the Nso people in Cameroon in the 1990s and 2000s, she found their motor skills were mostly advanced compared with German babies. She attributed the difference to the fact that Nso babies are in constant contact with caregivers and provided with regular exercise and massage. “Every culture emphasizes the domains of development that are considered important,” Keller says.

Motor skills can be acquired “out of order” and selectively accelerated or decelerated through cultural practices, research by Super, Gottlieb, Keller and others have shown.

In recent years, researchers have conducted experiments to see if training can accelerate motor skill development. At a public pool in Reykjavík, Iceland, one dynamic swim instructor taught a dozen 3- to 5-month-old babies to stand atop a hand or board – well in advance of the 9-month “norm” for standing, researchers reported in 2017 in *Frontiers in Psychology*.

One natural, unintended experiment came from advice from the American Academy of Pediatrics in the 1990s. To reduce the risk of sudden infant death syndrome, or SIDS, which is more likely to occur in babies who sleep on their bellies, the academy suggested that babies be placed on their backs to sleep. But back sleeping delayed when those infants developed the abilities to roll, sit, crawl and stand. Importantly, studies looking into the delay found that these babies eventually caught up to their stomach-sleeping peers. Just in case, the academy now recommends daily tummy time, where babies play on their stomachs to build strong muscles.

Cradled and bound

Rugged, mountainous Tajikistan is bordered by China, Afghanistan, Uzbekistan and Kyrgyzstan.



At almost 5 months old, this baby stands on a kickboard at a pool in Reykjavík, Iceland. A dozen 3- to 5-month-olds learned to stand well in advance of their peers – suggesting that training can speed the acquisition of motor skills in babies.

Following the collapse of the Soviet Union, the country experienced a civil war. Today, infrastructure remains poor, with snow and flooding making the winding, mountain roads impassable for much of the year. Those logistical challenges have limited Karasik's research to the capital city of Dushanbe and surrounding villages. She travels with behavioral scientist Scott Robinson, who got involved with the work while spending a semester in Adolph's lab.

Karasik, a Belarusian refugee who moved to the United States in 1989 at age 10, is well-suited to working in Tajikistan. She can communicate in Russian, which many Tajiks still speak, fostering a level of trust in Karasik not often afforded to outsiders. She has also recruited Dodojonova and other local Tajik women to run her project while she's away.

With so little known about gahvora cradles, especially in rural areas, Karasik's first order of business was to document Tajik life. In the villages Karasik and her team visited, families live in one-room clay huts and share labor and child-care duties with neighbors. Almost half the fathers work as laborers in Russia and are absent for extended periods; the rest work odd jobs or are unemployed. Electricity tends to work for only two hours in the morning and two at night, during which time families watch television and eat dinner. The gahvora is placed in the center of the room.

Karasik's team measured gahvora use through videos and interviews with mothers. All but three of 185 mothers interviewed used a gahvora, the team reported in October 2018 in *PLOS ONE*. Newborns spent anywhere from 8.5 to 23 hours a day in the cradle; 2-year-olds spent two to

14.5 hours. About 40 percent of mothers breast-fed babies while leaning over the gahvora, and 83 percent of the moms engaged in vigorous rocking that lasted anywhere from about four to 22 minutes at a time.

In July 2018, Karasik presented unpublished research in Philadelphia at the International Congress of Infant Studies showing that Tajik babies hit motor skill milestones months later than babies in the WHO study. For instance, at 1 year of age, almost all infants in the WHO sample were crawling and half were walking. At age 1, just 62 percent of Tajik babies are crawling and 9 percent are walking. Using WHO standards, almost half of all Tajik babies would be diagnosed with motor delays, Karasik says.

But Tajik babies seem to catch up to their Western peers by about age 4 with no discernible long-term repercussions, data collected by Karasik show. What Karasik really wants to understand moving forward is how being bound for such long stretches during those early formative years affects other areas of development and even babies' temperaments.

Walking and talking

The idea that the acquisition of a new motor skill triggers other skills is known as the developmental cascade. When a baby acquires a new way of getting around, the child's vantage point changes, along with interactions with caregivers and the ability to explore the environment, says Eric Walle, a developmental psychologist at the University of California, Merced. Walle is particularly interested in the link between walking and language.

After discovering that babies who can walk have larger vocabularies than infants who are still crawling, Walle decided to see what would happen to language skills if he tweaked when babies learned to walk. But "you can't really experimentally manipulate walking onset," he says.

So Walle did the next best thing. He took his research to Shanghai, where babies typically walk about six weeks later than U.S. babies. That difference may be because babies in urban China live in more cramped environments and have less opportunity to move around than U.S. babies.

He compared the language skills of 40 12.5-month-old U.S. babies with 42 Chinese babies, ages 13 to 14.5 months old. Both groups were almost evenly split between walkers and crawlers. His analysis, appearing in 2015 in *Infancy*, showed that the same divergence in language abilities seen between walking versus



Veronique Amenan Akpoueh carries her young grandson on her back as she roasts corn. The Beng people of Ivory Coast believe that infants yearn to return to a previous life. Holding babies constantly is thought to keep them happy so they forget that desire. It's seen as a way to reduce the risk of infant mortality.

crawling American infants also occurs in Chinese babies. In other words, language skills emerge alongside the ability to walk.

“Even though these kids were walking later, growing up in a very different culture, and exposed to a very different language, they were showing a similar difference,” Walle says. “Walking shakes up the system.”

A child's view

Karasik is keen to see if the gahvora influences how Tajik babies think. Testing that link in a remote region with a dodgy supply of electricity has proved challenging, though. For instance, eye trackers are often used to study how infants view the world around them. But typical eye trackers are designed to be stationary, which means they're heavy and expensive.

Enter visual perception researcher Kirsten Dalrymple of the University of Minnesota in Minneapolis. Her team has developed a portable eye tracker that runs on batteries, useful for remote villages. Dalrymple also had some idea about the areas of development to focus on, such as the ability to match sights and sounds, which in U.S. babies has been shown to develop alongside motor ability.

“Our brains have to learn: ‘Hey, every time I clap my hands together, this noise comes out.’ That's not something we're born with,” Dalrymple says.

Karasik and Dalrymple began by gauging when American babies develop that ability. Babies come into the lab, and the eye tracker sits on a nearby table, where it uses a camera to measure reflections coming off the eye. On a computer screen synced to the tracker, two cartoon animals jump up and down, but only one is paired with a “doink” sound.

When a baby's eyes focus only on the animal making noise, researchers interpret that as the baby correctly pairing sights and sounds. An unpublished pilot study of 30 babies in Minnesota suggests that pairing ability appeared at an age of around 9 months in those babies.

In January, Karasik traveled to Tajikistan and trained Dodojonova to use the portable eye tracker. If perception and action are linked, and Tajik babies' motor development is delayed relative to Western babies, then the ability to link sights and sounds should also be delayed. The researchers are analyzing their data now.

Karasik and her colleagues also hope to start collecting data on Tajik babies' temperaments, which in infants is thought to manifest as individual differences in reacting to events and regulating



emotions. Does restriction in a gahvora change how Tajik babies respond to people around them or behave outside the gahvora? “Even if babies are out, they may not be taking the opportunity to move,” Karasik says.

She plans to administer a standard temperament survey that asks moms to answer questions over a weeklong period and covers issues such as “How often does your baby play with a single toy or object for five to 10 minutes?” and “How often does your baby fall asleep within 10 minutes?”

The team suspects the gahvora teaches babies restraint. Back when the project first started, Tamis-LeMonda recalls, the researchers wanted to record babies' cries as they were put into the gahvora — an idea that was soon scrapped. The babies didn't fuss or cry.

The idea that the gahvora builds traits like patience and mindfulness resonates with Dodojonova, who has become one of the cradle's staunchest advocates. In recent years, she has taken to writing pamphlets calling on mothers to continue cradling. The practice is under threat, she says, from disposable diapers, which are now widely available, and Tajik pediatricians who embrace Western notions that are at odds with cradle use, such as tummy time and breastfeeding in the mother's arms.

The gahvora teaches children that “they cannot do everything that they want,” Dodojonova says. What parent wouldn't wish for that? ■

Explore more

■ Jaya Rachwani, Justine Hoch and Karen E. Adolph. “Action in development: plasticity, variability and flexibility.” *Handbook of Infant Development*, in press. bit.ly/ActionInDev

A Tajik child watches two cartoon pigs on a screen. Only one makes a “doink” sound when it bounces. Researchers use eye trackers to see when the child's eyes hone in on the noisy animal, indicating that the child has learned to pair sights and sounds, a skill that may arise alongside motor ability.

The Expanding Question

Scientists tackle conflict over how fast the universe is ballooning
By Emily Conover

In a room just steps from the ocean in Santa Barbara, Calif., astronomers and physicists shifted restlessly in their chairs. Sunshine and sea breezes beckoned, but the group had cloistered itself to debate one of the biggest quandaries in physics: How fast is the universe expanding?

Much is at stake. Scientists thought they had a handle on how the universe works, including how quickly it is spreading out. But a growing list of conflicting results on the expansion rate is calling into question fundamental knowledge about the contents of the universe and how it evolves over time.

In the last two decades or so, a theory known as the standard cosmological model has gained favor among scientists for its ability to explain a wide variety of cosmic observations. But a discrepancy in measurements of the universe's expansion could mean the model itself needs to drastically change.

Estimates based on exploding stars, or supernovas, suggest that the universe is growing approximately 10 percent faster than another method had predicted. That estimate was made with light emitted just after the Big Bang, about 13.8 billion years ago. Days before the meeting, a third measurement, based on observations of luminous objects called quasars, reinforced the controversy. When combined with the supernova estimate, it pushed the severity of the discrepancy beyond a statistical benchmark known as five sigma. The issue needed to be taken seriously.

Measurements of the universe's current expansion rate fall into two camps. The methods that use information from the early universe — like that post-Big Bang light, called the cosmic microwave background — result in lower expansion speeds than those relying on quasars and supernovas, denizens of the late universe. The seaside meeting, called “Tensions between the early and the late universe,” was organized to address this issue. It was held at the Kavli Institute for Theoretical Physics at the University of California, Santa Barbara.

At the front of the room on July 15, two Nobel Prize-winning

physics titans debated the appropriate level of alarm. Adam Riess, a cosmologist at the Space Telescope Science Institute in Baltimore, asked theoretical particle physicist David Gross: How would particle physicists refer to a discrepancy this large?

“If we found something like this ... we wouldn't call it a tension or a problem, but rather a crisis,” said Gross, of the Kavli Institute.

But not everyone agrees that the problem is real. In physicists' version of a mic drop, a team of researchers released a study online that evening challenging the narrative. A new version of the supernova technique found a value of the Hubble constant, the parameter that quantifies the universe's expansion, that fell in between the two conflicting sets of measurements from the early and late universe. When experimental error was taken into account, this new supernova value wasn't far from either camp's estimates. Declaring a crisis may be premature.

However, if the impasse can't be explained away by experimental error, “it would mean that there is really something very important that we do not understand from the very early universe,” says theoretical physicist

Vivian Poulin of France's CNRS and Laboratoire Univers et Particules de Montpellier. If unknown phenomena existed in the infant cosmos — such as a different type of dark energy or unknown subatomic particles — that could alter our understanding of how the universe has changed over time, and possibly bring the measurements back into agreement.

An inexplicable gap
One technique for measuring the expansion of the universe is to take a “baby picture” of the cosmos and extrapolate to present day. That infant image is the cosmic microwave background. To translate that information into today's expansion rate, scientists use the standard cosmological model.

An inexplicable gap

Based on cosmic microwave background measurements



The universe's expansion rate can be measured using type 1a supernovas. A remnant of one such stellar explosion is shown.

from the European Space Agency's Planck satellite, scientists have estimated that the universe is expanding at a rate of 67.4 kilometers per second for each megaparsec, or about 3 million light-years, of distance between objects (*SN: 3/21/15, p. 7*). The number leaves little wiggle room for disagreement: The experimental error is only 0.5 km/s/Mpc.

But within the last five years, supernova measurements have found larger expansion rates. The latest estimate from an effort led by Riess called SH0ES settled on 74.0 km/s/Mpc, give or take an error of 1.4 km/s/Mpc. That leaves an inexplicable 10 percent gap between the two estimates. Now "the community has started to take this [problem] extremely seriously," says cosmologist Daniel Scolnic of Duke University, who works on SH0ES.

It's unlikely that an experimental error in the estimate from Planck could explain the discrepancy. That prospect is "not a possible route out of our current crisis," cosmologist Lloyd Knox of the University of California, Davis said at the meeting. Plus, another technique with its basis in the early universe — the measurement of sound waves known as baryon acoustic oscillations — when combined with other measurements agrees with the slower expansion rate from Planck.

Instead, worries have centered on the possibility that the supernova measurements contain unaccounted for biases that push the SH0ES estimate to a larger value. "What keeps me awake at night is, what are the [biases] that we might not know about when we only do one method?" says cosmologist Wendy Freedman of the University of Chicago.

Freedman took it upon herself to check.

Distance woes

To measure how fast the universe is expanding right now, scientists need to combine two bits of information: how fast distant objects appear to be receding from us and how far away they are. The first is relatively easy. Scientists look for a redshift, a stretching of the wavelengths of light emitted by an object.

Measuring distances is much trickier. Astronomers employ "standard candles," celestial objects that emit a quantifiable brightness, such as explosions of a supernova variety called type 1a. As with a real candle, if an object's brightness is known, scientists can determine how far away it is by how much it has dimmed due to distance.

Setting the distance scale requires a "distance ladder," using

nearby objects of known brightness as a bridge to supernovas farther away. For one rung of that distance ladder, the SH0ES team uses stars known as Cepheids, which regularly vary in luminosity in a way that allows scientists to estimate the stars' overall brightness.

To check the previous supernova results, Freedman came up with a new distance ladder that she says is "completely different from the ground up." Instead of Cepheids, she and colleagues used stars called red giants, which, at a certain stage in their lives, achieve a maximum brightness that is the same for each star.

In that well-timed mic drop at the July meeting, Freedman unveiled her team's result. (The related paper is in press at the *Astrophysical Journal*.) The result fell in between the conflicting estimates from SH0ES and Planck, at 69.8 km/s/Mpc. With a calm firmness, Freedman pushed back on declarations of a crisis, saying that her team's result should cause researchers to pause (*SN Online: 7/16/19*).

Holy cow, HOLICOW

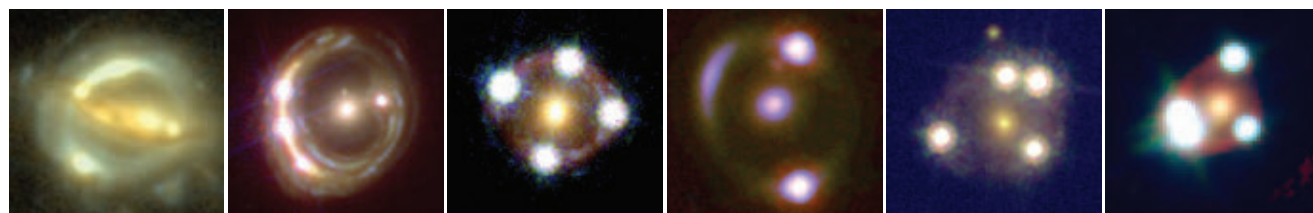
But even as Freedman's revelation weakened the case for calamity, momentum toward a declaration of crisis was already building. Just a few days before the meeting, the HOLICOW collaboration had posted two studies online at arXiv.org on the quasar measurement. That measurement of the Hubble constant was based on gravitational lensing of quasars, bright sources of light powered by a supermassive black hole at the center of a galaxy.

Just like a lens, massive objects can bend light's path. The researchers looked at quasars that had been split into multiple images by such gravitational lenses, making one quasar look like two or more. The phenomenon is similar to the doubled image of a fish that you might see as it swims near the corner of a fish tank.

Studying how each quasar's split images flicker over time resulted in an expansion rate closer to the late universe value — a Hubble constant of 73.3 km/s/Mpc. "It seems like this [crisis] is more real after our result," says cosmologist Geoff Chih-Fan Chen of UC Davis.

Crucially, the researchers did their work "blind," meaning that they hid the answer from themselves until the analysis was finalized. This technique can prevent an unintended tendency for analyzers to align their result with previously measured values of the Hubble constant. Despite that blinding,

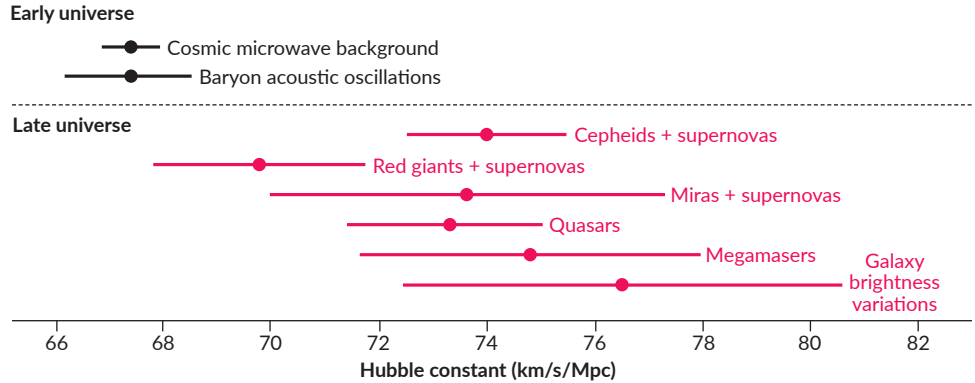
Observing the flickering of quasars can help scientists measure the expansion rate of the universe. In each box, one quasar appears as multiple images (bright dots) due to the bending of light called gravitational lensing. Researchers monitor those images for differences in the timing of flickers.



Early vs. late Estimates of the universe's expansion rate based on the physics of the early universe have lower values (black lines) than those based on the late universe (red lines). Some late universe measurements use type 1a supernovas in conjunction with stars known as Cepheids, red giants that have reached their peak brightness or Miras, red giants that pulsate in brightness over time. Other late universe estimates are based on luminous quasars, objects called megamasers and on how brightness varies within galaxies.

SOURCE: VIVIEN BONVIN

Estimates of how fast the universe is expanding don't line up



the result was like an “echo” of the SH0ES result, Chen says.

Meanwhile at the meeting, astronomer Mark Reid of the Harvard-Smithsonian Center for Astrophysics reported a Hubble constant measurement based on megamasers — clouds of gas swirling around a black hole that emit light of a particular wavelength, akin to a laser’s. That estimate was likewise in line with the higher set of values, 74.8 km/s/Mpc.

Other researchers at the meeting presented new measurements, based on variations in the brightness of a galaxy across the pixels of an image (76.5 km/s/Mpc) and on another supernova technique variation, using stars called Miras, red giants that pulsate in brightness over time (73.6 km/s/Mpc), instead of Cepheids or red giants at their peak stage of brightness.

The universe speaks?

Meanwhile, another cosmological puzzle is garnering attention, says cosmologist Hendrik Hildebrandt of Ruhr-Universität Bochum in Germany. There are hints of disagreements in measurements of the clumpiness of matter in the universe, as measured by a parameter known as sigma-8.

To detect this clumpiness, scientists survey the sky, looking for a weak variety of gravitational lensing in which galaxies appear to be slightly aligned with each other. This lensing can be used to infer the distribution of mass in the universe. But, much like with the Hubble constant, a measurement of sigma-8 performed by an international effort called the Kilo-Degree Survey disagrees with estimates based on the cosmic microwave background.

“The sigma-8 tension is the second question mark that we have,” Hildebrandt says. But the discrepancy is not as significant, he notes, and it hasn’t been studied as closely.

Some scientists are wondering if there’s any connection between this possible discrepancy and the expansion rate dilemma. If researchers determine that there is a second potential problem with their understanding of the universe, it would strengthen the case that something is wrong altogether.

If the crisis persists, a new theory will be needed that is consistent with all the data. But scientists have struggled to find a cohesive explanation. Almost any tweak to the standard

cosmological model — adding in new types of subatomic particles, for example — would conflict with other measurements, throwing physics into turmoil.

“We have so many different ways of probing the universe that it’s very hard to come up with an elegant theory that passes all the tests without creating new tensions,” says cosmologist Dillon Brout of the University of Pennsylvania.

One potential solution involves an addition to the mysterious dark energy that is causing the universe’s expansion to accelerate. An “early dark energy” could have acted in the universe’s youth, altering the expansion around the time the cosmic microwave background was released, Poulin and colleagues reported at the meeting and in the June 7 *Physical Review Letters*.

And disagreement over the Hubble constant has precedent: The constant has a history of confusing estimates, says Lucas Macri, an astronomer at Texas A&M University in College Station. In those earlier cases, “the universe was trying to tell you that you didn’t have the whole picture.” In one case, for example, some stars seemed older than the age of the universe. Since scientists need to know the universe’s expansion history to determine how old it is, if the Hubble constant estimates are off, the universe’s age is too. The resolution of that earlier question about the stars’ ages eventually came in the revelation of the existence of dark energy.


After days of discussion, the evidence had been tallied. The meeting organizers asked for a show of hands: Should the Hubble constant woes be called a tension, a problem or a crisis?

Cosmologists, it turned out, were a little hesitant to throw out what they thought they knew about the universe. Only a smattering of hands went up for “crisis.” Arguments that a solution might be found without revamping physics seemed to have held sway.

Still, if the Hubble constant puzzle persists, that could mean the universe is once again trying to speak up. ■

Explore more

- Adam Riess. “Local H0 from SH0ES.” KITP Conference: Tensions between the early and the late universe. Santa Barbara, Calif., July 15, 2019. bit.ly/KITPconfRiess



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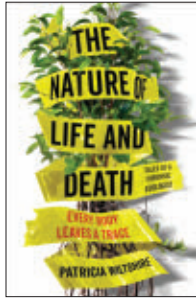
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The Nature of Life and Death
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BOOKSHELF

Pollen and spores star in tales of true crime

Even if a criminal doesn't leave behind fingerprints or DNA, detectives need not worry. Crime scenes are peppered with other clues — pollen and spores — that can trip up even the most careful crooks.

These clues are central to forensic ecology, in which scientists analyze biological material to help detectives solve crimes. In *The Nature of Life and Death*, botanist Patricia Wiltshire lays out the

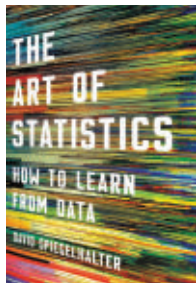
science underlying the discipline — which she helped pioneer in the United Kingdom — as she chronicles some of her most memorable cases of the last 20 or so years.

Early in her career, Wiltshire used the power of pollen and spores to analyze archaeological sites. The qualities that make these particles useful for studying the past also make them useful for solving crimes. The particles' natural polymers can be long-lasting, and in certain conditions, pollen and spores persist longer than other forms of evidence, even for thousands of years. More important for detectives,

these biological bits are often as distinctive as the plants and fungi that make them, providing telltale clues of where a crime has happened or where a criminal has been. In part because of their minuscule size, pollen and spores are particularly susceptible to static electricity, doggedly clinging to the clothing and hair of victims and perpetrators alike. Criminals often don't even realize they're covered in the tiny particles.

The combination of pollen and spores at a site can be as distinct as a fingerprint, especially when dealing with rare plants or fungi, or pollen that isn't spread far and wide by the wind, Wiltshire explains. By studying the material, she has, for example, determined where and during which season crimes have occurred. In one murder case, Wiltshire used pollen and spores from a gardening tool, the tennis shoes of the murderer and the foot pedals of the victim's car to identify the woodland locale in northern England where the victim's body had been dumped. The same sorts of clues can also help police narrow down where a sexual assault has happened and how the crime unfolded, thus bolstering a victim's claim or exonerating the wrongly accused.

Fascinating through and through, the tales Wiltshire shares are worthy of any true-crime novel or TV drama such as *NCIS*. — *Sid Perkins*



The Art of Statistics
 David Spiegelhalter
 BASIC BOOKS, \$32

BOOKSHELF

Telling the real truth about statistics

There are, as the saying goes, three kinds of lies: lies, damned lies and statistics. David Spiegelhalter is here to keep you from being duped by data.

If you're seeking a plain-language intro to statistics, or just want to get better at judging the reliability of numbers in the news, Spiegelhalter's *The*

Art of Statistics is a solid crash course. The book is less about learning how to use specific mathematical tools than it is about exploring the myriad ways statistics can help solve real-world problems — and why statistical claims often have to be padded with caveats.

Spiegelhalter, a statistician at the University of Cambridge, keeps things lively by tying new concepts to questions. For instance, should you fret that eating bacon will increase your risk of bowel cancer? The relative risk might make you think so: People who eat a bacon sandwich every day have an 18 percent higher risk of bowel cancer than those who don't. But looking at the absolute risk — a rise of 6 to 7 cases per 100 people — may put your mind at ease.

Spiegelhalter's narration is encouraging, and he knows where beginners are likely to get tripped up. He makes dense sections easier to parse by including frequent recaps and lots

of data visualizations, and tucking equations into footnotes.

The Art of Statistics is alight with his enthusiasm for how statistics can be used to glean information for court cases, city planning and a host of other sectors. But Spiegelhalter warns readers not to forget the assumptions and uncertainties inherent in any analysis, and tells many cautionary tales about the ways statistics can go astray. Patchy samples and logical missteps can lead to faulty conclusions. And bad-faith statistical practices have contributed to the reproducibility crisis in psychology and other areas of science (*SN*: 4/2/16, p. 8). Perhaps the most flagrant example is how social psychologist Daryl Bem manipulated study designs and cherry-picked data to publish statistically significant results in 2011 that suggested humans have extrasensory perception.

Spiegelhalter doesn't let the media off the hook, either. Many of the questions he uses to introduce topics are drawn from misleading news reports. Such debunked articles include one claiming that going to college increases your risk of getting a brain tumor — which mistook correlation for causation in data on socioeconomic status and tumor diagnoses — and another where confusing risks and ratios caused a media outlet to state that a cholesterol medication increased risk of muscle pain by up to 20, not 2, percent.

The Art of Statistics leaves readers with a better handle on the ins and outs of data analysis, as well as a heightened awareness that, as Spiegelhalter writes, "Numbers may appear to be cold, hard facts, but ... they need to be treated with delicacy." — *Maria Temming*

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Climate Change Chronicles

No single species has ever been responsible for big changes on Earth. Until now. Human activities, particularly the burning of fossil fuels, have emerged as a driving force in changing the chemistry of Earth's atmosphere. Through news stories, features and explainers, our yearlong series, Climate Change Chronicles, investigated these changes, what the new science suggests is causing them and how life on Earth is adapting. Here are just a few of the stories from the series.



The big melt: Earth's ice sheets are under attack

Due to rising temperatures in Earth's oceans and atmosphere, Antarctica's rate of ice loss has increased from roughly 40 billion tons per year in the 1980s to around 250 billion tons per year currently. Scientists say that the rate of ice loss could increase tenfold by the end of the century. Rapidly melting ice sheets around the world could raise sea levels up to 1.8 meters (about six feet) by 2100, threatening coastal cities. – Douglas Fox

Read more: www.sciencenewsforstudents.org/big-melt

Warning: Climate change can harm your health

Between 2030 and 2050, a quarter million more people will die each year than would if climate change were not a factor, the World Health Organization predicts. Threats range from extreme heat to more air and water pollution to the spread of infectious diseases. The higher the average global temperature climbs, the worse climate's health impacts will be, experts say. But the more scientists and engineers learn about climate change and its impacts, the better prepared people will be to deal with those impacts. – Kathiann Kowalski

Read more: www.sciencenewsforstudents.org/climate-change-warning



Warming pushes lobsters and other species to seek cooler homes

As the world warms, lobsters are chasing their preferred temperatures, spreading into places once too cold and leaving those that are now too warm. This movement is not unusual. Many plants and animals around the world, on land and in the sea, are also on the move. As a result, old ecosystems are falling apart and new ones are forming. Some species will be winners. Others will be losers. This is also true for the people who depend on these ecosystems for food, jobs and transportation. – Sarah Zielinski

Read more: www.sciencenewsforstudents.org/lobsters-ecosystems





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AUGUST 3, 2019

SOCIAL MEDIA

Unsettling science

The creepy sensation we feel when seeing humanlike robots (an example shown below) may have roots in a region of the brain called the ventromedial prefrontal cortex, **Maria Temming** reported in “Why some robots are so unsettling” (SN: 8/3/19, p. 12). Reddit user **burtzev** joked about the finding: “One small step for neuroscience; one giant leap for horror films.”



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Aging mind-set

*Subtle messages that can shift perceptions of aging in older people from negative to positive might lead to better health, **Robin Marantz Henig** reported in “Positive spin” (SN: 8/3/19, p. 22).*

One study reported in the story found that older people exposed subliminally to positive age-related words performed better on memory tests compared with people exposed to negative age-related words. “I wonder if the effects were simply from negative/positive words and not necessarily age-related words. Would the results have been the same with words like ‘ugly’ or ‘smart?’” reader **Jeff Haugh** asked.

“It’s quite possible that people would respond negatively to subliminal exposure to words like ‘ugly,’ and positively to words like ‘smart,’” **Henig** says. In this study, the scientists went to great pains, through the use of focus groups, to be sure that the words in the experiment were specifically words that people associate with aging stereotypes, she says. But subsequent work by these scientists and others “tended to confirm that it’s the words that are both negative and age-related that do a double whammy kind of damage,” **Henig** says.

Coral conundrum

*A coral disease discovered in Florida is spreading through the Caribbean, **Cassie Martin** reported in “Mystery disease is ravaging coral reefs,” (SN: 8/3/19, p. 14). Scientists in Florida are turning to antibiotics, while researchers in the Caribbean are removing sick corals from reefs.*

Readers online were concerned that the antibiotic treatment could lead to widespread drug resistance in marine ecosystems.

“We have a mixed relationship with our feeling on antibiotics,” says **Karen Neely**, a marine biologist at Nova Southeastern University in Fort Lauderdale, Fla. Antibiotic resistance is a concern, but the risk of not using antibiotics in this case is huge: The disease could wipe out entire coral species from Florida reefs, she says.

To lessen the chance of antibiotic resistance in the environment, **Neely** and others treat sick corals with a paste that releases an antibiotic directly into coral tissue instead of the surrounding water.

Mantis vision


*In praying mantises, four types of nerve cells are involved in 3-D vision, **Laura Sanders** reported in “How praying mantises can see in 3-D” (SN: 8/3/19, p. 32).* Reader **David Kollas** was surprised to learn that the praying mantis is the only insect known to see in 3-D. “Recently I have watched large black and white dragonflies moving quickly up and down between tightly spaced rows of young potted apple tree clones in my orchard nursery,” **Kollas** wrote. “When chased or chasing, they can find small openings between the trees in a row, darting to an adjacent alleyway without hesitation or collision... at full speed! I have puzzled about such confident ability. But now I am near incredulity, thinking they must do it all in what is seen as a two-dimensional world!”

Whether adult dragonflies are capable of what scientists consider to be true 3-D vision is an open question. Definitive experiments that involve studying the differences between how each eye views an object have yet to be done, says neuroscientist **Ronny Rosner** of Newcastle University in England.

Insect scientist **Robert Olberg** notes that dragonflies probably judge depth in part with a trick called motion parallax. It is the effect you get when you look out of a moving car and near objects appear to move faster than objects in the distance. “Exactly how much depth perception adult dragonflies have is still a matter of debate, but my personal opinion is that dragonflies can judge distance pretty well,” says **Olberg**, of Union College in Schenectady, N.Y. Dragonflies have incredibly fast visual systems, he says. That speed plus “an impressive flight control system could explain the remarkable maneuverability [**Kollas**] describes in his orchard nursery,” **Olberg** says.

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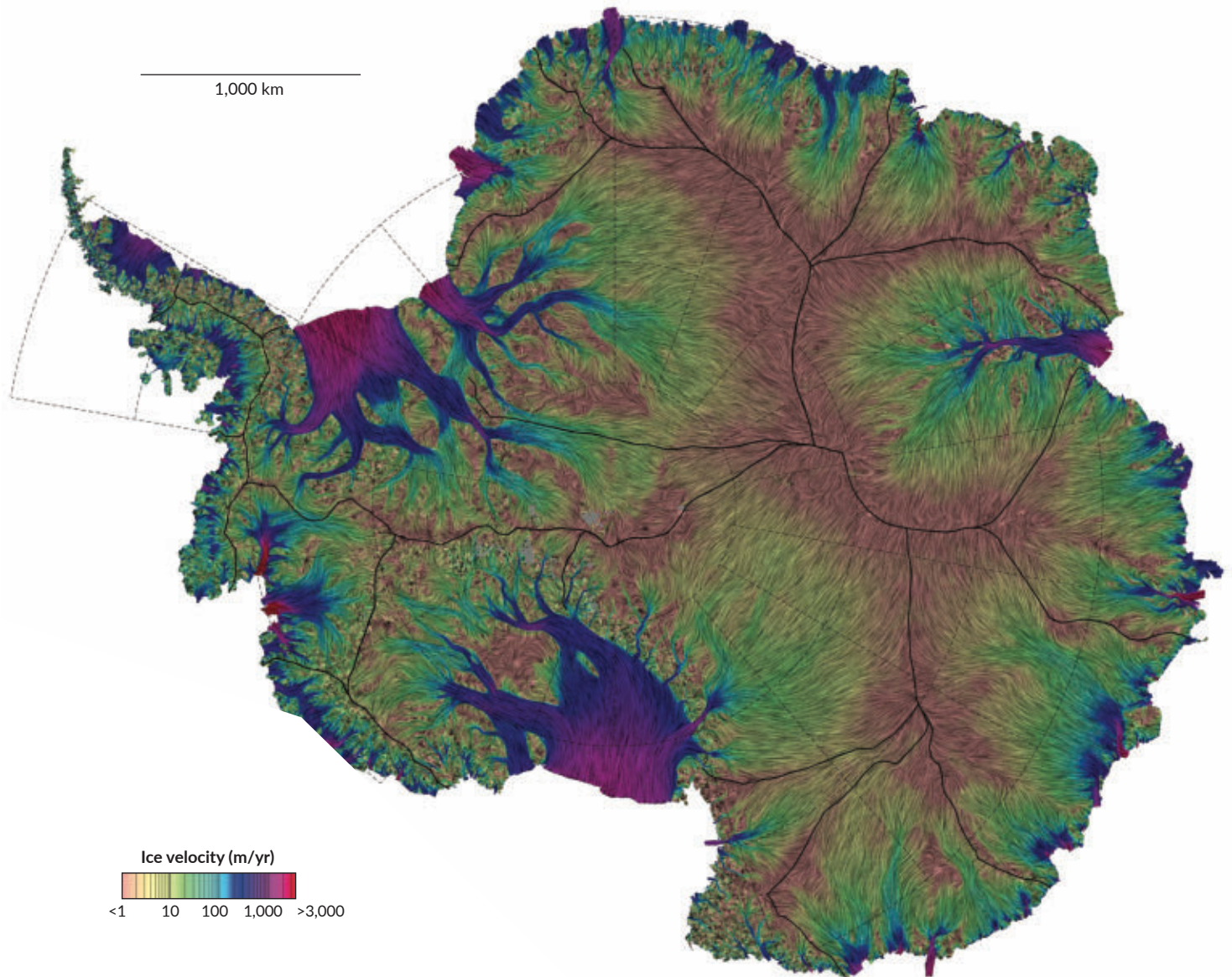
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How fast (and slow) Antarctica's ice moves

Decades of satellite observations have now provided the most detailed look yet at how ice in Antarctica sheds into the Southern Ocean.

The new map, described online August 23 in *Geophysical Research Letters*, is based on an ice-tracking technique that is 10 times as precise as those used in previous surveys. The method offers the first comprehensive view of the velocity of ice flow across Antarctica from areas of high elevation (thick black lines in the map) to the coasts.

Inland ice moves incredibly slowly, the map reveals, with much of that ice plodding along at less than 10 meters per year (beige and yellow). Closer to the ocean, rapidly melting ice can travel hundreds to thousands of meters per year (blue, purple and red).

Glaciologist Eric Rignot of the University of California, Irvine and colleagues uncovered the subtle movements of Antarctic ice with a technique called synthetic-aperture radar phase interferometry. By using a satellite to bounce radar signals off a patch of ice, researchers can determine how quickly that ice is moving toward or away from the satellite. Combining observations of the same spot from different angles reveals the speed and direction of the ice's motion along the ground.

Charting the flow of Antarctica's ice sheet so exactly could help improve forecasts for how much ice the continent stands to lose to the ocean in the future. Ice melting off of Antarctica is a major driver of global sea level rise (*SN: 7/7/18, p. 6*). — *Maria Temming*

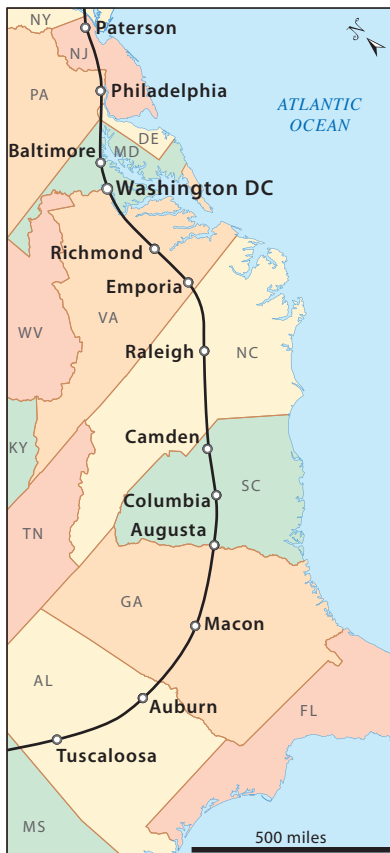
» GEOLOGIC ROAD TRIP OF THE MONTH

GREAT FALLS OF THE POTOMAC

Many an early seafaring captain, sailing from the Old World to the New World, hoped to gain historical immortality by discovering the Northwest Passage, the long-sought-after waterway through North America that would connect Europe and Asia. Explorers investigated every river entering the Atlantic Ocean, but on each they found a waterfall marking the upstream limit to navigation—and failure.

Colonists built villages by these cascades and turned obstruction to advantage, using the white water as a source of energy to move waterwheels and power mills. In time the settlements developed into metropolitan areas that today share a common geologic heritage—they are Fall Line cities. Geologically the Fall Line is the east-facing escarpment marking the contact between the upland landscape of the Piedmont Province and the lowland region of the Atlantic Coastal Plain. It can easily be traced—on maps and on the ground—from Tuscaloosa, Alabama, to north of Paterson, New Jersey.

The Fall Line is actually a zone rather than a single, narrow line, and the rapids and waterfalls that characterize it at any given locale



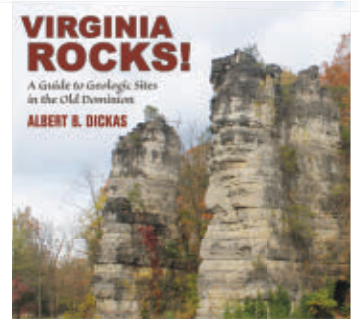
A series of riverfront cities define the trace of the Fall Line (heavy black line) along the East Coast. This contact generally marks the effective limit of upstream navigation.

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may extend for miles. On the Potomac River, the zone of the Fall Line extends from Great Falls Park downstream 15 miles to the geologic contact between Coastal Plain sediments and Piedmont crystalline rock, exposed beneath the I-66 bridge crossing Theodore Roosevelt Island, immediately west of the Watergate Complex in Washington, DC.

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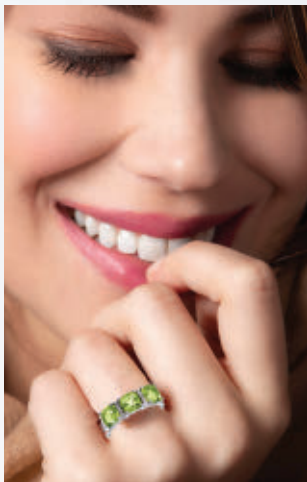


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