SN
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Low-Dose Aspirin Fails Test

World's Oldest Drawing

Birth of a Neutron Star

Superconductors Getting Warm

Scientists to Watch

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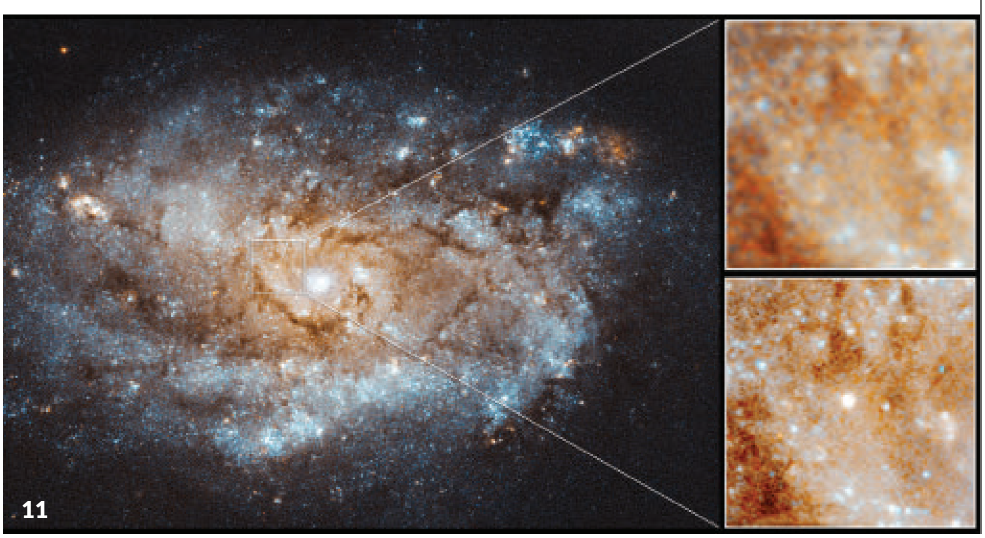
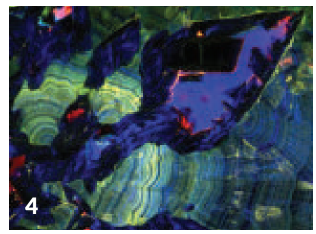
ScienceNews

Feature

News





Departments

COVER These young scientists, the SN 10, are tackling big problems in sustainable energy, medicine, astronomy and technology. *Sam Falconer*

SN 10, CLOCKWISE FROM TOP LEFT: BRYCE VICKMARK; BRYCE VICKMARK; DEPT. OF CHEMISTRY/UIUC; CENTER FOR ADVANCED STUDY IN THE BEHAVIORAL SCIENCES AT STANFORD UNIV.; INSTITUTE FOR ADVANCED STUDY; AMY MANLEY/SYRACUSE UNIV.; C. HAMILTON; MARÍA CECILIA ABARCA/UNIVERSIDAD DIEGO PORTALES; A. SHRIVASTAVA; MEGAN MENDENHALL/DUKE UNIV.; BOTTOM, FROM LEFT: NASA, ESA, J. DEPASQUALE/STSCI; MAYANDI SIVAGURU AND JESSICA SAW/BRUCE FOUKE LAB/ CARL R. WOESE INST. FOR GENOMIC BIOLOGY/UNIV. OF ILLINOIS

Celebrating successes while examining failures

At *Science News*, we focus intently on the "what" of science: what's new in fields from astronomy to zoology. But we also step back and consider the "who," "how" and "why" of the scientific endeavor.

In this special issue, we profile 10 young scientists who aren't afraid to challenge the paradigms of how science is practiced. Rather than stick to one discipline, collaborating across fields seems ingrained in their DNA. And their willingness to leap boundaries and merge seemingly unrelated areas of expertise (engineering and public policy with psychology, for example) to take a fresh look at stubborn problems is getting results.

"She sees things that other researchers do not see," astronomer Kenneth Freeman says of one of our honorees, astrophysicist Paula Jofré. That quality could be applied to each of our honorees. They share a curiosity that drives them forward.

For the third year in a row, we've commissioned artist Sam Falconer to illustrate our SN 10 cover. He has a terrific way of turning the stories of 10 very different researchers into one engrossing image that is fun to explore — a treasure map to the daily work of science. Falconer also illustrated our June 23 cover on mathematician Emmy Noether, the unsung hero of modern-day physics (*SN: 6/23/18, p. 20*). He never disappoints.

Science has its share of disappointments, however. Our mission to cover the "how" and "why" of science also requires us to investigate where scientists fall short. In recent months, we've covered the gender gap in academic publishing (*SN: 5/26/18, p. 32*), as well as a National Academies of Science, Engineering and Medicine report that found that more than half of women in academia have been sexually harassed (*SN Online: 6/22/18*).

Staff writers Bruce Bower and Tina Hesman Saey have been following the replication crisis — the fact that many studies, when repeated by other scientists, don't deliver the same results. Replication serves a core fact-checking function, and the premise is that any new finding should be taken with a grain of salt until it's been verified by others. That's been especially true in the social sciences, where an overreliance on null hypothesis testing as proof of significance has led to a lot of shaky results.

"The social and behavioral sciences are in the midst of a reformation in scientific practices," Brian Nosek, director of the Center for Open Science and a professor of psychology at the University of Virginia in Charlottesville, told Bower (*SN: 9/29/18, p. 10*).

This may sound like bad news compared with the stellar work of our SN 10 honorees. But confronting the replication crisis, along with improving the research process and peer review, is essential to building a solid foundation for the science of the future, which the scientists we've profiled here are hard at work creating.

As we cover the breadth and depth of science, I'll make sure we keep you informed on the exciting work of the next generation of great scientists, as well as where the practice of science falls short. — *Nancy Shute, Editor in Chief*

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SSP

DEGREES OF IMPACT

Dr. Herrera-Estrella, the President's Distinguished Professor of Plant Genomics, will serve as the director of the Center for Functional Genomic of Abiotic Stress, which will examine how plants adapt to thrive in the presence of environmental stresses such as extreme heat and cold, drought and in the presence of brackish water sources. Known and respected worldwide for his work in cotton genomics, Dr. Herrera-Estrella was named one of the 100 most influential people in biotechnology by Scientific American in 2015. His arrival at Texas Tech was made possible by a $5 million grant from the State of Texas Governor's University Research Initiative (GURI) and matched by the university.

Luis Rafael Herrera-Estrella
National Academy of Sciences, Member
College of Agricultural Sciences & Natural Resources
Department of Plant and Soil Science

TEXAS TECH
UNIVERSITY

Excerpt from the October 12, 1968 issue of *Science News*

50 YEARS AGO

550-year-old seed sprouts

A seed of the South America herb achira (*Canna* sp.), taken from an ancient Indian necklace, has germinated, and the young plant is growing well.... Carbon-14 dating of bones at the site sets the seeds' age at about 550 years.... The plant from the old seed appeared to have a disturbed gravity orientation, but is still growing fairly normally.

UPDATE: Scientists continue to test plants' staying power, growing plants from older and older seeds. A roughly 1,300-year-old lotus seed (*SN: 8/31/02, p. 132*) and then a 2,000-year-old date palm seed (*SN: 7/5/08, p. 13*) broke the record for world's oldest viable seeds. Then in 2012, Russian scientists grew a plant from tissue frozen in Siberian permafrost more than 30,000 years ago (*SN: 4/7/12, p. 15*). These successes give hope to seed bank programs that keep plant species in cold storage for future generations.

A loggerhead shrike violently shakes small vertebrate prey — such as this dangling lizard.

IT'S ALIVE

These songbirds violently fling and impale prey

Bite a mouse in the back of the neck and don't let go. Now shake your head at a frenzied 11 turns per second, as if saying "No, no, no, no, no!"

You have just roughly imitated a hunting loggerhead shrike (*Lanius ludovicianus*), already considered one of North America's more ghoulish songbirds for the way it impales its prey on thorns and barbed wire.

Once the shrike hoists its prey onto some prong, the bird will tug the carcass downward "so it's on there to stay," says vertebrate biologist Diego Sustaita. He has witnessed a shrike, about the size of a mockingbird, steadying a skewered frog like a kabob for the grill. A bird might dig in right away, keep the meal for later or just let it sit around and demonstrate the bird's sex appeal (*SN Online: 12/13/13*).

Shrikes eat a lot of hefty insects, mixing in rodents, lizards, snakes and even small birds. The limit for impaling may be close to the shrike's own weight. A 1987 paper reported on a shrike killing a cardinal not quite two grams lighter than its own weight and then struggling to lift off with its prize. Recently, Sustaita got a rare chance to video how the shrikes kill their prey.

Conservationists breed one loggerhead shrike subspecies on San Clemente Island. That's about 120 kilometers west of where Sustaita works at California State University San Marcos. Sustaita set up cameras around a caged feeding arena and filmed shrikes, beak open, lunging to catch dinner. "They're aiming for the prey's neck," he says.

That's a very shrikey thing. Falcons and hawks attack with their talons, but shrikes evolved on the songbird branch of the bird family tree — without such powerful grips. Instead, shrikes land on their feet and attack with their hooked bills. "The bite happens at the same time the feet hit the ground," Sustaita says. If a mouse somehow dodges, the shrike pounces again, "feet first, mouth agape."

Reading several decades of gruesome shrike papers, Sustaita first thought the real killing power came from the bird's bill, with bumps on the side, wedging itself between neck vertebrae and biting into the spine. Shrikes definitely bite, but based on videos, Sustaita now proposes that the shaking may help immobilize or kill prey.

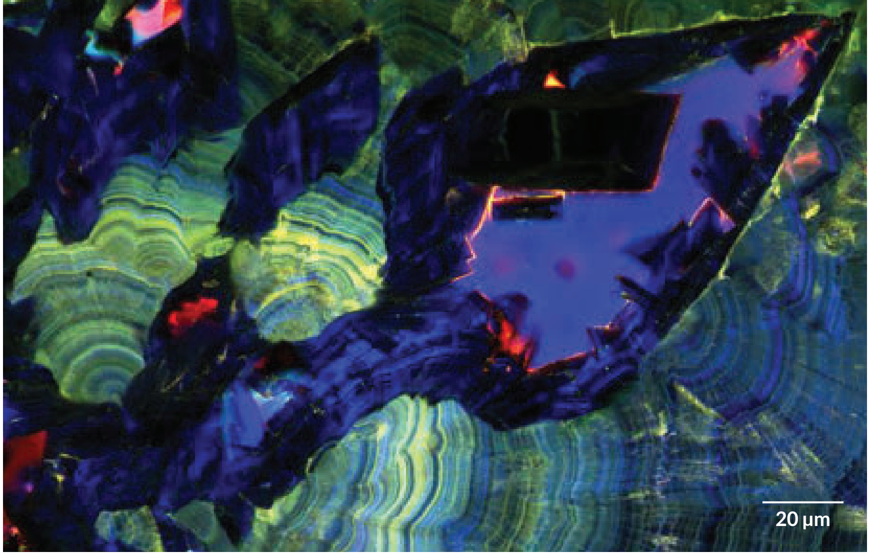
He and colleagues discovered that the San Clemente shrikes fling their mouse prey with a ferocity that reached six times the acceleration of Earth's gravity, the researchers report September 5 in *Biology Letters*. That's about what a person's head would feel in a car crash at about 3 to 16 kilometers per hour — "not superfast," Sustaita says, but enough to give a person whiplash.

In a small mouse, such shaking looks more damaging. Video analysis showed that the mouse's body and head were twisting at different speeds. "Buckling," Sustaita calls it. Just how much damage twisting does versus the neck bite remains unclear. And there's a whole other question: How does a shrike manage not to shake its own brain to mush?

— *Susan Milius*

DANIEL W. CLARK, U.S. NAVY

Watch a loggerhead shrike shake its prey at **bit.ly/SN_shrike**



PICTURE THIS

Suprising beauty found inside kidney stones

Crystal formations in Yellowstone's hot springs helped researchers understand stones much closer to home — in our kidneys. In his field research, geobiologist Bruce Fouke had never seen a stone that "doesn't grow and dissolve, grow and dissolve." But that went against the medical dogma that kidney stones don't dissolve.

So Fouke, of the University of Illinois at Urbana-Champaign, teamed up with an interdisciplinary research group for "a good, geological look at a kidney stone."

Most kidney stones are made of primarily calcium and oxalate, found in nuts, beets and other foods. Shining ultraviolet light on thin sections of a kidney stone revealed colorful mineral strata (green, light blue and yellow layers in fluorescence micrograph above) and collections of new growth (dark blue) that Fouke describes as "beautiful crystals."

The array of crystal hues comes from organic materials — microbes, kidney cells and the chemicals they produce — trapped within the mineral layers, the team explains September 13 in *Scientific Reports*. Bursts of color and different shapes map a stone's history, and show that the crystals do dissolve and leave voids that are then filled by new crystals. Fouke suspects that, like the microbes in Yellowstone's hot springs, kidney microbes may jump-start crystal growth. *— Aimee Cunningham*

FROM TOP: MAYANDI SIVAGURU AND JESSICA SAW/BRUCE FOUKE LAB/CARL R. WOESE INST. FOR GENOMIC BIOLOGY/UNIV. OF ILLINOIS; DAILY HERALD ARCHIVE/SSPL/GETTY IMAGES

SCIENCE STATS

Human gene recount ups the number

Counting how many genes are in the human genetic instruction manual, or genome, isn't easy. A gene's very definition has changed in the last 15 years.

Genes used to be defined as stretches of DNA with instructions that are copied into RNA and turned into proteins. But scientists now know that not all genes produce proteins; some make RNAs with other functions in a cell.

Researchers still don't agree on how many "protein-coding genes" there are. Estimates range from 19,901 to a new count of 21,306, published August 20 in *BMC Biology*. The number of RNA-producing genes is even murkier, says Steven Salzberg, a biostatistician at Johns Hopkins University. His team found 25,525 RNA-producing genes, for a total of 46,831 human genes. "I will not be surprised if 10 years from now, we still don't have an agreed-upon number," Salzberg says.
— Tina Hesman Saey

46,831

Latest tally of human genes

Jocelyn Bell Burnell in 1968.

QUOTED

Jocelyn Bell Burnell wins big in physics

Jocelyn Bell Burnell first noticed the odd, repeating blip in 1967. As a University of Cambridge graduate student, she had been reviewing data from a radio telescope that she had helped build near campus. The signal's source was something entirely unknown: a pulsar, or a rapidly spinning stellar corpse that sweeps beams of radio waves across the sky like a lighthouse. Her pulsar find revolutionized astrophysics and led to the 1974 Nobel Prize in physics — from which she was famously excluded. Now age 75, Bell Burnell received the Special Breakthrough Prize in Fundamental Physics on September 6. She is donating the $3 million prize money to create scholarships for underrepresented minorities. *— Lisa Grossman*

***SN*: What have pulsars taught us?**

Bell Burnell: We've learned a lot about extreme physics, because pulsars are really, really extreme. They're about 10 miles [or 16 kilometers] across, but they weigh as much as the sun, a thousand million million million million tons. Very small, very heavy, very peculiar composition. We're using pulsars to test some of [Albert] Einstein's theories. His ideas are standing up very well (*SN: 2/3/18, p. 7*). And we're developing ideas ... for using these things as navigation beacons, when we start traveling through the galaxy in spaceships.

***SN*: Why donate the money to diversity initiatives?**

Bell Burnell: Diverse bodies are often more successful, more flexible, more robust. I'd like to see more diversity in science, and I'd like more people who often don't get the chance to do research given the chance.

Read the full Q&A with Bell Burnell at **bit.ly/SN_BellBurnell**

News

MATTER & ENERGY

Superconductivity record challenged

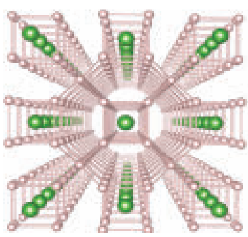
Hydrogen compound appears to work at fairly high temps

BY EMILY CONOVER

Superconductors are heating up, potentially dethroning a world record-holder.

Two studies report evidence of superconductivity — the transmission of electricity without resistance — at temperatures higher than seen before. The effect appears in compounds of lanthanum and hydrogen squeezed to extremely high pressures.

All known superconductors must be chilled to function, making them difficult to use in real-world applications. One that works at room temperature could be integrated into electronic devices and transmission wires, potentially saving vast amounts of energy currently lost to electrical resistance. So scientists are constantly on the lookout for higher-temperature superconductors. The current record-holder, hydrogen sulfide, which also must be compressed, works only below 203 kelvins, or about –70° Celsius (*SN: 12/26/15, p. 25*).



The compound LaH_{10} is composed of 10 hydrogen atoms (pink) for each lanthanum atom (green). This hydrogen-rich material was predicted to exhibit superconductivity.

HANYU LIU

The new evidence for superconductivity is based on a dramatic drop in the resistance of the lanthanum-hydrogen compounds when cooled below a certain temperature. One team of physicists found that their compound's resistance plummeted at 260 kelvins (–13° C), the temperature of a very cold winter day. The purported superconductivity occurred when the material had been crushed with almost 2 million times the pressure of Earth's atmosphere by squeezing it between two diamonds. Some samples even showed signs of superconductivity at higher temperatures, up to 280 kelvins (about 7° C), physicist Russell Hemley of George Washington University in Washington, D.C., and colleagues reported in a study posted online August 23 at arXiv.org.

Another group found evidence of superconductivity in a lanthanum-hydrogen compound under chillier, but still record-breaking, conditions. The compound was crushed in a diamond press to about 1.5 million times Earth's atmospheric pressure. When cooled to about 215 kelvins (–58° C), its resistance falls sharply, Mikhail Eremets, a physicist at the Max Planck Institute for Chemistry in Mainz, Germany, and colleagues reported in a paper posted online August 21 at arXiv.org.

It's not clear what the exact structures of the chemical compounds are and whether the two groups are studying identical materials. Differences between the two teams' samples might explain the temperature discrepancy. By scattering X-rays off their compound, Hemley and colleagues showed that the material's structure was consistent with LaH_{10}, which contains 10 hydrogen atoms for every lanthanum atom. Hemley's team had previously predicted that LaH_{10} would be superconducting at a relatively high temperature.

The results are "very exciting," says theoretical chemist Eva Zurek of the University at Buffalo in New York. However, the studies are not conclusive: They have not been peer reviewed and do not yet show an essential hallmark of superconductivity called the Meissner effect, in which magnetic fields are expelled from the superconducting material (*SN: 8/8/15, p. 12*). But the results agree with the previous theoretical predictions made by Hemley and colleagues. So, Zurek says, "I would hope and suspect that this is indeed ... correct." ■

HUMANS & SOCIETY

World's oldest drawing found

South African rock displays 73,000-year-old design

BY BRUCE BOWER

A red, crosshatched design adorning a rock from a South African cave may take the prize as the oldest known drawing.

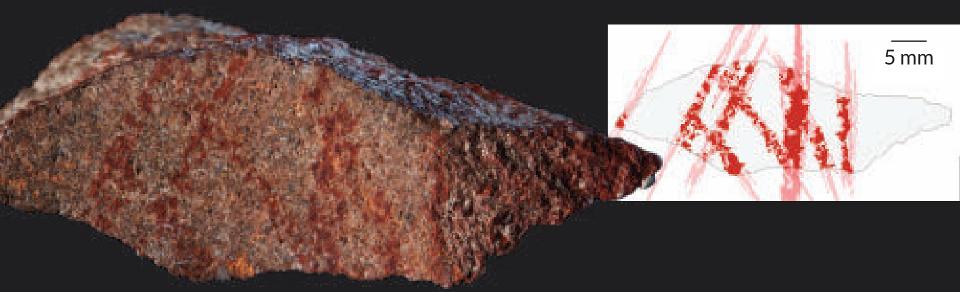
Ancient humans sketched the line pattern about 73,000 years ago by running a chunk of pigment across a smoothed section of stone in Blombos Cave, scientists say. Until now, the earliest drawings dated to roughly 40,000 years ago on cave walls in Europe and Indonesia.

The discovery "helps round out the argument that *Homo sapiens* behaved essentially like us before 70,000 years ago," says Christopher Henshilwood, an archaeologist at the University of Bergen in Norway.

Henshilwood's team noticed the ancient drawing while examining thousands of stone fragments and tools excavated in 2011 from cave sediment. Other finds have included 100,000- to 70,000-year-old pigment chunks engraved with crosshatched and line designs (*SN Online: 6/12/09*), 100,000-year-old abalone shells containing remnants of a pigment-infused paint (*SN: 11/19/11, p. 16*) and shell beads from around the same time.

The faded pattern consists of six upward-oriented lines crossed at an angle by three slightly curved lines, the researchers report online September 12 in *Nature*. Microscopic and chemical analyses showed that the lines were composed of a reddish, earthy pigment known as ocher.

The lines end abruptly at the rock's edges, indicating that a larger and possibly more complex version of the drawing originally appeared on a bigger stone, the researchers say. Tiny pigment particles dotted the rock's drawing surface, which had been ground smooth. Henshilwood suspects the chunk of rock was part of a large grinding stone



The 73,000-year-old red marks on this stone from a South African cave are remnants of a crosshatched design that may be the earliest known drawing. The inset shows what the larger pattern would have looked like as it extended beyond the edges of the surviving piece of rock.

on which people scraped pieces of pigment into crayonlike shapes.

Crosshatched designs similar to the drawing have been found engraved on shells at the site, Henshilwood says. So the patterns may have held some sort of meaning for their makers. But it's hard to know whether the crossed lines represent an abstract idea or a real-life concern. Some modern hunter-gatherer societies create abstract-looking designs that actually depict animals, objects or people, he says.

Whatever the drawing's original significance, it shows that Stone Age people in southern Africa communicated something they considered important by applying crosshatched patterns to different surfaces, says archaeologist Paul Pettitt of Durham University in England. "If there is any point at which one can say that symbolic activity had emerged in human society, this is it."

But archaeologist Maxime Aubert of Griffith University in Southport, Australia, isn't so sure. Henshilwood's team can't exclude the possibility, for example, that the apparent drawing resulted accidentally from people sharpening the tips of pigment chunks on rocks to make Stone Age crayons, Aubert says.

Henshilwood disagrees. Experimental reproductions of the crosshatched pigment pattern, drawn on rocks like those at the South African cave, indicate that the lines were intentionally produced and were originally darker and better defined, he says. Previous evidence also suggests that ancient humans at the cave used pigment as a glue ingredient and possibly as a sunscreen. But the experimental drawings produced too little powder to use as a glue additive or a sunblock. Ancient pigment wielders appear to have wanted only to draw a design on the stone.

Henshilwood's team has demonstrated how to identify deliberate drawings at ancient human sites by excluding other possible explanations for making pigment strokes, says archaeologist Gerrit van den Bergh of the University of Wollongong in Australia. "It is likely that further evidence for early symbolic behavior will be found in the very near future." ■

BODY & BRAIN

Superbugs' new foe has sneaky tactics

Antibiotic uses a novel way to get around bacteria's defenses

BY LAUREL HAMERS

Drug-resistant bacteria have a new challenger. A new molecule can kill deadly strains of common bacteria, such as *Klebsiella pneumonia* and *Escherichia coli*, that are resistant to most existing antibiotics. The potential drug works differently from currently available antibiotics, which may make it harder for bacteria to develop resistance, researchers report in the Sept. 13 *Nature*.

Most antibiotics kill bacteria by weakening their cell wall or by preventing the production of certain proteins. But over time, bacteria have evolved ways to circumvent these drugs. And as antibiotics are used frequently in both hospitals and agriculture, resistant bacterial strains are becoming more common. Infections with multidrug-resistant microbes are particularly worrisome, because these superbugs can turn usually easy-to-treat illnesses like urinary tract infections or strep throat into deadly ordeals.

The new molecule inhibits a key enzyme in the cell membrane that helps the bacteria secrete proteins. "We're hitting a new target," says study coauthor Peter Smith, an infectious disease researcher at Genentech, a biotech company based in South San Francisco, Calif. A new target means that strategies that bacteria use to evade existing antibiotics won't work here, giving the molecule an edge.

When the enzyme is blocked, proteins build up in the cell membrane until the membrane bursts, ultimately killing the bacterial cell, says Floyd Romesberg, a chemist at the Scripps Research Institute in La Jolla, Calif., who wasn't part of the study. Romesberg developed precursors to the antibiotic in his lab, but the new version is more effective, he says.

In tests in cultured human cells and in mice, the molecule killed off a variety of common gram-negative bacteria that cause infections in humans, including *E. coli* and *Pseudomonas aeruginosa*, and was also effective against gram-positive bacteria. Gram-negative bacteria, named because of how they appear when stained for viewing under a microscope, are notoriously difficult to attack with antibiotics because of the microbes' hard-to-penetrate cell membrane (*SN: 6/10/17, p. 8*). The molecule also destroyed bacterial strains that are resistant to multiple kinds of antibiotics.

The molecule will need to go through additional testing and tweaking before it can be used in humans, Smith says. And it's not a permanent solution to the growing problem of antibiotic resistance. Eventually, if molecules of this type are widely used as antibiotics, bacteria will evolve resistance, as they always do. But for now, it's a step ahead. ■

FROM LEFT: CRAIG FOSTER; C.S. HENSHILWOOD *ET AL*/*NATURE* 2018

HUMANS & SOCIETY

Huge ‘word gap’ may not exist

Poor kids hear as many words as better-off kids, study says

BY BRUCE BOWER

A scientific takedown of a famous finding known as the 30-million-word gap may upend popular notions of how kids learn vocabulary.

Research conducted over 20 years ago concluded that by age 4, poor children hear an average of 30 million fewer words than their more well-off peers. Since then, many researchers have accepted the reported word gap as a driver of later reading and of writing problems among low-income youngsters.

But here’s the rap on the word gap: It doesn’t exist, says a team led by psychologist Douglas Sperry of Saint Mary-of-the-Woods College in Indiana. In a redo of the original study, virtually no class differences appeared in the number of words addressed to young children by a primary caregiver, his team reports in a study to be published in *Child Development*.

What’s more, after including speech spoken to children by various caretakers, as well as family members’ conversations that the youngsters could easily overhear, kids in some poor and working-class communities heard more words on average than middle-class youngsters, the scientists say. “It’s time to turn a skeptical eye to the word-gap claim,” Sperry says.

Researchers usually treat word learning as a product of one or both parents regularly talking to a child. But different, equally effective ways exist for children to learn vocabulary, Sperry says. Depending on culture and community, word learning depends on a main caretaker talking to a child, many caretakers talking to a child and youngsters overhearing family members talking, he says (*SN: 2/17/18, p. 22*).

The original word-gap study included 42 children in Kansas from four communities — poor, working class, middle class or wealthy professional. Sperry’s group analyzed data on word use collected during home observations of 42 children in five communities — poor whites in South Baltimore, poor blacks in Alabama, working-class (largely blue-collar) whites in Indiana and Chicago, and middle-class (largely white-collar) whites in Chicago.

Videotaped home observations began when children were 18 to 30 months old and continued intermittently until kids reached 32 to 48 months. Most primary caregivers were children’s mothers.

Primary caregivers in poor, black Alabama families directed an average of 1,838 words per hour to their children. That’s close to the 2,153 words per hour for high-income, white caregivers in Kansas in the original word-gap study. The earlier study reported that primary caregivers on welfare in Kansas spoke an average of 616 words per hour to their children, about one-third the total spoken to poor, black children in the new study. Primary caregivers from working-class and middle-class families in the new study uttered an average of 1,048 to 1,491 words per hour to youngsters.

Accounting for multiple caregivers increased the average number of words spoken hourly to children in each community by at least 17 percent. In Alabama’s poor, black households, that boosted words heard by 58 percent.

In addition, kids in those households overheard an average of 3,203 words per hour. Eavesdropping figures reached no higher than about 2,500 words per hour in the other communities. Greater numbers of older siblings in the poor, black families contributed to that disparity, the researchers suspect.

The results convincingly reject claims of a word gap for poor children, says cultural anthropologist Jennifer Keys Adair of the University of Texas at Austin.

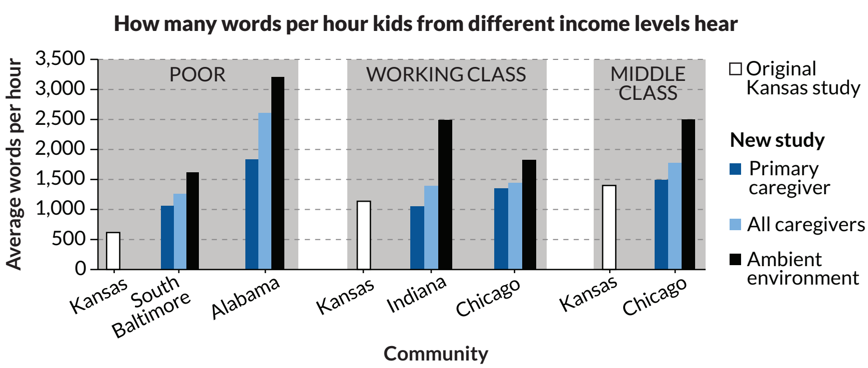
White, middle-class parents and many educators wrongly assume that vocabulary learning always works best via one-on-one interactions of parents with children, or teachers with grade school students, Adair says. That assumption may not apply to kids from other cultural backgrounds. Adair has found, for instance, that first-graders from Latin American immigrant families — who were allowed to devise classroom projects, collaborate with one another and ask questions without raising their hands — did especially well three years later on state English assessments.

But some child researchers say the new study falls short of showing that poor kids are generally exposed to as much language as better-off peers.

“Overhearing language about death and taxes — topics of interest to adults — can never be as effective for language learning as participating in ... conversations about what matters to children,” psychologist Roberta Golinkoff of the University of Delaware in Newark and colleagues write in a commentary that will appear in the same journal.

Sperry and his colleagues plan next to study the role that overheard speech and social context play in language learning. ■

Everybody’s talking In two studies about 20 years apart, researchers eavesdropped on families to tally how many words young children hear per hour. The new findings (colored bars) contradict an alleged “word gap” between poorer and more well-off kids found in the original Kansas study (white bars), which looked only at words uttered to children by primary caregivers.



D.E. SPERRY, L.L. SPERRY AND P.J. MILLER/*CHILD DEVELOPMENT* 2018; ADAPTED BY E. OTWELL

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Undergraduate Student Population	2,967
Graduate Student Population	917
Student to Faculty Ratio	17:1
Co-op Job Offer Rate	70%
Percent of Students Taught by Faculty	100%
Percent of Graduating Class with an International Education Experience	46%
Number of Living Alumni	25,143
Average Starting Salary for Swanson School Graduate	~ $60,000

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LIFE & EVOLUTION

Strange fossils turn out to be animals

Cholesterol traces in the rock rule out vegetable, mineral

BY CAROLYN GRAMLING

Cholesterol clinched it: A group of strange Precambrian fossils are among the oldest known animals in the rock record.

Organic molecules preserved with fossils of the genus *Dickinsonia* confirm that the creatures were animals rather than fungi or lichen, a study in the Sept. 21 *Science* says. A team led by paleontologist Ilya Bobrovskiy of Australian National University in Canberra analyzed levels of steroids in the fossils, which date to between 571 million and 541 million years ago. The researchers found an abundance of cholesterol that points firmly to the animal kingdom.

The finding "gets rid of the more outlandish hypotheses about what these objects were," says MIT geobiologist Roger Summons, who cowrote a related commentary in the same issue of *Science*. "You can't argue with chemistry."

Dickinsonia are part of the enigmatic Ediacara biota, the collective name for a burst of strange, alienlike life-forms that flourished during the Precambrian Eon. Ediacarans, named for the Ediacara Hills in Australia, are found in Precambrian-aged rocks around the globe.

The new study was conducted on Ediacaran fossils extracted from a remote coastline in northwest Russia along the White Sea. The site is difficult to access — Bobrovskiy had to helicopter in and rappel down a cliff to collect the fossils — but the rewards are worth it, paleontologists say: The fossil-bearing rocks at the site haven't been cooked and twisted by tectonic forces. The rocks are so pristine, in fact, that they still contain traces of soft tissue containing organic molecules, which researchers can use as biomarkers to help identify the fossils.

That's particularly helpful when it comes to the Ediacaran fossils. They've proven difficult to place on the tree of life as they bear little resemblance to any known creatures (*SN: 5/18/13, p. 20*). These fossils are several centimeters across, so large enough to see with the naked eye. But their strange shapes — *Dickinsonia* resemble ribbed ovals that are symmetrical around a central axis, for instance — had stumped scientists. Most paleontologists suspected that *Dickinsonia* were animals. But some researchers argued they could be fungi, lichens or even giant, single-celled creatures called protists (*SN: 1/26/13, p. 15*).

Biomarkers in the soft tissue provide a new line of evidence. To collect the organic molecules, the scientists removed thin films of organic matter from the rocks, and then extracted the molecules in the lab using solvents. The high-precision work must happen

Alienlike fossils dating to between 571 million and 541 million years ago include species of *Dickinsonia* (shown). Scientists have figured out what kind of organism these fossils were.

I. BOBROVSKIY/AUSTRALIAN NATIONAL UNIV.

GENES & CELLS

Human skeletal stem cells found

Cells could one day be used to repair joints, mend bones

BY TINA HESMAN SAEY

Repairing bones and cartilage may get easier thanks to newly discovered human skeletal stem cells.

Scientists found the stem cells — which give rise to bones, cartilage and the spongy bone that harbors bone marrow — in fetal bones, adult bones and fat, researchers report in the Sept. 20 *Cell*. The researchers also reprogrammed adult cells into skeletal stem cells. A ready supply of such cells could one day help doctors repair or replace joint cartilage, heal broken bones more quickly, build up bone in osteoporosis patients and even grow new bone and cartilage for reconstructive surgeries.

Those applications are still far in the future, says Clifford Tabin, a developmental geneticist at Harvard Medical School who was not involved in the study. "The current study is an extremely important advance," he says, "but there is work to be done before [skeletal stem cells] can contribute to changing the landscape of orthopedic medicine."

Other stem cells collected from fat and cartilage can be coaxed into making bone or cartilage under special circumstances (*SN: 3/19/16, p. 23*), but those cells are not the dedicated skeletal cells discovered in the new study, says coauthor Michael Longaker, a plastic surgeon at Stanford University School of Medicine.

Longaker's team found skeletal stem cells in the rapidly growing portion of a fetal femur and transferred them to lab dishes where they could multiply. Continued self-renewal is an important characteristic of stem cells. To determine whether the cells could multiply indefinitely, researchers transplanted human skeletal stem cells into mice under the outer layer of the rodents' kidneys. The transplanted stem cells grew into bones on the mice's kidneys. Stem cells from those newly grown bones were transplanted into another mouse, where the stem cells again made bone.

The skeletal stem cells could form bone, cartilage and spongy bone, but “under extremely clean conditions to avoid contaminants,” says study coauthor Jochen Brocks, also of Australia National University.

As a control, the team extracted organic material from the rocks surrounding the *Dickinsonia* fossils. Steroids isolated from these rocks turned out to be about 70 percent stigmasteroid, an organic molecule found in algae. That’s consistent with the likely marine setting for the Ediacarans: The creatures were thought to dwell in shallow waters, atop microbial mats.

But the fossils themselves were strikingly high in cholesterol relative to other steroids: Cholesterol made up between about 85 and 93 percent of all steroids in different fossils of the genus.

“The nearly 100 percent proportion of cholesterol in the *Dickinsonia* fossils tells us it must have been an animal,” Brocks says. Today, cholesterol is produced by bacteria in the guts of animals.

Next, the team plans to look for biomarkers from other Ediacarans in the White Sea rocks — and there are plenty of intriguing options, Brocks says. “The coolest target is the rangeomorphs,” he says. “These weird creatures are constructed like a fractal. No modern animal is built like that.” ■

didn’t make fat or other tissues. That result shows that these stem cells are specific to the skeleton.

Longaker’s team tracked down adult skeleton stem cells by cataloging the types of RNA produced in the fetal skeletal stem cells. Different types of RNA reveal the genetic instructions encoded in DNA, which determine a cell’s identity and function. Skeletal stem cells in adult bones and fat that make the same RNAs also made bone, cartilage and spongy bone when transplanted into mice.

The team also manipulated embryonic-like stem cells, or induced pluripotent stem cells, into becoming the skeletal stem cells. The ability to grow skeletal stem cells in a dish “is particularly promising, as you can grow as many of these as you wish,” Tabin says. ■

ATOM & COSMOS

Birth of a neutron star possibly spotted

Astronomers have followed supernova 2012au for several years

BY LISA GROSSMAN

For the first time, astronomers may have watched a massive stellar explosion give rise in real time to a superdense corpse called a neutron star.

Observations of supernova 2012au, first spotted in 2012 in a galaxy 77 million light-years from Earth, show charged oxygen and sulfur atoms fleeing the scene of the explosion at 2,300 kilometers per second. That visibility suggests that the shells of gas surrounding the dense remains of the original star are being lit up from within by a pulsar, a type of fast-spinning, radiation-spewing neutron star, researchers report online September 12 in *Astrophysical Journal Letters*.

“It’s proof positive, a smoking gun,” says coauthor Dan Milisavljevic, an astrophysicist at Purdue University in West Lafayette, Ind. “We’ve seen this supernova from the explosion up until this transformation into the neutron star.” Now astronomers have a chance to test theories about how supernovas and their aftermaths evolve in real time.

Milisavljevic and colleagues first monitored SN 2012au for a year following the explosion, and found that it faded more slowly than most supernovas of its kind. That could have meant that a pulsar was contributing energy to the explosion, keeping the lights on longer.

Sometimes supernovas appear to brighten again when the dead star’s outer layers of gas slam into hydrogen atoms that float between stars. So Milisavljevic and colleagues followed up in June. Six years after the explosion, SN 2012au was still relatively bright. The team saw no signs of hydrogen in the wavelengths of light around it. Instead, the team found the lit-up ionized oxygen and sulfur atoms making a quick getaway. Those heavier atoms would trail hydrogen as material leaves a supernova explosion, forming an inner shell of ejected gas.

Astronomers have seen other pulsars lighting up their surroundings in our galaxy. But this would be the first time the phenomenon has been seen outside the Milky Way and so soon after the explosion, says astrophysicist Samar Safi-Harb of the University of Manitoba in Canada, who was not involved in the new observations. “We don’t know what happens between the explosion itself and those remnant stages,” she says. If the findings prove true, “we have an example of how [a supernova remnant] manifests itself in those early stages.” It’s still possible something more exotic is happening in SN 2012au, Safi-Harb says. “Only time will tell.” ■

NASA, ESA, J. DEPASQUALE/STSCI

Supernova 2012au, which exploded in the galaxy NGC 4790 (shown), was absent in a 2001 Hubble Space Telescope image of the galaxy (top), but visible as a bright dot in 2013 (bottom).

MATH & TECHNOLOGY

Graphene could speed up electronics

The 2-D material boosts signals from gigahertz to terahertz

BY MARIA TEMMING

Graphene just added another badge to its supermaterial sash.

This single layer of carbon atoms can transform electronic signals at gigahertz frequencies into higher-frequency terahertz signals — which can shuttle up to 1,000 times as much information per second, new experiments show.

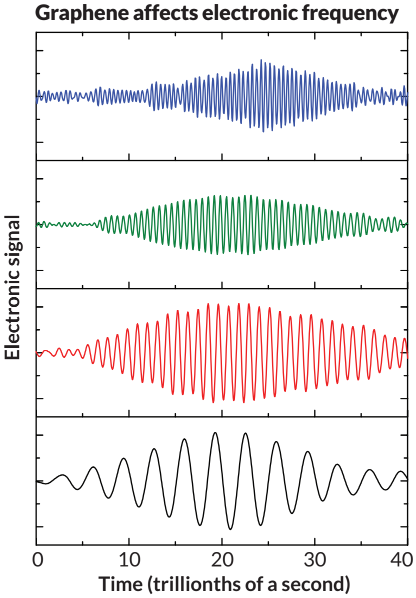
Electromagnetic waves in the terahertz range are notoriously difficult to create, and conventional silicon-based electronics have trouble handling such high-frequency signals (*SN: 3/28/09, p. 24*). But graphene-based devices process and send information at terahertz frequencies, allowing them to work much faster than today's devices, researchers report online September 10 in *Nature*.

Dmitry Turchinovich, a physicist at the University of Duisburg-Essen in Germany, and colleagues injected a sheet of the atom-thick material with 300-gigahertz radiation. When those electromagnetic waves hit the graphene, electrons in the material rapidly heated and cooled, releasing electromagnetic waves with frequencies up to seven times as high as the incoming radiation.

"This is yet another amazing result for graphene," says Orad Reshef, a physicist at the University of Ottawa who was not involved in the work. The 2-D material has been hailed as a supermaterial for such extraordinary abilities as conducting electric current with no resistance.

Graphene converted more than a thousandth, a ten-thousandth and a hundred-thousandth of the original 300-gigahertz signal into waves at 0.9, 1.5 and 2.1 terahertz. That's remarkably high for a lone layer of atoms, says Tsuneyuki Ozaki, a physicist at the National Institute of Scientific Research in Quebec City who was not involved in the work.

Graphene-based computer components that can deal in terahertz "could be used, not in a normal Macintosh or PC, but perhaps in very advanced computers with high processing rates," Ozaki says, or in super high-speed nanodevices. ■



Crunch time Graphene takes incoming gigahertz waves (black) and transforms them into waves in the terahertz range that have three, five and seven times the original frequency (red, green and blue).

EARTH & ENVIRONMENT

Wetlands may survive rising seas

Washed-in sediment could build up coastal marshes

BY CAROLYN GRAMLING

Rising sea levels don't have to spell doom for the world's coastal wetlands. A new study suggests that salt marshes and other wetlands could accumulate soil quickly enough to avoid becoming fully submerged. And if humans are willing to allow wetlands to move inland as the seas rise, the coastal fringes could not only survive but could also substantially increase their global area, researchers report in the Sept. 13 *Nature*.

These coastal zones, which globally cover 200,000 square kilometers, filter pollutants, pull and store carbon dioxide from the atmosphere and protect communities from storms. Sea level rise projections suggest that 20 to 90 percent of coastal wetlands could disappear by 2100, depending on how warm the planet gets and how high the seas rise.

But previous estimates of wetland resilience don't consider that rising seas inundate marshes more frequently, particularly those at lower elevation, says Mark Schuerch, a coastal geographer at the University of Lincoln in England. The water carries sediment, so more frequent deliveries may help some wetlands rapidly build up soil elevation even as the water rises.

Schuerch and his team considered global warming scenarios leading to sea level rise of 29 to 110 centimeters by the year 2100. The researchers also looked at global coastal population data. Factoring in sediment supply alone helped some: Even under the highest sea level rise scenario, global wetland losses dropped 30 percent rather than 90 percent.

Introducing human adaptations proved even more significant, allowing coastal wetlands not only to survive, but also to thrive. Making way for inland marsh migration — moving seawalls, rerouting roads and giving up waterfront real estate, for instance — could increase the total wetland area around the planet by as much as 60 percent, the team found.

That's a long shot, Schuerch admits. Other scientists call it unrealistic. But the study is a good first approximation of what sediment changes and policy shifts could mean for coastal wetlands, says Jonathan Woodruff, a coastal geologist at the University of Massachusetts Amherst whose commentary appears in the same issue of *Nature*. "Putting numbers to that is really important," he says, yet many questions remain. Little research exists on what happens as wetlands migrate inland, for example: That process may not be so simple. ■

H.A. HAFEZ *ET AL*/*NATURE* 2018

BODY & BRAIN

Daily low-dose aspirin could be harmful

Benefits don't outweigh risks for healthy older people, studies say

BY AIMEE CUNNINGHAM

Taking a daily dose of aspirin may not be a good idea for healthy elderly adults, researchers say.

A trio of papers based on a large-scale clinical trial finds that the drug doesn't help to stave off heart attacks, strokes, dementia or physical disability. In fact, people in their golden years who took a low dose of aspirin daily were more likely to suffer serious internal bleeding than those who took a placebo.

The clinical trial, called ASPREE, or Aspirin in Reducing Events in the Elderly, included more than 19,000 adults. About half were randomly assigned to take 100 milligrams of aspirin per day and the other half took a placebo pill for about five years.

> "Aspirin is not a benign drug."
> JEFFREY BERGER

The papers, published online in the *New England Journal of Medicine* on September 16, "once again remind us that aspirin is not a benign drug," says cardiologist Jeffrey Berger of New York University School of Medicine, who was not part of the research.

"There's a lot of misunderstanding of the original data in support of aspirin," he says. The notion that everyone in old age should take aspirin to prevent a first heart attack or stroke, Berger says, "is not borne out from the evidence to date." Yet a 2015 study found that nearly half of 2,039 U.S. adults ages 45 to 75 who didn't report a history of cardiovascular disease were regularly taking aspirin.

"If you've had a heart attack, it's not debatable: Aspirin saves lives," Berger says. Clinical trials have shown that low-dose aspirin significantly reduces subsequent heart attacks and strokes in those patients, equating to about 10 to 20 fewer of these events per 1,000 people per year. That benefit outweighs the increases seen in occurrences of internal bleeding.

What's unsettled is whether aspirin can help prevent a first heart attack or stroke in people without cardiovascular disease. The new work casts additional doubt.

The research — by Anne Murray, the medical director of the Berman Center for Outcomes and Clinical Research at Hennepin Healthcare in Minneapolis, and colleagues — focused mostly on Australians and some white Americans ages 70 and older. But the study group also included some black and Hispanic Americans 65 and older.

Rates of cardiovascular disease, including heart attacks and stroke, were about the same in the two groups: 10.7 events per 1,000 people per year on aspirin and 11.3 events per 1,000 on the placebo. But those on aspirin were significantly more likely to develop a major hemorrhage, or bleeding, in the stomach, intestines or brain, with 8.6 events per 1,000 people compared with 6.2 events per 1,000 on the placebo.

Murray and colleagues also looked at aspirin's impact on dementia and disability. "Those are the two things that play the largest role in whether people are able to remain independent" in their later years, Murray says.

Perhaps the blood-thinning and anti-inflammatory properties of aspirin might decrease those risks by ameliorating abnormalities in the brain's small blood vessels that have been linked to impairments in thinking and movement, the researchers thought. But that hypothesis didn't pan out. The combined rates of dementia, physical disability and death were nearly the same between the aspirin and placebo groups: 21.5 events versus 21.2 events per 1,000 people per year.

"There really are no measurable benefits of taking low-dose aspirin" for healthy elderly adults, Murray says. "Certainly the benefits don't outweigh the risk of bleeding." ■

MATTER & ENERGY

Sound waves can make bubbles in levitated drops of liquid

Save your breath: A new way to make bubbles requires only sound waves. Scientists made the bubbles in levitated drops of liquid, held aloft with sound waves. Tweaking the sound waves caused a drop to balloon into a bubble.

Increasing the intensity of the sound made the liquid first buckle into a concave shape. Then the sound waves resonated inside the droplet's newly formed cavity, causing a rapid expansion of the liquid film until it closed in on itself into a hollow bubble, researchers report online September 11 in *Nature Communications.*

The floating bubbles last a surprisingly long time — tens of minutes. As kids know, a soap bubble on a wand sticks around only a short while before the soapy solution drains to the bubble's bottom and it pops (*SN: 1/21/17, p. 32*). But the levitation slows down the liquid's drainage, putting off the bubble's burst. *— Emily Conover*

ATOM & COSMOS

Saturn has two hexagons, not one, swirling around its north pole

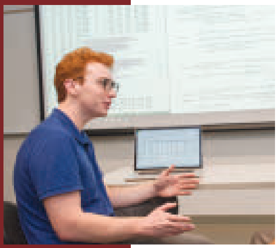
A new hexagon has emerged high in the skies over Saturn's north pole.

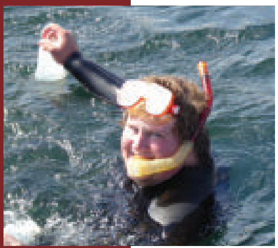
As spring turned to summer in the planet's northern hemisphere, a six-sided vortex appeared in the stratosphere. Surprisingly, the polar polygon seems to mirror the famous hexagonal cyclone that swirls in the clouds hundreds of kilometers below, researchers report online September 3 in *Nature Communications.*

Infrared maps of the atmosphere, created from data collected by the Cassini spacecraft before it dove into Saturn last year (*SN: 9/2/17, p. 16*), show that from 2014 to 2017, a warm, swirling mass of air started developing over the north pole. That wasn't surprising — but the six-sided shape came as a bit of a shock. It suggests that the underlying hexagon somehow controls what happens in the stratosphere. These sorts of insights could help researchers understand how energy moves around in other planetary atmospheres. *— Christopher Crockett*

UNIVERSITY OF REDLANDS

STUDENTS EMBRACE EXPLORATION AND INQUIRY





How did science students at the University of Redlands spend their summer? Spencer Tibbitts went swimming—in 45-degree water to collect samples. Hannah Bockenfeld went on a hike—through a field of bees and wasps. These students, and 27 of their peers, spent 10 weeks immersed in exploration and inquiry through the U of R's Student Science Research Program.

The program is a donor-funded opportunity for students to focus on a research project alongside a biology, biochemistry, chemistry, computer science, or physics professor.

Johnston Center for Integrative Studies student Hannah Bockenfeld and Biology Professor Dustin VanOverbeke spent the summer monitoring pollinators, such as bees and wasps, comparing areas reseeded with native plant species to invaded (non-reseeded) areas.

Biochemistry majors Christina Hanson and Yuanming Song sought to lay the foundation for medical solutions for addiction and/or mood disorders, building on the work on peptides of their chemistry professor, Michael Ferracane.

Chemistry Professor Rebecca Lyons was happy to have chemistry major and spatial studies minor Spencer Tibbitts join her ongoing study to determine the impact of chemical stressors on the eelgrass around the San Juan Islands, a critical habitat for juvenile fish and base for the local fishing industry.

Building on a lifelong fascination with statistics and experience as chief investment officer for the Redlands Student Investment Fund, math and computer science double major Torin Bakos, worked with Pani Chakrapani, professor of computer science, to develop software to study trends in stock market behavior.

To learn more about programs and opportunities for hands-on research at the University of Redlands, visit www.redlands.edu/ssr.

FEATURE

THE SN 10

SCIENTISTS TO WATCH

Meet 10 scientists who defy limits to tackle big problems

Scientific disciplines, as we know them, are a fairly recent invention. As late as the 18th century, both amateur and professional scientists let their intellect range unfettered. The great Renaissance painter Leonardo da Vinci explored architecture, engineering, geology, botany and more. He is credited with inventing the helicopter, a diving suit *and* painting the *Mona Lisa*.

Only later did scientific disciplines emerge as a powerful way to speed learning as scientific knowledge accumulated rapidly. Today's scientists, including this year's SN 10 researchers, are stepping over these boundaries to borrow tools and inspiration from other fields to solve knotty questions facing science and society.

Members of the SN 10 class of 2018 are skilled at moving between scientific worlds. One uses physics to learn how cell movement in the lungs encourages asthma. Another sees architecture in how volcanoes build planets. Several venture into other fields to help answer difficult questions in their own fields: Maybe the proteins of biology can teach a materials scientist how to make self-repairing batteries.

This is the fourth year that *Science News* is spotlighting a group of early- and mid-career scientists who are breaking ground. It's a confident, tough group. Try to set limits or box these people in and they bristle. Some had childhood experiences that opened their minds to the possibilities of scientific research. Others dug in their heels to do something that an adult said would be too difficult.

From a pool of standout researchers nominated by Nobel laureates and recently elected members of the National Academy of Sciences, *Science News* staff chose 10 to introduce on these pages. The scientists, all under 40, come from different backgrounds and fields of study. But their colleagues and mentors describe many of them in the same way: fearless, with a thirst for knowledge and a drive to grasp the unknown, boundaries be damned.
— Cori Vanchieri

Ibrahim Cissé, 35
PHYSICS AND BIOPHYSICS
MIT

BRYCE VICKMARK

His movies reveal cells' secrets

By Tina Hesman Saey

Ibrahim Cissé expected to join his father's law firm one day. "There were no scientists where I grew up in Niger," says the MIT biophysicist. "I certainly didn't know [science] was a profession one could do."

But Cissé's parents had a telling clue about their young son's eventual career path — a door sign that read: "Laboratoire de Cissé."

Cissé learned about experiments in books, but his school in Niger's capital city, Niamey, didn't have a lab. So, when he was about 10 or 11, he converted a storage room in his family's house into an experimentation space. Behind that handmade sign, he tore apart electronics, rewired them, built new things with the parts and dreamed about becoming an astronaut on the space shuttle.

"People knew that anything that went into my lab was fair game for me to break apart," he says.

At 17, Cissé moved to North Carolina to learn English. Later, on registration day at North Carolina Central University in Durham, a historically black college, a physics professor quizzed him about math and science and suggested Cissé major in physics. Then came the magic words: "We have a grant from NASA." Recalling his cosmic childhood dreams, Cissé became a physics major.

Now 35, Cissé is "everything you could want in a young scientist," says Anthony Hyman, a biologist at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden, Germany, who follows Cissé's work. "He's dynamic, enthusiastic and interested."

These days, Cissé, a newly minted American citizen, is breaking paradigms instead of electronics. He and colleagues are making movies with super-resolution microscopes to learn how genes are turned on. Researchers have spent decades studying this fundamental question.

COURTESY OF CISSÉ LAB

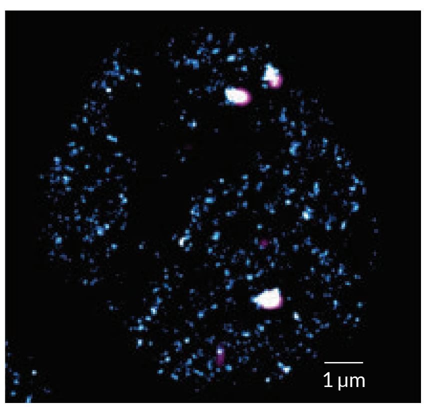
Cissé thinks physics can help biologists better understand and predict the process of turning genes on, which involves copying genetic instructions from DNA into RNA. His work describes how and when proteins congregate to instigate this process, which keeps cells functioning properly throughout life.

Cissé was encouraged by physicist Carl Wieman, who won the Nobel Prize in physics in 2001 for his work on Bose-Einstein condensates, to apply for a fellowship to work at a big research university. As a result, Cissé spent a summer at Princeton University learning soft condensed matter physics, the study of properties of liquids and other materials that can change shape, as it applied to randomly packing M&M's into a jar. That work resulted in his first scientific paper, published in 2004 in *Science*.

During postdoctoral research, Cissé made what seems like a simple tweak to a single-cell microscopy technique, called PALM, that made his future discoveries possible, says Taekjip Ha, a biophysicist at Johns Hopkins University who was Cissé's graduate mentor at the University of Illinois at Urbana-Champaign.

With PALM, Cissé examined RNA polymerase II in action. The enzyme is crucial for turning DNA instructions into the RNA messages that are read to build proteins.

"He didn't just use PALM to obtain pretty images," Ha says. Cissé added "a time dimension." Rather than taking



A super-resolution microscope image shows bubbles of RNA polymerase II (cyan), the enzyme that copies DNA into RNA, interacting with bubbles of Mediator (magenta), a complex of proteins that gives the polymerase a signal to turns genes on.

> "He didn't just use PALM to obtain pretty images. [Cissé added] a time dimension."
>
> **TAEKJIP HA**

stationary snapshots, Cissé made movies that showed that RNA polymerase II forms clusters that fall apart once their job is done. The discovery was published in 2013 in *Science*.

"That finding was pretty provocative," Ha says. Until then, researchers had thought that RNA polymerases formed stable factories that would park near a gene's starting point and idle, waiting for other proteins to give them a push to turn the gene on.

A few years later, in 2016, Cissé and colleagues reported in *eLife* that the amount of time an RNA polymerase cluster stays together determines how many RNA messages are produced from a gene, a measure of how active the gene is.

In his latest studies, published in the July 27 *Science* (*SN: 7/21/18, p. 14*), Cissé and colleagues present evidence that proteins involved in turning on genes rapidly coalesce into concentrated droplets just before the process of copying DNA into RNA begins. Like water molecules condensing into a raindrop and then evaporating, proteins can quickly form these droplets and then disperse.

Individual proteins spend only seconds in the condensates, but collectively the molecules turn on genes. And bubbles of condensed proteins may interact with other bubbles, sometimes several, to turn on multiple genes at once.

The idea is controversial. Some researchers argue that this condensation process isn't necessary to start gene activity.

To Cissé, knowing about these "bubbles" means researchers can draw on the physics of condensation — such as knowledge about cloud formation, rain and snow — to understand how gene-activating proteins behave and predict what will happen next. ■

There's chemical logic to the microbiome

By Rachel Ehrenberg

Emily Balskus, 38
CHEMISTRY AND MICROBIOLOGY
HARVARD UNIVERSITY

Chemist Emily Balskus of Harvard University is out to expose the crimes and misdemeanors of microbes living in the human gut. She's shown, for example, how a common gut bacterium interferes with a heart failure treatment: The microbe breaks down the medication before the drug can do its job.

Balskus, 38, originally imagined a career making complex molecules in the lab. "She can do chemistry that very few people in the world can do," says synthetic chemist Eric Jacobsen, her Ph.D. adviser at Harvard.

But she became intrigued by how microbes make molecules with such ease, when synthesizing those molecules can be so challenging. As a postdoctoral fellow at Harvard Medical School, Balskus attended a seminar about the human microbiome — the catchall term for the trillions of invisible beings that live in and on us. She was hooked.

"I just thought it was fascinating," she says. "We have all these microbes living in us from the time we are born. They're such an intricate part of our bodies. They're interacting with us, yet we know so little about them."

A growing body of evidence links several illnesses to changes in the body's microbial communities. Rather than focusing on what those organisms are, Balskus is focusing on how they cause trouble. "We really don't understand ... how they are exerting their influence," Balskus says. "It's a major obstacle, and it's what makes this work so exciting."

An interest in the "how" emerged early for Balskus: During elementary school in Cincinnati, she and her classmates designed an experiment to prove that green food coloring diluted in water was still there, even when it was no longer visible. "I came up with the idea that we could boil down all the water and get the food coloring back," she recalls. It worked.

> "[Microbes] are such an intricate part of our bodies ... yet we know so little about them."
> EMILY BALSKUS

Fast-forward to 2011 when Balskus used more advanced chemistry skills to solve a century-old puzzle. She had read a report linking high blood levels of a compound called TMAO to heart disease. Since the early 1900s, scientists had known that gut microbes convert the essential nutrient choline into the gas TMA, a precursor to TMAO. How the conversion came about was unknown.

"This was the first time that I was like, 'This is something I can do, I can figure out how this happens,'" Balskus says.

Researchers already knew that choline-digesting microbes kick off the process by cutting a carbon-nitrogen bond. That reaction looked familiar to Balskus. Some bacteria use a particular enzyme to cleave that very bond in an unrelated reaction. And the genes behind that bond-cutting enzyme had been identified. So Balskus combed through catalogs of bacterial DNA looking for similar genes whose functions were unknown.

The approach worked. Balskus found a cluster of genes that appeared to be responsible for the choline-chopping enzyme. She and her then graduate student Smaranda Craciun showed in 2012 in the *Proceedings of the National Academy of Sciences* that numerous microbes, including ones in the gut, also carry genes for the previously unknown choline-metabolizing enzyme.

"She's sort of like a detective that's looking at a mix of different clues," says molecular geneticist and collaborator Peter Turnbaugh of the University of California, San Francisco. "She's got this chemical logic that really informs what to go after."

While much of her work to date has revealed microbes behaving badly, Balskus hopes that some will prove to be a force for good. In a 2018 commentary in *ACS Infectious Diseases*, Balskus and then graduate student Abraham Waldman detailed how elucidating microbial chemistry could change medicine, turning antibiotics, for example, into highly precise tools for fighting ills, rather than the blunt instruments they are today. Other small molecules made by microbes, or delivered to perturb them, may be part of the intervention landscape of the future that could work against infections like HIV, tuberculosis and malaria, Balskus says.

Her work has also revealed new mysteries to solve. A 2017 report in *Cell Host & Microbe* by Balskus and others suggests that activity by the choline-cutting microbes could play a role in obesity and may diminish the availability of the nutrient to mom and fetus during pregnancy. How this activity interacts with diet and genetics in any one person is not yet clear. In time, perhaps chemistry will tell. ■

BRYCE VICKMARK

Powering a future of sustainable energy

By Laurel Hamers

Joaquín Rodríguez-López, 35
ELECTROCHEMISTRY
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Joaquín Rodríguez-López was jolted into the world of electrochemistry. When he realized in college that he could hook up a machine to some wires and transform chemicals into energy, he was "completely sold," he says.

Today, he's tackling one big obstacle to expanding affordable renewable energy on the U.S. electrical grid: storage. The flow batteries that store large amounts of energy generated by wind and solar power need to more efficiently hold that energy for times when the sun isn't shining or the breeze dies down.

In his lab at the University of Illinois at Urbana-Champaign, Rodríguez-López, 35, has designed a new type of material to store electric charge in these batteries, making them more efficient. And he's not stopping there. "We design new ways of looking at materials, and we design better materials," he says.

His collaborator at the University of Illinois, Jeffrey Moore, praises his "deep knowledge and ... willingness to share it." Rodríguez-López has always had a community-focused mind-set. Growing up in Mexico, he entertained himself for hours at home with *Encyclopedia Britannica*. But at school, he says, he'd hang around with kids who weren't doing as well academically. He liked helping them out.

Today, he's still drawn to collaboration, working with Moore and others via the Joint Center for Energy Storage Research, an initiative funded by the U.S. Department of Energy to bring new battery and fuel cell technology from research labs to commercialization.

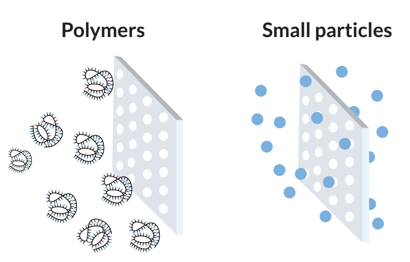
"He's really shown an ability to get a team working together toward a common goal," Moore says.

One important goal for materials science today is to build better batteries (*SN: 1/21/17, p. 22*). The ubiquitous lithium-ion battery adeptly powers cell phones and laptops, but it's not necessarily the best way to store the large quantities of energy generated by wind turbines or solar panels, Rodríguez-López says. So a major focus in his lab has been on bettering the flow battery.

A flow battery has two big tanks loaded with solutions, one positively charged and one negatively charged. The tanks are separated by a membrane, where the two solutions meet and undergo chemical reactions that generate a flow of electrons, or electric current. To make a lithium-ion battery store more electric charge requires scaling up its positively and negatively charged electrodes, which are made of expensive materials. To scale up a flow battery, just increase the size of the tanks for not much more cost.

"Instead of having big electrodes, you have big tanks," says Rodríguez-López. It's a simpler way to store a large amount of power generated by wind or solar for later use.

But in today's flow batteries, the reaction-driving particles sometimes leak across the membrane, wasting energy. Rodríguez-López and colleagues have designed a new kind of bulky particle that still dissolves well in liquid but can't cross the barrier. These polymers, described in 2014 in the *Journal of the American Chemical Society*, link dozens or even hundreds of smaller units in an array of shapes. The particles store and discharge electric energy in the battery through a series of chemical reactions that progress along the polymer unit by unit, like a flame moving up a match.



Keep out Joaquín Rodríguez-López and colleagues have designed polymers too big to seep through the membrane between a flow battery's positively and negatively charged solutions, so the battery doesn't waste energy.
SOURCE: G. NAGARJUNA *ET AL*/*J. AM. CHEM. SOC.* 2014

When Rodríguez-López began this research a few years ago, it was a side project for the Joint Center for Energy Storage Research, where materials scientist George Crabtree of Argonne National Laboratory in Lemont, Ill., is director. Today, Crabtree says, the work is a major focus of the center.

Rodríguez-López is thinking bigger than designing new materials, though. He's also using new techniques to figure out why and how these materials behave the way they do so he can troubleshoot more rationally and, ultimately, get the molecules to do exactly what he wants.

For example, he's become an expert in scanning electrochemical microscopy so he can watch electrons move as chemical reactions progress along his lengthy molecules. He uses the technique to aim for ideal properties in his batteries.

Looking forward, Rodríguez-López says he'd like to bring more biological influence into his molecule-designing work. After all, he says, cells are filled with bulky proteins finely tuned for specific jobs. Some can repair themselves when broken, while others can self-destruct. Understanding nature's complexity, he says, could help him design materials for batteries that react in more sophisticated ways. ■

FROM TOP: DEPT. OF CHEMISTRY/UIUC; T. TIBBITTS

The psychology of saving the planet

By Bruce Bower

When Shahzeen Attari was growing up in Dubai, her father ran a machine shop. Her mother, a gregarious people person, worked at a bank.

Shahzeen Attari, 37
ENVIRONMENTAL DECISION MAKING
INDIANA UNIVERSITY BLOOMINGTON

"My curiosity about how things work came from my father," Attari says. "I learned to love getting to know people from my mother."

That yin-yang background may explain why Attari, now at Indiana University Bloomington, found a way to merge the practical and the personal in her scientific pursuits, by blending civil and environmental engineering with public policy and psychology.

At age 37, she has become a leader in the study of how people think about conservation, energy use and climate change. At its heart, Attari's research explores people's difficulties in grasping complex physical systems. She has studied the ways in which people underestimate their own water and energy use.

"We live in a world that must dramatically reduce its use of fossil fuels and water, but efforts to encourage people to change their behavior have proven notoriously difficult," says communications researcher Edward Maibach of George Mason University in Fairfax, Va. "Shahzeen's research has taught us much about why that is and what can be done to improve our efforts," says Maibach, who studies public understanding of climate change.

Her graduate school adviser at Carnegie Mellon University in Pittsburgh, environmental engineer and air quality researcher Cliff Davidson, noticed her interdisciplinary bent when she arrived with an undergraduate degree in engineering physics. In graduate school, Attari decided on a joint degree in engineering and public policy. "Students who pursue degrees in engineering and public policy are almost always holistic thinkers as opposed to narrow, focused thinkers that delve only into one topic," says Davidson, now at Syracuse University in New York.

Attari's 2009 dissertation on how people might decrease energy consumption in the face of global climate change marked her as a rare physical scientist interested in behavioral and social perspectives. Soon, psychologists David Krantz and Elke Weber recruited her to the Center for Research on Environmental Decisions, part of Columbia University's Earth Institute.

There, Attari led a study that suggested people know surprisingly little about their daily energy use and how best to save energy. Participants in a national online survey were asked to recommend ways to conserve energy. Volunteers cited less effective behaviors, such as turning off lights, over more effective approaches, such as installing high-efficiency lightbulbs.

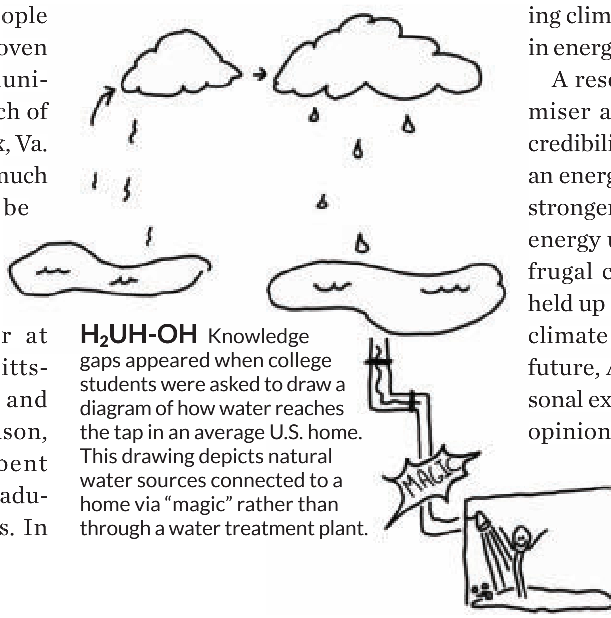
Those findings, published in 2010 in the *Proceedings of the National Academy of Sciences*, highlighted a need for product labels and energy conservation campaigns that do a much better job of informing people how to most effectively reduce energy consumption, Attari says.

Public understanding of the water system also needs an upgrade, Attari found. In the wake of a furor over high lead levels in drinking water in Flint, Mich. (*SN: 3/19/16, p. 8*), she and colleagues asked 457 college students to draw diagrams of how water reaches home taps.

Nearly one-third of participants failed to draw a drinking water treatment plant that filters and disinfects water from natural sources before delivering it to homes. And 1 in 5 incorrectly drew wastewater returning directly to the environment from home pipes, rather than through a sewage treatment plant, Attari's team reported in 2017 in *Judgment and Decision Making*. Attari hopes to learn if educating people about how their local water systems work will change their attitudes on policy. It's an open question whether better-informed citizens would want and demand funding to remedy crumbling sewage pipes and other infrastructure concerns.

On climate change, Attari's research suggests that scientists can spread a more effective message by shrinking their own carbon footprints. In online experiments she conducted with Krantz and Weber, nearly 3,000 volunteers read different versions of stories about hearing a leading climate researcher advocate for cuts in energy use.

A researcher described as an energy miser at home received much higher credibility ratings than one described as an energy guzzler. Participants reported stronger intentions to reduce their own energy use after reading about energy-frugal climate scientists. The finding held up even among those who regarded climate change as unimportant. In the future, Attari wants to look at how personal experiences and feelings influence opinions about climate science. For an interdisciplinary environmental engineer like Attari, people are complex systems, too. ■



H_2UH-OH Knowledge gaps appeared when college students were asked to draw a diagram of how water reaches the tap in an average U.S. home. This drawing depicts natural water sources connected to a home via "magic" rather than through a water treatment plant.

FROM TOP: CENTER FOR ADVANCED STUDY IN THE BEHAVIORAL SCIENCES AT STANFORD UNIV.; S. ATTARI ET AL/*JUDGMENT AND DECISION MAKING* 2017

Douglas Stanford, 31
THEORETICAL PHYSICS
INSTITUTE FOR ADVANCED STUDY AND STANFORD UNIVERSITY

Calculating chaos in a black hole

By Emily Conover

Douglas Stanford's fascination with black holes had its origins in an unlikely place: a sailboat.

Starting at age 10, Stanford spent five years sailing around the world with his parents and two sisters. Sailboats are "like a physics laboratory," Stanford says. Keeping the boat on course requires balancing the forces induced by wind and water. "You can see really simple physics effects happening," he says.

Today, Stanford, 31, applies his physics know-how to more abstract problems: black holes, quantum mechanics and chaos.

His work as a theoretical physicist at the Institute for Advanced Study in Princeton, N.J., has already revealed new insights, including the discovery that black holes reach the pinnacle of chaos — nothing can be more chaotic than a black hole. That revelation reinforces the notion that black holes are some of the most extreme oddities in the universe and, importantly, it might aid the search for a new and improved theory of gravity.

In chaotic systems, a tiny tweak can have cascading effects that drastically alter the outcome. The most famous example is the butterfly effect, a hypothetical scenario in which a butterfly flaps its wings, and the tiny change in airflow affects when and where a tornado appears (*SN Online: 9/16/13*).

On a quantum level, Stanford and theoretical physicist Stephen Shenker showed in calculations that black holes exhibit similarly chaotic behavior. Changes to a black hole — as minor as throwing a single particle into the abyss — can drastically shift how the black hole behaves.

One key to understanding this chaos is that black holes aren't fully black. The cosmic giants radiate a faint haze of particles, the result of pairs of quantum particles that are constantly blipping in and out of existence everywhere in space (*SN: 11/26/16, p. 28*). When this process occurs near a black hole's edge, some of the particles can escape, producing what's known as Hawking radiation (*SN: 4/14/18, p. 12*).

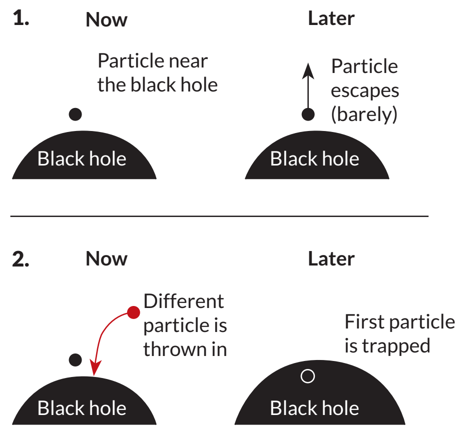
Studying Hawking radiation reveals black holes' chaotic nature, Stanford and Shenker, of Stanford University, reported in 2014 in the *Journal of High Energy Physics*.

Imagine throwing a single electron into a black hole — a tiny change for the behemoth. "It's one particle and a huge, ginormous black hole," Stanford says. But that minuscule change alters the Hawking radiation the black hole emits, like a butterfly flapping its wings and redirecting a distant sailboat.

Adding a particle increases the black hole's heft and slightly expands its event horizon, the boundary from within which nothing can escape (*SN: 5/31/14, p. 16*). Hawking radiation that would otherwise have been emitted gets stuck inside the expanded black hole. A seemingly insignificant alteration has ballooning effects — the definition of chaos.

Stanford then took this idea a step further. In 2016 in the *Journal of High Energy Physics*, he, Shenker and Juan Maldacena of the Institute for Advanced Study showed theoretically that the repercussions of a small tweak to a black hole snowballed as fast as physically possible. That snowballing makes black holes the most chaotic system allowed by the laws of nature.

Stanford's colleagues say he's poised to uncover even bigger insights. "He is a deep thinker and a powerful calculator, a rare, winning combination that one



Trapped Imagine a black hole with a particle nearby, in danger of falling in (1). Sometime later, that particle may escape. But if another particle is tossed in (2), the black hole will expand, preventing the original particle from getting away. Making a minor change to the black hole changes the outcome — an indicator of chaos. SOURCE: D. STANFORD

finds in the very best physicists," says Raphael Bousso, a theoretical physicist at the University of California, Berkeley. Despite his young age, Stanford has secured a position as an associate professor at Stanford University, where he will move in April.

Maldacena says working with Stanford made him feel like a student again. "He corrected my mistakes and gave me good ideas." That's no small feat. Maldacena is a giant of quantum gravity and string theory known for discovering mathematical oddities that physicists are still pondering (*SN: 10/17/15, p. 28*).

By understanding the link between tiny particles and gigantic black holes, Stanford and others hope to tackle a knotty conflict between two of physics' most important theories. The aim is to formulate a theory of quantum gravity, combining two theories that have long clashed: quantum mechanics and general relativity. The mismatch hints that something big is deeply wrong at the heart of physics. Stanford's new ideas about black holes could help scientists find a solution.

"It's possible that he is one of those rare individuals [who] will really change the direction of science," Shenker says. "I look forward to seeing whether I'm right." ■

FROM LEFT: INSTITUTE FOR ADVANCED STUDY; T. TIBBITTS

Lisa Manning, 38
PHYSICS AND BIOLOGY
SYRACUSE UNIVERSITY

When cells are movers and shakers

By Aimee Cunningham

Think of tissues as mosh pits of cells. The cells may not be able to crowd surf, but they can jam.

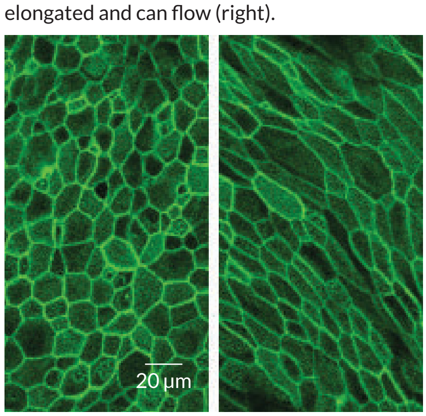
Specifically, cells can undergo a jamming transition, a physical role change that was previously known to occur only among foams, sand and other nonliving materials. It's one of the ways that physicist Lisa Manning has shown how cells get physical with each other — for good and bad.

Manning, 38, describes cells' behavior in terms of the mechanical forces they exert on one another. Her approach has led to a new understanding of a host of biological processes that involve cells on the move, including embryonic development, wound healing and even asthma and cancer.

"Forces at the cellular scale are important for properties of tissues," says Jean Carlson, a physicist at the University of California, Santa Barbara who was Manning's graduate adviser. "Lisa has been a real leader in thinking that way."

Manning first blended physics and biology in high school. She was encouraged by her physics teacher in Park Hills, Ky., Sister Mary Ethel Parrott, to try building a biochemical fuel cell, which produces energy from a microbial community. Manning created a mathematical model to figure out the sweet spot: the right amount of sugar to keep the microbes fed and the system running smoothly.

Human airway epithelial cells (stained green) in normal tissue (left) are "jammed," that is, they act more solidlike. But when mechanically compressed to mimic airway narrowing during an asthma attack, the cells become elongated and can flow (right).



> That feeling of discovery is incredibly addictive.
>
> LISA MANNING

"That feeling of discovery is incredibly addictive," Manning says. She also realized she could describe important aspects of a complex system using a fairly simple mathematical model. "That's basically what I do today," she says. And the benefits were more than inspirational; her efforts won first place in the engineering category at the 1998 Intel International Science and Engineering Fair, a program of Society for Science & the Public, which publishes *Science News*.

Later, as a graduate student in physics, Manning studied the behavior of granular materials, collections of distinct particles. Granular materials can flow like a liquid or jam together like a solid. For example, sand acts like a solid when densely packed, but freed, it pours like a liquid.

Other students in Carlson's research group were mixing physics with biology, and after attending a conference on embryonic development, Manning thought the physics of granular materials could be applied to biological systems, too. She has proved that early hunch right.

For instance, Manning developed a simulation showing that biological materials can indeed jam. "Lisa gets credit for this whole picture," says physicist James Sethna of Cornell University. Her work "makes it clear how close the [cellular] behavior is to this jamming transition."

Manning found that the transition to a jammed state depends on cell shape, which is governed by stickiness and stiffness. Cells have surface proteins to adhere to nearby cells and a kind of internal skeleton that stiffens them.

She predicted a counterintuitive

FROM TOP: AMY MANLEY/SYRACUSE UNIV.; JENNIFER MITCHEL/PARK LAB AT HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

notion: When cells are rounder and stick less to each other, they jam and become more solidlike. When cells are more elongated and stick more to each other, they can unjam and flow.

This theory — that sticky, elongated cells flow — proved to be true in real life and a potential problem in asthma, Manning found in a collaboration with airway epithelial cell biologist Jin-Ah Park of Harvard T.H. Chan School of Public Health and colleagues. Normally, healthy airway epithelial cells grown in the lab are jammed. "They look like cobblestones," Park says.

Reconstructing what goes on in the airways of asthma patients, Park and her colleagues had observed that compressing the cells to mimic a bronchospasm, which restricts airways, made the cells elongate and move. Manning's theory perfectly predicted the cells' behavior, Park says.

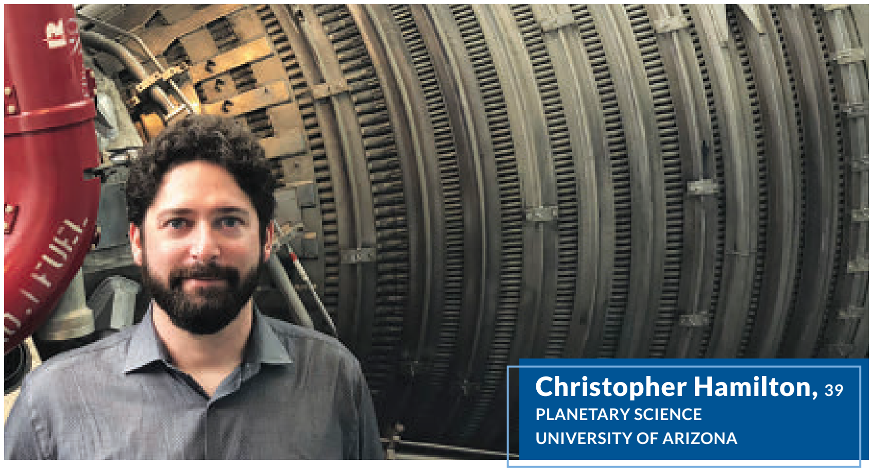
The team also compared the jamming transition in healthy airway epithelial cells with those from patients with asthma, reporting the findings in 2015 in *Nature Materials*. In asthma, airway epithelial cells don't respond properly to injuries from viruses, bacteria or pollutants, leading to excess inflammation and narrowed airways. Cells from patients with asthma, grown in a special culture that mimics the airway environment, stayed mobile for up to two weeks before stabilizing and jamming; healthy cells jammed sooner, in about six days.

Park suspects that the excessive motion might correspond to a delay in the ability of airway cells in asthma patients to repair after environmental injury. She and colleagues hope to learn how to manage the forces in airway cells for asthma patients. Figuring out how to help those cells stabilize might lead to new treatment approaches.

Manning has also modeled how forces affect cell behavior during embryonic development and cancer.

"My hope really is that we are providing a complementary approach to the work in biology," Manning says. "I think we may be able to identify unexpected targets for therapy." ■

C. HAMILTON



Christopher Hamilton, 39
PLANETARY SCIENCE
UNIVERSITY OF ARIZONA

The architecture of other worlds

By Carolyn Gramling

Christopher Hamilton wanted to be an architect.

Yet the planetary scientist at the University of Arizona in Tucson is exploring a very different kind of built environment: the strange structures created by volcanoes on worlds across the solar system, from Earth to Mars to the moon.

And he's using an unusually diverse toolbox of techniques, including neural networks used in artificial intelligence and good old-fashioned geologic field mapping.

"He is constantly moving between worlds," says planetary geologist Laura Kerber of NASA's Jet Propulsion Laboratory in Pasadena, Calif. "It's one of the extraordinary things about him."

Hamilton's first crossover — switching from architecture to geology as an undergraduate student at Dalhousie University in Halifax, Nova Scotia — has a certain logic. "A blueprint and a geologic map are extraordinarily similar," says Hamilton, 39. Each can tell you what was there before, how something was built and how it could be dismantled.

That's where lava, a fundamental part of shaping any terrestrial planet, comes in. To understand how otherworldly volcanic landscapes formed, scientists first look closer to home, seeing how lava shapes features on Earth that act as stand-ins for alien terrain.

Iceland, for example, "is truly an otherworldly place," Hamilton says. During college, he spent a year there studying and mapping volcanic structures buried beneath a thick blanket of emerald green moss. The structures are remnants of one of the largest volcanic eruptions in recorded history.

About 240 years ago, the volcano Laki awoke in fury, sending molten basalt lava pouring across the landscape. When the lava encountered water bodies, such as swamps or lakes, boom! Powerful steam explosions left deep dents in the ground. Scientists call these craterlike structures volcanic rootless constructs, or cones, because they are not connected to any underground magma supply.

Mars has similar terrain. Early images of the Red Planet suggested that the ground was littered with rootless constructs, offering tantalizing clues to the planet's watery past. Hamilton made the study of these features the focus of his Ph.D. research at the University of Hawaii at Manoa.

Working with adviser Sarah Fagents, Hamilton mapped 167 groups of rootless cones on Mars. The researchers estimated that the constructs formed when lava flowed across the region sometime between 250 million and 75 million years ago. The lava interacted with abundant water ice that simulations suggest was buried at least 42 meters beneath the surface. Those interactions may also have created short-lived hydrothermal systems that could have been a habitable environment for microbes, the researchers hypothesized in 2010 in the *Journal of Geophysical Research: Planets*.

"He's a very inquisitive, thirst-for-knowledge kind of person," Fagents says. "He has an ability to really delve deep into a problem — and he's not afraid to jump into new areas."

In fact, by the time he finished his Ph.D., Hamilton was thinking about unfamiliar environs. "I didn't want to just focus on a single place," he says. "I wanted to understand how different geologic processes work throughout the solar system." At NASA's Goddard Space Flight Center in Greenbelt, Md., from 2011 to 2014, Hamilton turned his attention to other extraterrestrial volcanic processes.

One project focused on Jupiter's innermost moon, fiery Io, the most active volcanic body in the solar system. Researchers have long thought that Io's intense volcanism results from what's known as "tidal heating" of the presumably solid moon. Competing gravitational tugs from two nearby moons and Jupiter itself squeeze and stretch Io, heating its insides. But that hypothesis doesn't fully explain Io's heat production. Hamilton demonstrated in 2015 that observations better match simulations if Io is considered to be partly fluid.

Iceland is dotted with rootless cones (one shown, left, at Lake Mývatn), which form when lava flows across a watery landscape. Mars, too, has these false craters, remnants of the Red Planet's watery past. This one (right) is in Amazonis Planitia, a region covered in ancient lava.

Today, Hamilton leads a research group that's studying volcanic processes on Earth to understand how these processes can shape the surfaces of other worlds. The team is devising a proposal to NASA to study Io's tidal heating more thoroughly with the aid of a computer algorithm that can identify patterns of tidal heating captured in hundreds of thousands of satellite images.

He's also working with Kerber on another proposal to NASA for a low-cost mission to send a rover to Earth's moon to rappel into ancient lava tubes known as skylights. The desire to understand how these tubes formed and what they're made of is reminiscent of one of Hamilton's earliest studies, in which he reconstructed how lava channels formed from a 1970s lava flow at Hawaii's Kilauea volcano.

A theme runs through Hamilton's work: To truly explore — and, possibly, someday inhabit — other worlds, scientists must first understand what materials and resources are available on those worlds. It is, in a way, another kind of architecture. ■

Mapping stars across generations

By Lisa Grossman

Paula Jofré wants to map the galactic lineage of every star in the Milky Way. It's like tracing your family tree, if your grandparents were supernovas.

Jofré, 36, is an astrophysicist at Universidad Diego Portales in Santiago, Chile, where she studies the inner lives and histories of stars. She measures the wavelengths of the light that stars emit to figure out which chemical elements the stars contain and in what proportions.

Then she does something unusual: She borrows a technique from biology to trace the stars' evolution.

Much like an archaeologist examining the DNA in ancient human remains to trace a population's history, Jofré uses modern stars' contents to track how their stellar ancestors moved around the Milky Way. Her best-known work, and the research of which she's most proud, uses those elements as a proxy for DNA to chart the first family tree of the Milky Way's stars.

She got the idea as a postdoc at a University of Cambridge event organized by an art history student. The focus was how scientists visualize

Paula Jofré, 36
GALACTIC AND STELLAR ASTROPHYSICS
UNIVERSIDAD DIEGO PORTALES, SANTIAGO, CHILE

CLOCKWISE FROM TOP LEFT: HANSUELI KRAPF/WIKIMEDIA COMMONS (CC BY-SA 3.0); UNIV. OF ARIZONA, JPL-CALTECH/NASA; MARÍA CECILIA ABARCA/UNIVERSIDAD DIEGO PORTALES their results. There, she met Cambridge anthropologist Robert Foley, who showed her how evolutionary trees can trace relationships of members of a species over time. Suddenly she realized that stars, too, pass down bits of themselves to successive generations. Perhaps, she thought, these generations could also be traced back in time.

Soon, she and Foley hashed out the stellar family tree project at dinner in a Cambridge dining hall — "very much like a Harry Potter room," she says, where all the fellows wear academic gowns. Stars obviously don't procreate like animals, the pair agreed, but dying stars do pass on their chemistry.

That happens because stars forge heavy elements, such as carbon and iron. When the stars die, they often explode and spread those elements throughout the cosmos. The next generation of stars, born from collapsing clouds of gas containing those elements, picks up elements from the earlier generation.

> "We could use these trees to learn something about the evolution of our whole galaxy."
> PAULA JOFRÉ

And thus a family is born. Stars from the same gas cloud should have almost identical chemistry, something like how siblings have similar DNA. The analogy is close enough that Jofré, Foley and colleagues built a three-branched tree showing the relationships of 21 of the sun's sibling stars in 2017 in the *Monthly Notices of the Royal Astronomical Society*. The team also reported that two of the branches were known groupings — one was the Milky Way's thin disk of stars, and the other was the older thick disk that surrounds it.

The third branch revealed new connections, showing that Jofré's technique does more than map known star relationships. The approach can reveal new information about past stellar nurseries.

By expanding to more groups of stars, "we could use these trees to learn something about the evolution of our whole galaxy," Jofré says. "That has been so exciting."

Other astronomers call the technique original and inventive, if a little unorthodox.

"Paula Jofré impressed me as being very innovative," says astronomer Kenneth Freeman of the Australian National University in Canberra. "She sees things that other researchers do not see."

Payel Das of the University of Oxford, a collaborator on the Milky Way project and a close friend, calls Jofré "really brave" as a researcher. "She's very confident, which is really nice. I think especially now — we're going through this crisis of women in physics and science and all this — we need this confidence."

Jofré has never shied away from unpopular paths. Before she graduated from an all-girls high school in Santiago, a guidance counselor spoke to her class about the importance of choosing a career that would leave time for family. One shouldn't choose a career in, say, astronomy.

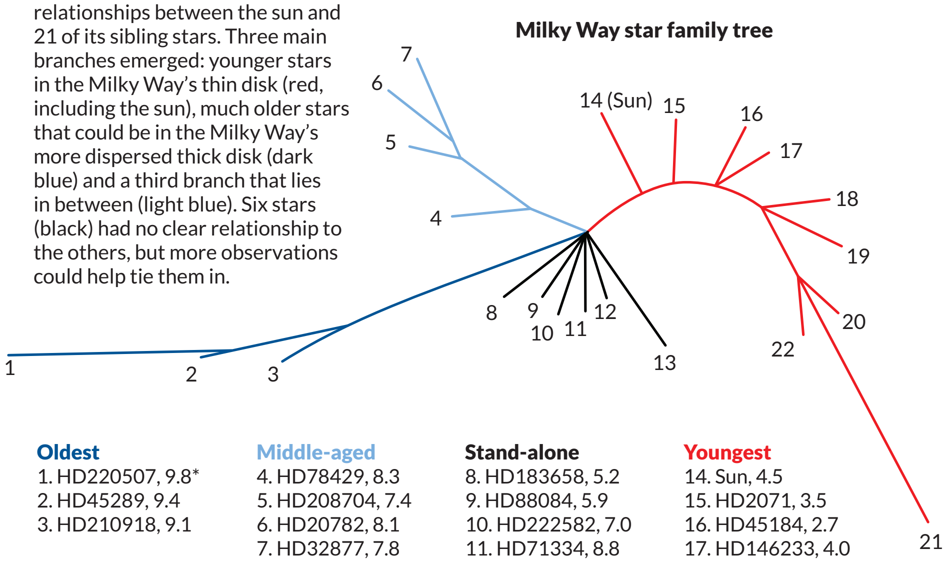
"The whole class looked at me," says Jofré, who had been interested in astronomy since childhood. The moment only strengthened her resolve. "This woman trying to say, 'please don't do that,' was for me an argument to say, 'please do it.' "

The question of whether astronomy is compatible with a family came up sooner than Jofré expected: Her first child was born before she and her partner, Thomas Maedler, finished their Ph.D.s. Their second was born during her first postdoctoral fellowship. Being the only parents in their graduate cohort was difficult. "You feel quite lonely when you're the only one," Jofré says.

But contrary to the guidance counselor's warnings, parenthood has been grounding for the two and helped keep them focused on what's important — "which is not like, papers, papers, papers, papers, papers," as Maedler puts it. "We're always this little nucleus, the four of us, this little atom that is walking around."

For Jofré, science has been inextricably entwined with family — not just the sun's, but her own. ■

All in the family Paula Jofré and colleagues mapped out chemical relationships between the sun and 21 of its sibling stars. Three main branches emerged: younger stars in the Milky Way's thin disk (red, including the sun), much older stars that could be in the Milky Way's more dispersed thick disk (dark blue) and a third branch that lies in between (light blue). Six stars (black) had no clear relationship to the others, but more observations could help tie them in.



Oldest
1. HD220507, 9.8*
2. HD45289, 9.4
3. HD210918, 9.1

Middle-aged
4. HD78429, 8.3
5. HD208704, 7.4
6. HD20782, 8.1
7. HD32877, 7.8

Stand-alone
8. HD183658, 5.2
9. HD88084, 5.9
10. HD222582, 7.0
11. HD71334, 8.8
12. HD28471, 7.3
13. HD96423, 7.3

Youngest
14. Sun, 4.5
15. HD2071, 3.5
16. HD45184, 2.7
17. HD146233, 4.0
18. HD8406, 4.1
19. HD92719, 2.5
20. HD27063, 2.8
21. HD96116, 0.7
22. HD134664, 2.4

*Star name, age (in billions of years)

JOFRÉ ET AL/MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY 2017, ADAPTED BY T. TIBBITTS

AI wrangles torrents of information

By Maria Temming

The world is awash in data. Anshumali Shrivastava may save us from drowning in it.

Every day, over 1 billion photos are posted online. In a single second, the Large Hadron Collider can churn out a million gigabytes of observations. Big data is ballooning faster than current computer programs can analyze it.

"We have this huge ocean of data," says electrical and computer engineer Richard Baraniuk at Houston's Rice University, "and we've got to suck it out through a garden hose."

Anshumali Shrivastava, 33
COMPUTER SCIENCE
RICE UNIVERSITY

So Shrivastava, 33, a computer scientist at Rice, is designing a new generation of artificial intelligence programs to efficiently process floods of information.

"He's very creative" in his strategies to wrangle unwieldy datasets, says Piotr Indyk, an electrical engineer and computer scientist at MIT. "Some of these things I say, 'I wish I came up with that.' They're clear, beautiful and they work."

Shrivastava got into artificial intelligence because number-crunching algorithms that solve real-world problems are "where you see math in action," he says. But as a Ph.D. student in computer science at Cornell University, Shrivastava realized how inefficient artificial neural networks, today's premiere AI programs, really are.

Neural networks are made of pieces of computer code called artificial neurons. To learn a task such as image recognition, an AI network might study labeled images, with each of the artificial neurons in the network gaining expertise at recognizing certain patterns.

But even as they specialize, all neurons in a typical network keep studying all incoming information. When the network sees a cat photo, for example, even neurons responsible for noticing trucks pay attention. That's unnecessarily time- and energy-consuming, Shrivastava says.

In graduate school, Shrivastava found a way to identify and activate only the neurons most relevant to each input. He used hash functions, computational tools that organize records in databases much like the Dewey Decimal System organizes books in a library.

Shrivastava fashioned a set of hash functions to organize and quickly locate virtual neurons in a network based on their relevance to a given input — so you could find all the cat neurons and ignore the truck neurons.

"I was thinking about this problem for more than two years," he says. "You keep all your hard problems in the back of your head." He'd return to this one and usually get nowhere. But the day the path to an answer came to him, he solved it in a couple of hours. He recalls sitting in his bedroom, reading and rereading his solution to convince himself it would actually work.

The system he came up with may be considered "the best research work in machine learning in that year," says Moshe Vardi, also a computer scientist at Rice. The work won the Outstanding Paper Award at the 2014 Conference on Neural Information Processing Systems.

Since then, Shrivastava has built an image-classifying neural network that works about as well as standard networks, but uses 95 percent fewer computations. Such efficiency could free up time and energy for an AI program to process other information, for instance, audio for speech recognition, paving the way for more versatile artificial intelligence.

He has also developed other ways to streamline computation since joining the Rice faculty in 2015. He's "incredibly bright and incredibly fast," Vardi says. "We sometimes have to run after him because his mind is racing ahead."

Shrivastava and colleagues at Rice and Duke University recently applied hashing to databases of Syrian civil war victims. Getting an accurate death count to help prosecute perpetrators of crimes against humanity has proved difficult. Databases of victims reported by family members, the media and other sources contain duplicate records; it would take a computer more than a week to compare all 354,000 records to each other to find repeats. Once Shrivastava's computer program assigned each record in four victim databases a hash code, it used those codes to identify likely duplicates in just a couple of minutes. The program, reported in June in the *Annals of Applied Statistics*, then checked only those records for matches.

Closer to home, Shrivastava and colleagues created a smartphone app for navigating shopping malls or other large buildings based on photos of a person's surroundings. The app distilled user-taken photos into hash codes to compare with reference photo codes, pinpointing locations within two seconds.

> We sometimes have to run after him because his mind is racing ahead.
> MOSHE VARDI

With the flood of big data growing, it would be easy for Shrivastava to get overwhelmed and discouraged. Fortunately, "there's not a glum bone in his body," Baraniuk says.

Shrivastava might stall on a particular problem for months before getting the kind of brain blast that led to his hash-based eureka moment. But when he can kick a slow-moving computer system into high gear, he says, "that's worth it." ■

A. SHRIVASTAVA

Jenny Tung, 36
GENETICS AND EVOLUTIONARY ANTHROPOLOGY
DUKE UNIVERSITY

How social stress messes with genes

By Susan Milius

Jenny Tung is skeptical when she hears that her older sister, Wenny, compares Jenny's science to their father's golf.

He played so much because he found it "a big, fat, hairy challenge," Wenny said, proposing that Jenny also is drawn to challenges by their difficulty.

Jenny Tung protests. Yet she doesn't deny that her research tackles a big, hairy question: Why does a tough social life go along with worsening health, even a greater risk of death?

Tung, 36, combines evolutionary anthropology and genomics at Duke University to answer this "why," from the tiniest details of what social adversity does to DNA to the vast evolutionary forces that shape connections between genes and social life.

Social scientists have long observed that people of high social status tend to live longer than those on society's bottom rung — by a decade or more in some studies.

But basic questions remain: Why does a low-status life undermine health, and how is biology involved? Maybe wealthier people pay for the best health care or find safer jobs. Or healthier humans might find it easier to become wealthier and more successful.

Monkeys, however, haven't evolved health care or what a human would call a job. The animals offer Tung the chance to see more clearly how social hierarchies affect DNA, and thus health.

In one of her more striking papers, Tung and colleagues found that shifting the social rank of female rhesus macaques changes how prone their immune systems are to chronic inflammation (*SN: 12/24/16, p. 7*), which, in humans, appears to be a risk factor for heart disease and other illnesses.

The researchers monitored macaque immune systems and gene activity of captive females living in groups and then shuffled all animals of particular rank into new groups so that different hierarchies formed. Tung put all the formerly top females into the same group, for instance, so that only one of them would continue to enjoy life as number one.

Overall, a female's immune status improved or faltered according to whether her social status rose or fell, Tung and colleagues reported in 2016 in *Science*. Testing to see which genes became more or less active as a monkey's social fortunes changed has revealed some biochemical pathways that may turn out to explain the physical costs of a sinking status.

For studying social influences on gene regulation, "Jenny is certainly among those at the forefront of technical genetics sophistication," says Steve Cole of UCLA's medical school. He studies social impacts on gene regulation in people and has found healthful effects from life satisfaction and worrisome impacts of loneliness. Tung, he says, is the only researcher in the field who has experimentally manipulated monkey social status.

Captive monkeys, however, live relatively plush lives. To see if rank and a tough start in life loom as large in the wild with its extra perils, Tung turned to data from baboons she has visited in Kenya's Amboseli National Park. Generations of monkeys have been observed there since 1971.

For 196 Amboseli female baboons, Tung and colleagues checked for six forms of hardship early in life, such as a severe drought or the deprivations encountered by a daughter of a low-ranked mom. Baboons that suffered at least three of these disadvantages as youngsters died on average 10 years earlier than those with no more than one misfortune, the researchers reported in 2016 in *Nature Communications*. Even in the wild, social adversity plays a role in lifelong health.

Social hardships shorten lives among female baboons in Kenya's Amboseli National Park.

In upcoming papers, Tung says, her new findings may begin to clarify whether a tough social life, at least among monkeys, causes poor health or is a consequence of it.

"Jenny is not cut from any familiar mold as a scientist," says Tung mentor Susan Alberts, chair of Duke's evolutionary anthropology department, who calls Tung "inherently interdisciplinary."

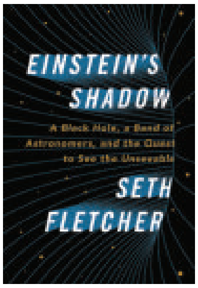
Tung herself remembers being asked as a student whether she saw her future science self at a computer pushing computational boundaries, standing in the field watching animals or wearing a white coat at a lab bench. "I didn't want to give any of those up," she says.

She traces her thinking back at least to freshman year at Duke, when an interdisciplinary seminar introduced her to an evolutionary framework for considering values such as altruism. The framework, she says, "felt sensible ... like an empirically driven, scientifically minded way of explaining hard problems in the world." Now she's using that framework to tackle a long-standing social-adversity question that she's intensely curious about. So what if it's big and hairy. ■

FROM LEFT: MEGAN MENDENHALL/DUKE UNIV.; S. ALBERTS/DUKE UNIV.

BOOKSHELF

Einstein's Shadow explores what it takes to snap a black hole's picture



Einstein's Shadow
Seth Fletcher
ECCO, $26.99

Right now, a ragtag team of astronomers, assembled from institutes across the globe, may be peering in wonder at the first picture of a black hole's shadow. The quest to create such an image has involved a massive level of scientific coordination, combining data from telescopes at eight observatories scattered from the South Pole to Hawaii to the Atacama Desert in Chile. In *Einstein's Shadow*, journalist Seth Fletcher provides a twisting narrative of the project's inception and how it grew into a worldwide effort.

Called the Event Horizon Telescope, or EHT, the project is "the biggest telescope in the history of humanity," EHT director Shep Doeleman of the Harvard-Smithsonian Center for Astrophysics says in the book. EHT unifies far-flung radio telescopes through a technique called very long baseline interferometry, which involves combining the light waves spotted by each telescope to determine how the light adds up, through a process called interference. Using this technique, EHT can achieve resolution equivalent to picking out a doughnut on the moon. That extreme capability is what's needed to capture a picture of EHT's main target: the gigantic black hole at the center of the Milky Way.

EHT captured its first data in 2006, but has yet to produce an image of a black hole. After adding more telescopes and improving the technology, in April 2017, EHT took data aimed at capturing the silhouette of the Milky Way's central black hole (*SN Online: 4/5/17*). Those data are still being analyzed.

No one has ever directly seen a black hole, so scientists still debate the details of what black holes are like. A boundary known as an event horizon is thought to exist at the edge of each black hole. This border, beyond which nothing can escape (*SN: 5/31/14, p. 16*), is what EHT is attempting to image.

Close to the event horizon, physics becomes utterly strange, with space and time warped by intense gravity. There, Einstein's general theory of relativity, which describes gravity, clashes with quantum mechanics, the theory of physics on small scales. Scientists are still unsure how to reconcile the two theories (see Page 23), but an image of the black hole's boundary could provide hints.

Einstein's Shadow gives a feel for what it takes to image a black hole, thanks to Fletcher's accounts of researchers scrounging for funding, pleading for telescope time and wishing for good weather. Leaders of the collaboration squabble over power and responsibilities. Observations fail due to technical difficulties. Astronomers bite their fingernails as delicate equipment is driven up a bumpy mountain road.

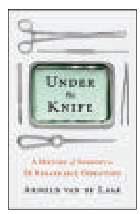
Telescope upgrades and malfunctions get detailed explanations in the book. Astronomy buffs will probably enjoy those passages, but others may find them a bit dull. That feeling, however, may put readers in astronomers' shoes — science sometimes can be slow.

We won't know what EHT saw until the team releases its results. According to Doeleman, that should happen early next year. If EHT eventually unveils a black hole portrait, the dirty and dull work that was necessary to get the project off the ground will likely be glossed over in media coverage. *Einstein's Shadow* reveals parts of the scientific process that, like the Milky Way's gigantic black hole, are usually left in the dark. That process is worth bringing to light. *— Emily Conover*

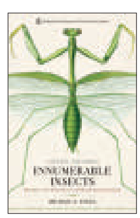
Scientists hope to image a black hole's shadow (simulations shown) to reveal secrets of gravity.

D. PSALTIS, A. BRODERICK

BOOKSHELF



Under the Knife
Arnold van de Laar
A surgeon uses wit and his expertise to describe 28 of history's most interesting operations and to offer insights into the future of medicine. *St. Martin's Press, $29.99*



Innumerable Insects
Michael S. Engel
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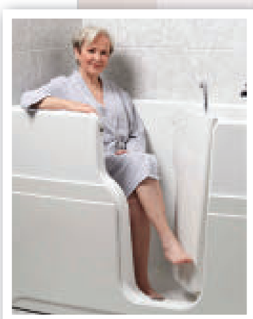

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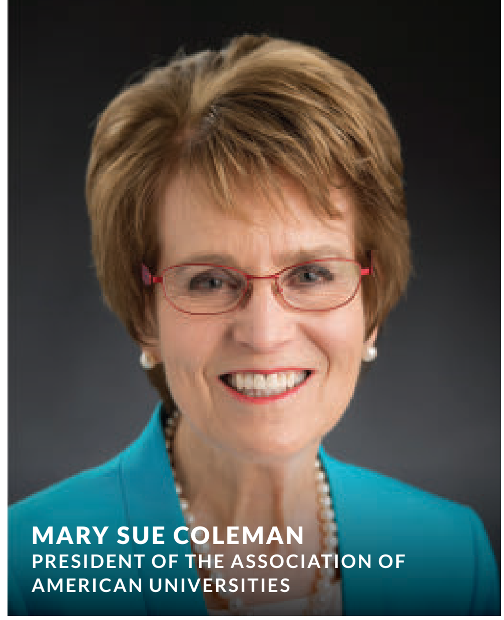
CONVERSATIONS WITH MAYA



MARY SUE COLEMAN
PRESIDENT OF THE ASSOCIATION OF AMERICAN UNIVERSITIES

ASSOCIATION OF AMERICAN UNIVERSITIES

Maya Ajmera, President & CEO of Society for Science & the Public and Publisher of *Science News*, sat down to chat with Mary Sue Coleman, President of the Association of American Universities and a former President of the University of Michigan. Coleman is an alumna of the 1961 Westinghouse Science Talent Search (STS) and the 1959 and 1960 International Science and Engineering Fair (ISEF). She is also a member of the Society's Board of Trustees. We are thrilled to share an edited summary of the conversation.

I understand you had an opportunity to meet President John F. Kennedy and Vice President Lyndon B. Johnson while you were in Washington, D.C., competing in STS. Do you remember that experience, and what was that like for you?

We knew that meeting the president was an extraordinary opportunity. What we didn't understand was that Kennedy wouldn't be with us very long after that. In retrospect, it was bittersweet.

All the girls were instructed to wear white gloves and hats to the White House to meet with the president and vice president. Everybody was totally smitten with Kennedy because he was a young, fresh, energetic face of the presidency in a way that everybody was excited about. When he was killed, I couldn't quite believe that I had that experience of meeting President Kennedy. It was very, very meaningful, and I've remembered it forever.

What was your experience at ISEF like?

I was engaged in local science fairs before 1959. I went to a lab school that was associated with the University of Northern Iowa, and the faculty was very encouraging, giving me space and time to do my project, which aimed to demonstrate the development of resistance in bacteria to penicillin. It was very simple, but it was exciting for me.

The fair was exhilarating to me because I was able to meet more students interested in science. I was the only person in my small school who was interested in scientific research and participated in science fairs. Through ISEF, I was able to meet other students from around the country and some international students.

How did STS and ISEF affect your career? We hear from a lot of alumni that the fairs were a pivotal moment in their lives.

STS, in particular, convinced me that I was good enough to compete at the highest levels. I competed during the time of the Sputnik threat. And so I got lots of outreach from companies, from individuals around the state, who just said, "Oh, we're so glad you're interested in science." I felt like I was doing something extraordinarily important, not only for myself but for the country.

You're a trailblazer. You were a university professor with a Ph.D., at a time when there weren't a lot of women in the sciences. What kind of challenges did you face?

I was a chemistry major at Grinnell College in Iowa. There were other women who majored in chemistry, and also women in graduate school, but there were no women professors. That was something that I found fairly troubling. In fact, when I went to Chapel Hill in 1990 as a university administrator, I put together some analyses of both Duke University and the University of North Carolina about the number of women faculty. I became quite vocal about increasing the number of women professors.

I never felt like people said, "You can't do this." I always got encouragement everywhere I went. That's not to say I didn't face obstacles. The first roadblock that I recall facing was obtaining a faculty position at the University of Kentucky. There were no women on the biochemistry faculty, and I had to spend more time as a postdoctoral fellow than was ideal — but I also learned a lot during that time. Eventually, I was able to get a faculty position.

Mary Sue Coleman displays her 1961 Science Talent Search project, "Studies in Bacterial Mutation."

I think one of the reasons that I've been successful is that I've always promoted opportunity for everybody. Young men in science need just as much support as young women because it's tough. It's a tough environment, and it's a highly competitive environment. We need to be nurturing everybody in the nation who wants to go into science.

You were a chemistry major at a liberal arts college. What are your thoughts on the importance of liberal arts?

Even though I was a chemistry major as an undergraduate, I took art courses. I loved learning about history and literature. I think the critical thinking skills I learned from a liberal arts institution have served me extraordinarily well.

You were president at the University of Michigan from 2002 through 2014 at a difficult time for the state, economically. How did you navigate that and help the campus community?

Michigan went into the Great Recession earlier than most other states and had a far more negative experience. It was a very, very difficult time. Unlike many public universities, the University of Michigan had the advantage of a robust culture of philanthropy. I activated it in a way that I think was really in a crisis mode, but I was also very strategic. This was a time when most universities stopped hiring great faculty, but I put aside money for hiring, which enabled us to hire several hundred additional faculty members. We landed the best people because nobody else was hiring. I thought, if you're going to spend money, spend it where it's going to make a difference, and it made a huge difference.

As president of the Association of American Universities, you are familiar with the issues facing college campuses across the country. What are the biggest challenges facing universities today?

Affordability and access are always big issues for students. I think a lot more cooperation among institutions could be helpful. Students might need to start their college career at a community college and then transfer. We must also work more vigorously on communicating the value of higher education.

In 2010, you were asked by Secretary of Commerce Gary Locke to cochair the National Advisory Council on Innovation and Entrepreneurship. And then in 2011, President Barack Obama asked you to help launch the Advanced Manufacturing Partnership. What did you do in those roles?

As you may recall, those were initiatives of the Obama administration and the Department of Commerce during the Great Recession, when it was important to highlight a rebirth of American manufacturing. It was important for us to talk about key issues, like why America should care about manufacturing and whether it was bad for our nation to outsource advanced manufacturing to the world. We were trying to give advice, both to the administration and to Gary Locke, about what commerce could do to help stimulate innovation. I was thrilled to be part of it.

One of the things you said that has always stuck with me is "talent is everywhere." You've long promoted the educational value of diverse perspectives in the classroom and also within the academic community. Why is that such an important issue for you?

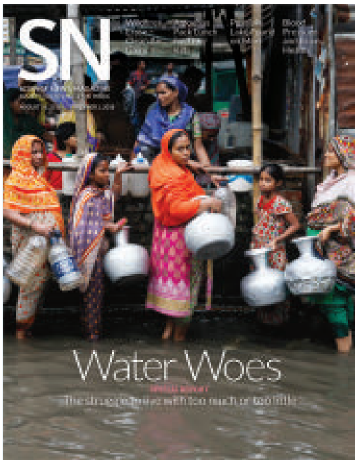
I think part of it has to do with the time I spent growing up in the South and realizing inequities that existed in opportunities for young people. I have always felt like access to education is a key factor in creating a democratic society. You need to have an educated populace — I don't think ignorance and democracy go hand in hand very well. And so I've just cared a lot about student access. Part of student access involves ensuring students can afford college. That's why we had to raise so much money at Michigan through philanthropy so that we could recruit students from everywhere.

What advice do you have for young people moving into higher education or their careers?

I encourage young people to avail themselves of all the educational opportunities that they have because I believe that the more education you have, the more opportunities and options you have in your life. That's why I'm so appalled by the pundits who declare you don't need to go to college. Is that what they really want for their own children? And so, I tell young people, I hope you love education. I hope you have the advantage of being in an environment where you have excellent teachers and where people can get you excited. There is a huge and wonderful world out there, and you don't want to be in a position where you don't know what you don't know.

There are so many challenges in the world today. What keeps you up at night?

I worry about the skepticism about facts, and I worry that some people don't believe evidence. I worry about people who don't understand that climate change is the future. It's happening now, and it's based on solid scientific research and scientific discovery. If we lose the ability as a nation to rely on those who are discovering new information, that is going to affect us. ◆



AUGUST 18, 2018 & SEPTEMBER 1, 2018

Life signs

*Scientists estimate that there are roughly 10 billion liters of liquid water beneath ice sheets on Mars, **Lisa Grossman** reported in "Lake of liquid water detected on Mars" (*SN: 8/18/18 & 9/1/18, p. 6*).* Some online readers wondered what the detection meant for the possibility of life on the Red Planet.

Grossman wrote about that question in "What does Mars' lake mean for the search for life on the Red Planet?" (*SN Online: 7/27/18*). The ice sheets covering the lake on Mars are roughly –68° Celsius. That's nearly 30 degrees colder than the coldest environments on Earth in which life can thrive, **Grossman** found during her reporting. For the water to be liquid at such low temperatures, it must be extremely salty — too salty for even Earth's salt-loving microbes. It's possible, however, that some Martian organisms that flourished when the planet was wetter and warmer could have adapted to the cold, salty environs, researchers say.

Fired up

*Bigger, more frequent wildfires are largely responsible for worsening air quality in the western United States, **Laurel Hamers** reported in "Wildfires threaten clean air gains" (*SN: 8/18/18 & 9/1/18, p. 9*).*

"Forgive the pun, but it burns me up when I read about climate change as the only mentioned possible cause of wildfires in the West," reader **Corine Elwart** wrote. "A century and a half of fire suppression carries much, if not most, of the blame.... Before the advent of Smokey Bear policies, natural and human-caused fires kept forests clear of litter on a yearly basis." She warned that continuing to suppress fires will result in further catastrophe.

Fire suppression policies are a big reason why some wildfires are a problem today, **Hamers** says. And climate change is making fires worse. "This particular story addressed the effects of wildfires, specifically air pollution, and not necessarily the causes of wildfires."

In the air

*In a first, researchers have built circuits on microscopic chips that can be mixed into an aerosol spray, **Maria Temming** reported in "Turning electronic chips into a spray" (*SN: 8/18/18 & 9/1/18, p. 8*).*

Although a sensor-laden spray could one day be used to track environmental and health hazards, some readers were concerned that electronic sprays could pose their own risks. "Imagine the impact to people who have respiratory problems when these chips become widespread in the atmosphere with no ability to control them!" reader **Ken Lapre** wrote.

The electronic sensors would not be sprayed into the open environment, says **Volodymyr Koman**, a chemical engineer at MIT who helped create the spray. "We're working purely in closed systems," he says. If researchers wanted to test the atmosphere for pollution, for example, they would collect an air sample in a container and then apply the spray.

"Also, scientists would need to keep track of the sensors, not just have the sensors float off into the wind," **Temming** adds. "Scientists have to physically collect and look at the sensors to see what they may have detected," she says. If some sensors do escape into the environment, **Kourosh Kalantar-Zadeh**, an electrical and chemical engineer at the University of New South Wales in Sydney, expects that the 2-D materials used to make the sensors would be fairly harmless.

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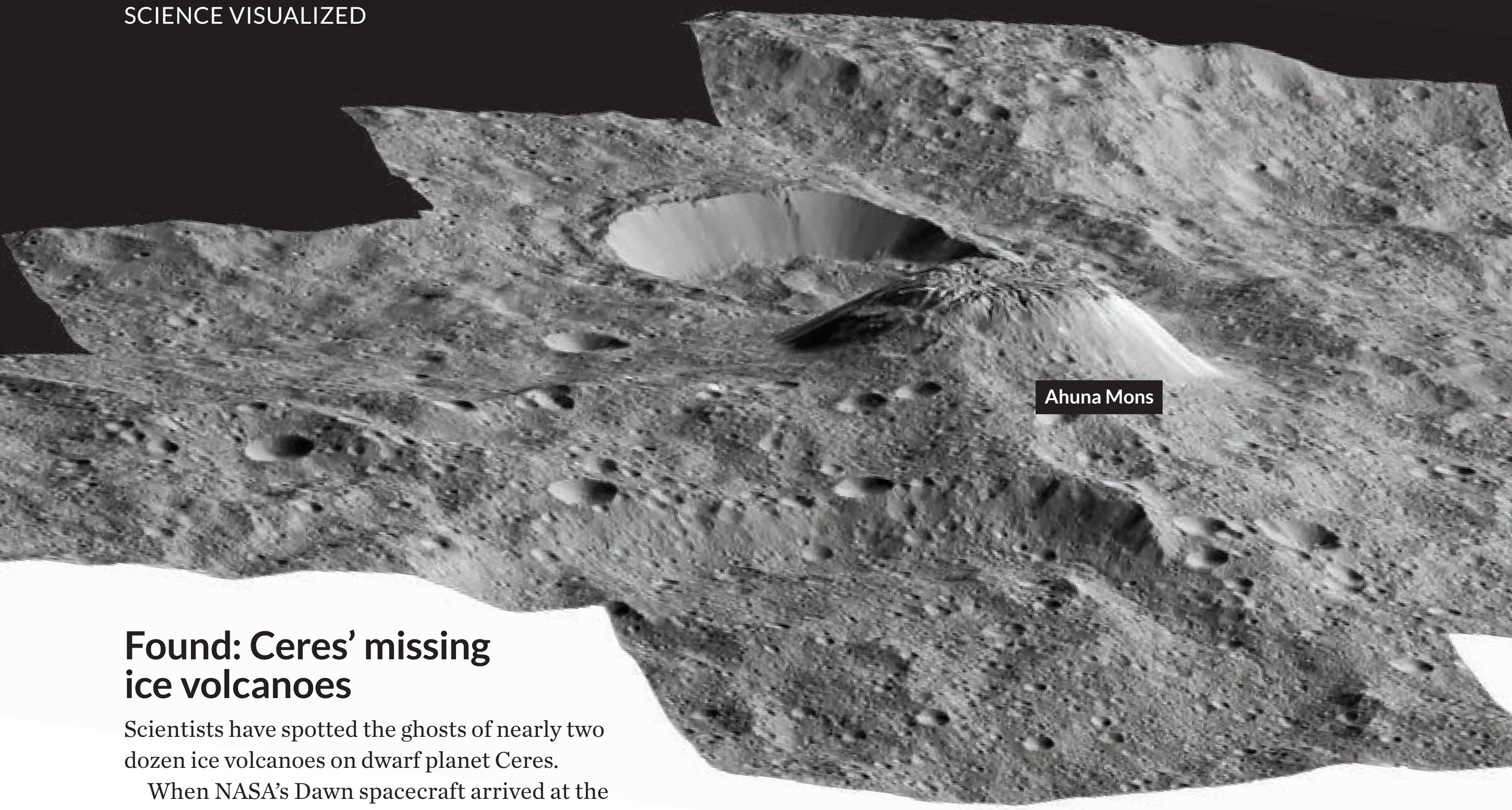


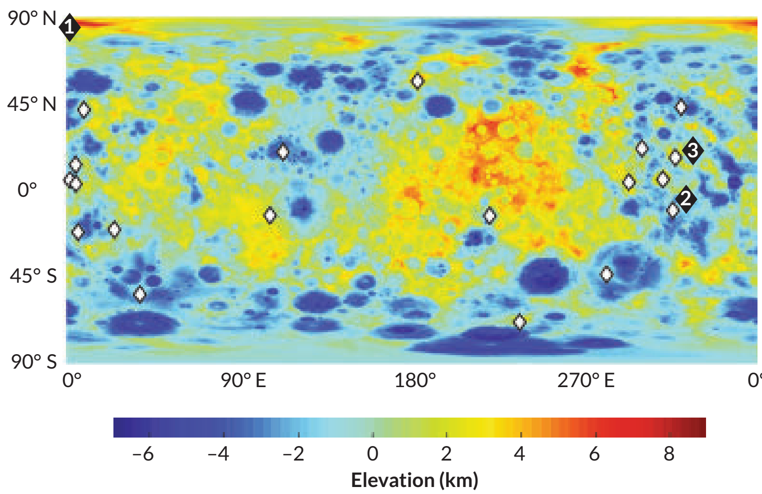
Found: Ceres' missing ice volcanoes

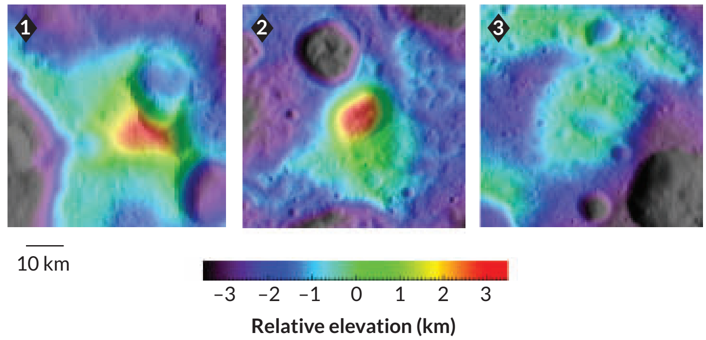
Scientists have spotted the ghosts of nearly two dozen ice volcanoes on dwarf planet Ceres.

When NASA's Dawn spacecraft arrived at the small world in the asteroid belt in 2015, researchers found just one cryovolcano: Ahuna Mons, a 4-kilometer-high mountain that formed at most 240 million years ago (shown above in Dawn images). Cryovolcanoes spew water, not magma, though it's unclear if Ahuna Mons is still active. But why Ceres didn't seem to have any other volcanoes was a mystery.

Now, using data from the probe, the remains of 21 more ice volcanoes have been located (all 22 sites marked with diamonds in the topographical map at right), researchers report September 17 in *Nature Astronomy*. The newly identified volcanoes formed hundreds of millions to about 2 billion years before Ahuna Mons, scientists estimate. Only one, called Yamor Mons (No. 1 in the images at right), is similar to Ahuna Mons (2) in size and steepness. The rest have slumped into shorter, wider domes over time (one example, 3).

The team calculates that the volcanoes, now inactive, should have spewed out an average of 10,000 cubic meters of water per year. Volcanoes on rocky planets, such as Earth, that erupt molten rock spew thousands of times as much material as that, even when taking the worlds' relative sizes into account. So icy volcanism seems less important to Ceres' history than rocky volcanism has been to other places, planetary scientist and study coauthor Michael Sori of the University of Arizona in Tucson and colleagues conclude. — *Lisa Grossman*





TOP: DAWN MISSION/JPL/NASA; OTHERS: M. SORI *ET AL*/*NATURE ASTRONOMY* 2018

GEOLOGIC ROAD TRIP OF THE MONTH

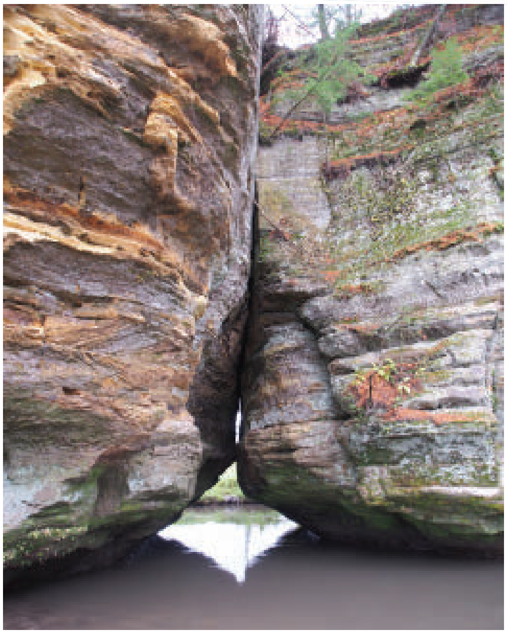
PIER COUNTY PARK AT ROCKBRIDGE

Lying along the west side of the Pine River in Richland County is a bold north-trending ridge of sandstone, about a half mile long, standing 60 feet above the surrounding plain. The south end of this sandstone mass lies within Pier County Park on WI 80 next to the village of Rockbridge. The north end lies on private land. The ridge is fragmented into several blocks by joints, or deep vertical cracks, and has been deeply eroded at its base on both its east and west sides by streams that have flowed on one or both sides at various times throughout its history. Today, the West Branch of the Pine River flows southeast toward the ridge where it has worked its way through one of the joints and under the sandstone mass to join the Pine River on the east side of the ridge. During flooding, both streams lap against the ridge, continuing their erosive work.

Where the West Branch cuts through the ridge, it has eroded stone along the joint to make a triangular passage, known as the Rockbridge, about 20 feet wide and 10 feet high. At the ridge's south end, at some point in the distant past, an overhanging slab of stone broke off and now stands upright like the point of a giant sword driven into the land. Long ago a road ran through the gap between the sandstone mass and this broken piece. That road is now a dead-end parking area that allows for easy viewing of the natural bridge.

The site has not been studied extensively, so there remains some uncertainty among geologists about the composition of the sandstone. The top layers of the ridge could be composed at least partly of sandstone of the Tunnel City Group, deposited around 500 million years ago in Cambrian time. The Ironton Sandstone, a strongly cemented member of the Wonewoc Formation, which underlies the Tunnel City, might be another component. Its iron oxide and silica cement resists erosion, so the Ironton Sandstone is responsible for many of the resistant ridges in the Driftless Area. The reddish streaks in the sandstone at Pier County Park indicate the presence of iron. The more erodible sandstone near the water level could be that of the softer member of the Wonewoc, the Galesville Sandstone. Cross-bedding, or sweeping layers in the sandstone, indicate that wind-formed sand dunes once lay here, probably near a Cambrian seashore.

Archeologists have found evidence in Pier County Park that Native Americans used the overhangs of the sandstone for shelter during winter months. The land was donated to Richland County in the early 1920s in order to preserve its unique beauty. Workers excavated a tunnel that allows visitors to walk through to the other side of the ridge. Stairways on both sides of the ridge take visitors to it summit where a path runs the length of it within the park.



The West Branch of the Pine River flows beneath Rockbridge—an eroded passage along a joint between blocks of sandstone. This is the east side of the bridge.

A view of the west side of the sandstone ridge looking north. The West Branch of the Pine River flows to the base of the sandstone mass then north along its base to Rockbridge (out of sight at center).