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Sweeteners

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SCIENCE NEWS MAGAZINE
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OCTOBER 18, 2014

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COVER STORY Combine a soil contaminant that feeds invasive grasses, a long-running drought and a spark and you get a fire that almost wiped out a threatened *Dudleya* species in California's Santa Monica Mountains. A group of scientists hopes to save the cliff-hugging plant. *By Nsikan Akpan*

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To improve semiconductors, superconductors and other materials, physicists think of a particle and its surroundings as one entity — a quasiparticle. Their imaginative approach may yield tangible products. *By Andrew Grant*

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An art-analyzing algorithm finds intriguing links between painters.

COVER Scientists Stephen McCabe (foreground), Sarah Chaney and Mark Elvin examine the Santa Monica Mountains 13 months after a wildfire. *Tarja Sagar/National Park Service*



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CLOCKWISE FROM TOP: COURTESY OF THE CUNDIFF GROUP AND BRAD BAXLEY/JILA; NATALIE JEAN/SHUTTERSTOCK; JOHN MITANI

Zero calories and other awe-inspiring science tales



Zero-calorie sodas always seemed a bit too good to be true. So it wasn't all that shocking to me when I heard (again) that artificial sweeteners may not be that good for you, as Rachel Ehrenberg reports on Page 6. (For a longer take on the sometimes confusing research on artificial sweeteners, read Bethany Brookshire's recent Scicurious blog

post at bit.ly/SN_sweeteners.) What is intriguing about the new study is the how. In mouse and limited human studies, saccharin appears to change the makeup of the microbial garden that flourishes in the gut, boosting blood sugar levels. Because high blood sugar is linked with a risk of diabetes and obesity, it's a worrisome finding. To me, the research is also a bit awe-inspiring, hinting at a complexity of interactions within the lowly human gut that few might have suspected in an earlier, pre-microbiome era.

The effort of botanists determined to save a rare native plant in the coastal mountains of California is also awe-inspiring, as Nsikan Akpan describes on Page 16. This fall,

scientists hope to begin a difficult, multiyear project to restore a cliff-growing succulent listed as threatened by federal agencies and almost completely wiped out by a wildfire. The story highlights one example of thousands of species living life on the edge. But this tale might just have a happy ending.

Physicists appear to like a good tale, too. Proof of that comes on Page 22 in Andrew Grant's explainer on quasiparticles, which are essentially fictional particles. But like great fiction, they carry the stuff of truth, serving as tools that allow physicists to better understand the world at very small scales. Quasiparticles, Grant says, are surprisingly practical and promise to lead to better solar cells and superconductors.

On Page 26 of this issue, readers will meet *Science News's* new publisher and learn about her unusual life story. What's striking about Maya Ajmera, who joined the Society for Science & the Public in August as CEO and president, is the entrepreneurial spirit and enthusiasm she brings to her new role. She ended our first meeting with the remark, "This is going to be so much fun." Stay tuned for the next chapter for SSP and *Science News*. — *Eva Emerson, Editor in Chief*

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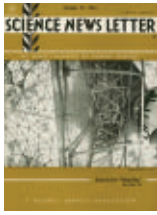
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Excerpt from the October 17, 1964, issue of *Science News Letter*

50 YEARS AGO

Hope for diabetes cure

Hope for the prevention and eventual cure of diabetes was given at the National Institutes of Health, Bethesda, Md., where specialists met to discuss techniques that should be used in population studies of the disease. An estimated 26 million people throughout the world have diabetes.... Insulin, discovered more than 40 years ago, still remains the best treatment, Dr. Howard F. Root, president of the Diabetes Foundation, Boston, said in an interview. “No pills by mouth are as effective as insulin,” he added.

UPDATE: In 2012, 29.1 million people in the United States alone had diabetes, and the number of cases worldwide was 371 million. Insulin remains the standard of care for those with type 1 diabetes, but researchers are examining other possibilities, from reprogrammed stem cells to a bionic pancreas. For type 2 diabetes, along with diet and lifestyle changes, pills such as metformin have been the treatments of choice since the 1970s, when they replaced drugs with similar mechanisms.



HOW BIZARRE

Mites are probably crawling all over your face

Take a really, really close look at your face. With the right tools, you'll likely find microscopic critters dwelling there. Relatives of spiders and ticks, these usually benign mites, *Demodex folliculorum* and *Demodex brevis*, wriggle into skin pores and hair follicles, including eyelashes. And every adult human may harbor these hitchhikers, researchers report August 27 in *PLOS ONE*.

Scientists analyzed DNA from skin gently scraped off the noses and cheeks of 29 North and South Americans. They detected genetic material from *Demodex* mites in samples from all 19 adult subjects and 70 percent of 18 year olds. In earlier studies, researchers pulled the arachnids off 100 percent of human cadavers

The tail of a mite, shown in pink in this false-color scanning electron micrograph, sits behind a hair in a hair follicle. Microscopic mites like this one live on the face of every adult human on the planet, a new study suggests.

but only 10 to 20 percent of the living. The new findings suggest that everyone harbors the mites post-puberty, Megan Thoemmes of North Carolina State University and colleagues say.

Logging the genetic samples in a mite database revealed that *D. brevis* mites differ by geographical region: New World mites were genetically distinct from those in China. If confirmed on a larger scale, the genetics of *D. brevis* mites could provide insight into human migration over millennia. — *Nsikan Akpan*



MYSTERY SOLVED

Death Valley's sailing stones caught on the move

For nearly a century, Death Valley's sliding rocks have amazed visitors and stumped scientists. Despite etching trails longer than football fields into the dried mud, no one had ever seen the stones move.

Last winter, researchers employed GPS trackers and time-lapse photography to monitor dozens of rocks ranging from petite pebbles to hefty boulders. On December 20, they caught more than 60 stones sliding in unison at slothlike speeds of 2 to 5 meters per minute. The team describes the event August 27 in *PLOS ONE*.

Numerous explanations have been proposed for the mass movements over the years, ranging from earthquakes to aliens. Tagging the rocks revealed that ice and wind power the locomotion. During some winters, rainwater pools in the normally bone-dry lakebed and freezes into thin rafts of floating ice. As the wind blows against these rafts, the ice pushes against the rocks, forcing them to grind along the mud and leave behind the telltale tracks. — *Thomas Sumner*

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Artificial sweeteners may tip scales toward diabetes

In mice and people, saccharin disrupts microbes in gut, alters glucose metabolism

BY RACHEL EHRENBERG

Consuming artificial sweeteners may spur the very health problems that dieters try to avoid. A new study of mice and a small number of people finds that saccharin meddles with the gut's microbial community, triggering metabolic changes associated with obesity and diabetes.

Other zero-calorie sweeteners may cause the same problems, researchers say September 17 in *Nature*.

Though the finding is preliminary, four of seven human volunteers eating a diet high in saccharin developed impaired glucose metabolism, a warning sign for type 2 diabetes.

"This is very interesting and scary if it really does hold for humans," says Robert Margolskee of the Monell Chemical Senses Center in Philadelphia, who was not involved with the work. "There could be unintended consequences of these artificial sweeteners."

Until recently, most sugar substitutes were thought to pass through the intestine undigested, exerting little to no effect on the gut. As ingredients in diet soda, sugar-free desserts and a panoply of other foods, the sweeteners are touted as a way for people with diabetes and weight problems to enjoy a varied diet.

But the new study, led by computational biologist Eran Segal and immunologist Eran Elinav of the Weizmann Institute of Science in Rehovot, Israel, suggests that rather than helping people, the sweeteners may promote problems.

After 11 weeks of drinking water doped with the sweeteners saccharin, sucralose or aspartame, mice had abnormally high glucose levels in their blood after eating. Much of digested food gets broken down into glucose, the most common carbohydrate, which then enters the bloodstream to be used as fuel or stored, often as fat. When glucose metabolism is impaired, high blood glucose levels — a hallmark of diabetes — can result.

Since blood glucose levels were most

off-kilter in the saccharin-fed mice, the researchers zeroed in on this sweetener, which is found in Sweet'N Low, jams, salad dressings, vitamins and many other low- and no-calorie foods. The scientists gave saccharin to mice that were fed a high-fat diet. Those mice developed impaired glucose metabolism in as little as five weeks, suggesting that the sweetener had the same effect regardless of whether mice were lean or overweight. Meanwhile, mice eating glucose-laced water had normal metabolisms.

Then the scientists gave the saccharin-fed mice antibiotics to wipe out their intestinal bacteria. The mice's glucose metabolism recovered, suggesting that gut microbes might play an important role in that process. So the researchers transplanted fecal microbes from saccharin-fed mice into the guts of mice with microbe-free intestines. Those mice then developed impaired glucose metabolism.

Genetic analyses of the microbes in the mice's intestines revealed major differences in the microbial groups present in saccharin-fed mice compared with mice eating a regular diet.

"This is the home run experiment," says immunologist Cathryn Nagler of the University of Chicago. "It's telling you that it is some change in the bacterial community that is detrimental."

Why the bacterial community shifts is still unknown. Perhaps some bacteria thrive on saccharin and outcompete their neighbors, or maybe the sweetener kills off other bacteria. The mechanisms that disrupt glucose metabolism also remain mysterious. But it's clear that saccharin does not pass silently through the mouse intestine with no effect.

It also does not pass through people silently, Segal and Elinav's team suggests. When the researchers looked at



A new study finds that the artificial sweetener saccharin, an ingredient in Sweet'N Low, affects the microbes inhabiting the intestines of mice and people, leading to metabolic disorder.

40 people who reported eating artificial sweeteners and compared them with 236 people who did not, the sweetener-eaters were more likely to have had metabolic problems, including impaired glucose metabolism.

And when seven healthy volunteers ate the Food and Drug Administration's maximum acceptable daily dose of saccharin for about a week, four of them developed off-kilter glucose metabolism. Transferring feces from two of these four people into mice induced the same problems in the rodents, suggesting that gut microbes were to blame.

There is much more work to be done to replicate the finding with more people and figure out which bacterial species matter. But, says Nagler, the results are consistent with a bigger picture suggesting that some amenities of the relatively microbe-free modern Western society — such as heavy antibiotic use and cesarean sections — may actually promote disease.

"We have to respect the power of the microbiota," she says, "We need to step back and see what we are doing." ■

Gravitational wave discovery gives way to dust

New data offer no evidence to support BICEP2 results

BY CHRISTOPHER CROCKETT

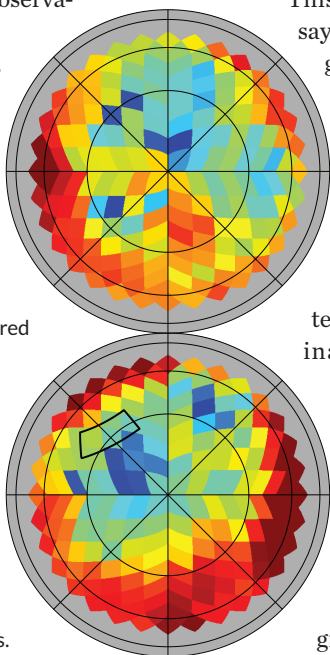
New data from the European Space Agency's Planck satellite spell more trouble for the claimed discovery of ripples in the fabric of space created moments after the Big Bang. The Planck data strongly suggest that dust in the Milky Way galaxy might account for the entire signal interpreted as gravitational waves by researchers using BICEP2, the Antarctic telescope responsible for the initial discovery announced in March.

If the BICEP2 observations hold up, they would be the first direct peek at the long-hypothesized epoch of inflation, a period of explosive cosmic expansion that followed the birth of the universe (*SN: 4/5/14, p. 6*).

In the months after the announcement, however, doubts surfaced. Many researchers wondered whether the BICEP2 team properly accounted for the amount of dust in the Milky Way, which might interfere with the observations (*SN: 6/28/14, p. 20*).

Planck's results, reported September 21 at arXiv.org, strongly suggest that BICEP2 didn't see gravitational waves, only dust in our galaxy.

Dusty skies Planck measured dust in the entire sky, finding regions (red) that are heavily contaminated and others (blue) that are relatively clear. The map looks above (top) and below (bottom) the plane of the Milky Way, centered on the galactic pole, with larger circles representing lower galactic latitudes. The black box (bottom) shows where BICEP2 looked for gravitational waves.



"There is more dust in the BICEP2 signal than they accounted for," says Jan Tauber, an ESA astronomer and Planck team member. But, he notes, there's enough uncertainty that gravitational waves might still lurk in the data.

Both BICEP2 and Planck observed radiation called the cosmic microwave background — the faint glow of the first light released into space as atoms formed out of the primordial fog 380,000 years after the Big Bang. BICEP2 looked for gravitational waves by hunting for twirling patterns imprinted on the alignment, or polarization, of this microwave light. The telescope stared at one patch of sky for nearly three years.

But interstellar dust — sootlike grains of carbon and silicon — can mimic the polarization pattern of gravitational waves. BICEP2 researchers took this into account by relying on six estimates of Milky Way dust. They also picked a part of the sky where dust should be sparse.

BICEP2 is more sensitive than Planck but it measured light at only one frequency, 150 gigahertz, where dust is hard to detect. Planck mapped the polarization of the entire sky at seven frequencies, many of which are more sensitive to dust. Those higher frequencies provided the first direct measurement of dust polarization over the entire sky.

"This is a significant change," says Lloyd Knox, a cosmologist at the University of California, Davis, who also works with the Planck team. BICEP2 relied on calculations to guess the interference from dust, he says. "Now there's a much better estimate of the contamination solidly grounded in data."

Jamie Bock, a Caltech cosmologist and one of the leaders of the BICEP2 team, admits that the initial analysis probably overestimated the strength of gravitational waves. "The

dust level is significant," he says. But it's too early to know whether dust makes up the entire signal. "The analysis is not a one-to-one comparison with the signal reported by BICEP2," he says.

That's because the instruments on BICEP2 and Planck are very different. Also, Planck's interpretation of the BICEP2 data relies on extrapolating from observations of the sky at 353 gigahertz down to BICEP2's frequency of 150 gigahertz. The extrapolation is guided by observations at intermediate frequencies of the entire sky. But there's no guarantee that dust seen in the patch of sky monitored by BICEP2 behaves the same as dust from other parts of the sky.

In July, the teams announced that they would share data to resolve the controversy. The teams plan to publish that analysis in late November.

Meanwhile, many cosmologists, including members of both BICEP2 and Planck, emphasize that the current maps are not the final word. "The results are not definitive," Knox says.

Scott Dodelson of the Fermi National Accelerator Laboratory in Batavia, Ill., agrees. While the Planck results imply dust is the culprit, he says, "there's lots of room to go one way or the other."

Planck discovered that no part of the sky is dust-free, but some patches are cleaner than the one chosen by BICEP2. "This will affect strategies for the future," Knox says, for the many other experiments hunting for gravitational waves.

"These data are invaluable," says Princeton cosmologist William Jones, who is in charge of SPIDER, a balloon-borne experiment designed to hunt for gravitational waves with observations at two frequencies. The balloon will launch over Antarctica in December.

The Planck maps, he says, will help the SPIDER team plan observations and sample patches of sky with minimal dust. If the data from different parts of the sky agree with one another, Jones says, then they probably have a common origin in the cosmic microwave background. Then the team can be confident that SPIDER is seeing gravitational echoes from the birth of the universe. ■

ATOM & COSMOS

Evidence for new particle vanishes

LHC data find no signs of a relative to the Higgs boson

BY ANDREW GRANT

A fresh analysis of data from the particle collider that delivered the Higgs boson has dashed physicists' hope that another new particle had emerged from the subatomic shrapnel.

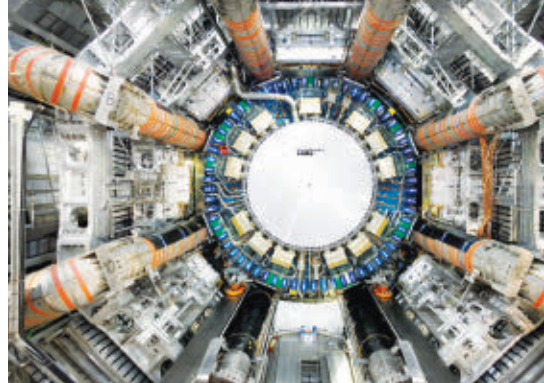
"We've learned that there's no obvious Godzilla particle hiding with the Higgs," says Tim Tait, a theoretical physicist at the University of California, Irvine. "Now we're going to have to look for more subtle signs of new particles." Discovering particles beyond the Higgs could help physicists understand mysterious components of the universe, such as dark matter.

In July 2012, physicists at the Large

Hadron Collider, or LHC, near Geneva, announced the discovery of the long-sought Higgs boson (*SN*: 7/28/12, p. 5). The Higgs was the last particle to be detected among those predicted by the standard model of particle physics.

CMS and ATLAS, the two LHC detectors that uncovered the Higgs in the debris of proton collisions, didn't observe the particle directly. Instead, they analyzed the shrapnel produced when a Higgs decays, less than a billionth of a trillionth of a second after it flashes into existence. Higgs bosons can decay in multiple ways; in one scenario, a Higgs transforms into a top quark or a W boson, either of which would in turn immediately break up into two long-lived, detectable photons.

Among the multiple Higgs decay products that helped prove the particle's existence, photons were the only ones that appeared more often than the standard model predicted. This intriguing photon excess suggested that a Higgs boson could



The ATLAS detector, shown during construction in 2007, has found no trace of a suspected new particle in addition to the Higgs boson.

decay into a third, unknown particle that would then break up into more photons.

"We were all a little hopeful," says Pierre Savard, a University of Toronto particle physicist with the ATLAS experiment. At least 100 researchers offered ideas for particles that could produce the photon results, Tait estimates.

But when CMS updated its data last year, the photon excess disappeared. And in a study posted August 29 at arXiv.org, ATLAS physicists report that the excess signal has disappeared in their data, too.

GENES & CELLS

Body microbes make useful molecules

Human microbiome produces thousands of drug candidates

BY TINA HESMAN SAEY

Microbes that inhabit the human body make a treasure trove of small molecules that could be developed into drugs such as antibiotics, cholesterol-fighters and chemotherapy agents, a new study finds.

An analysis of 2,430 bacterial genomes isolated from a variety of body sites shows that people's bacteria make some 44,000 different small molecules, researchers report September 11 in *Cell*. Small molecules are important for communication between bacteria and their hosts. Many drugs are also small molecules.

"Many [microbes] can make drugs like those we're already taking or evaluating in clinical trials," says study coauthor Mohamed Donia, a biochemist at Princeton University. One of the drug candidates Donia and colleagues discovered is an antibiotic produced by vaginal bacteria to fight pathogens.

This new work is a tour de force that

mines genetic data to uncover a wealth of new chemicals that may help shape human health, says Harvard University microbiologist John Mekalanos.

Most studies of people's resident microbes, known collectively as the microbiome, have focused on which bacteria inhabit particular body sites or how microbe mixes change with diet or disease. The new study delves deeper to give a fuller picture of how microbes interact with each other and with their human hosts, Mekalanos says.

"They really have uncovered the iceberg under the water," he says.

In the study, researchers combed publicly available data to find genes involved in synthesizing small druglike molecules. The data came from the Human Microbiome Project and other databases with "every single genome from every single

bug isolated from humans," Donia says.

In bacteria, genes involved in particular biochemical chain reactions usually cluster together in the genome. These "biosynthetic gene clusters" encode enzymes, each of which carries out one biochemical reaction to build a particular molecule, such as a sugar or antibiotic.

A typical human mouth contains 1,061 microbial gene clusters capable of making at least that many different molecules, the team discovered. Typical human guts have 599 gene clusters. Bacterial communities on the skin, in the airways and in the urogenital tract contain fewer clusters.

Bacteria use these small molecules to manipulate their environment, says Peter

Dorrestein, a chemical biologist at the University of California, San Diego. Some molecules, such as the vaginal antibiotic discovered in the study, are part of the ongoing chemical war between bacteria.

Other molecules, such as the hundreds of sugars called saccharides made by gut bacteria, may interact with human

44
thousand

Estimated number of different small molecules made by bacteria living on humans

“We have no strong hints of new physics,” Savard says.

While Tait admits it would have been exciting if the photon excess had held up, he stresses that there is plenty of opportunity for discovery in the future. Many theories positing new particles and forces predict only subtle deviations in LHC data from the standard model—effects that are too small to be weeded out until even more data are in hand.

And much more data are on the way. The LHC was shut down in February 2013 for upgrades, but it will resume particle smashing in spring 2015 (*SN Online*: 6/23/14). The improved collider will slam protons together at higher energies, perhaps revealing heavier particles inaccessible to the first-generation LHC. Plus, collisions will occur more frequently, providing more data to help physicists separate signal from noise. “To find new particles, we want to give it everything we’ve got,” Tait says. ■

immune system proteins to fuel or calm inflammation, or pave the way for a particular bacterium to settle into a niche. Dorrestein predicts researchers will find that fungi that live in the body make a plethora of manipulative molecules, too.

Most of the gene clusters in human-dwelling bacteria—30,000—have no known function. “It’s the stuff of bioscience fiction to imagine what all these things are doing,” Mekalanos says. For example, obese people’s microbes may make antibiotics that kill off bacteria that keep people lean. Microbes’ antibiotics may do double duty: In addition to killing rival bacteria, these molecules may also help microbes communicate with their human hosts, he speculates.

The newly discovered antibiotic, lactocillin, is a type of molecule called a thiopeptide. A similar molecule is in human tests for treating intestinal infections with *Clostridium difficile*. A bacterium called *Lactobacillus gasseri* makes lactocillin in the vagina, and some bacteria in the mouth also make the antibiotic. Other bacteria throughout the body produce their own thiopeptide antibiotics. ■

EARTH & ENVIRONMENT

Warming blamed for ice shelf collapse

Meltwater pressure may have triggered Larsen B’s breakdown

BY THOMAS SUMNER

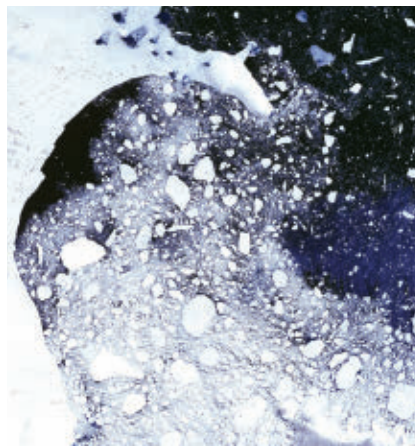
Balmy surface temperatures, not an unstable underbelly, probably prompted the largest ice shelf collapse ever recorded, researchers report.

In 2002, a Rhode Island–sized hunk of the Larsen B ice shelf on the Antarctic Peninsula shattered into thousands of icebergs during the area’s hottest summer on record (*SN*: 3/30/02, p. 197). Radar maps indicated that the point where the shelf floated off the seabed, called the grounding line, had retreated farther inland, triggering the overhanging ice to break off. Now seafloor sediments reveal that the grounding line was stable and had been for thousands of years before the collapse.

The finding, reported in the Sept. 12 *Science*, demonstrates that the grounding line wasn’t involved in Larsen B’s breakup, says study coauthor Eugene Domack, an earth scientist at the University of South Florida in St. Petersburg. “Up until now the community accepted that grounding line instability is needed for ice shelves to disintegrate,” he says. “We now show that surface warming alone can cause ice shelves to collapse.” He says other ice shelves could follow Larsen B’s lead as Antarctic surface temperatures rise (*SN*: 7/27/13, p. 18).

Ice shelves line 45 percent of Antarctica’s coast, helping stem the flow of the continent’s ice sheets and glaciers

Surface melting may have caused the 2002 collapse of Antarctica’s Larsen B, seen in the left half of a satellite photo before the breakdown.



into the ocean. Warm seawater can melt an ice shelf’s underside, pushing the grounding line inward until the ice snags on a seafloor formation such as a cliff or hill. Because the grounding line is too far under the ice to observe directly using submersibles or ice drills, scientists glean these deep ice movements from radar data collected by satellites and airplanes.

After Larsen B’s remains floated away, the location of the grounding line before the breakup became open water. That allowed Domack and colleagues to sample seafloor sediments that had accumulated over thousands of years beneath the ice. Based on the radiocarbon ages of shells found in the sediments, the team estimated how long ago each layer formed.

Because distinctive types and amounts of sediment form where an ice shelf meets the seafloor, the researchers could track the location of Larsen B’s grounding line over time. The team determined it hadn’t budged for at least 11,000 years. Domack suggests that scientists in 2002 simply mistook a seafloor trough for a grounding line on the radar maps. Grounding line instability, Domack concludes, did not contribute to the shelf’s collapse.

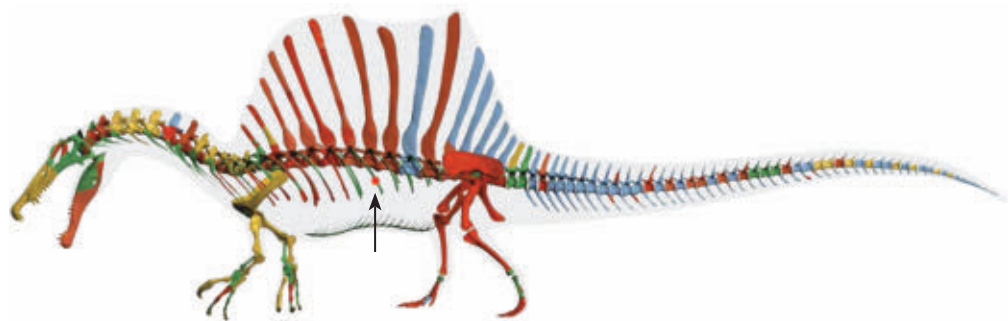
Domack thinks surface melting, previously considered a secondary mechanism in Larsen B’s collapse, was the prime trigger. During Antarctic summers, a layer of snow usually sits on top of the shelf and soaks up meltwater from thawing ice and glaciers, preventing it from forming large pools. During the warm summers leading up to the Larsen B collapse, the snow on the ice shelf melted and water collected in large lakes on the surface. Pressure from these lakes probably opened cracks in the ice, destabilizing the shelf, Domack says.

Glaciologist Eric Rignot of the University of California, Irvine remains unconvinced that surface melting on its own could have caused Larsen B’s collapse. He suggests other factors, such as warming ocean temperatures thinning the shelf’s underside, could have played a role. ■

LIFE & EVOLUTION

Lost-and-found dinosaur led a semiaquatic life

Fossil reconstruction revises view of *Spinosaurus*



BY SUSAN MILIUS

Fossils brought together by unlikely chances now suggest that the sail-backed *Spinosaurus* was no mere wade-in-the-water fish-catcher. Instead, it is the only known dinosaur that routinely took to the water.

Plenty of big reptiles plied prehistoric waters, but they weren't dinosaurs. Some dinos clearly ate fish, but that doesn't mean they swam much.

Now bones of a *Spinosaurus* traced to a freelance fossil digger's trove in Morocco have inspired a new look at the 15-meter-long predator, which was first described in 1915. Rising from the beast's back was a flap as tall as a human being. The Morocco finds, plus a digital model based on CT scans of them and other fossil material (*SN*: 10/4/14, p. 16), show that the species was "the first dinosaur with unmistakable adaptations for a life spent to a large extent in water," says Nizar Ibrahim of the University of Chicago.

Other researchers are excited by the find. "An extinct animal that we already thought was kind of weird was actually even stranger," says paleontologist Lawrence Witmer of Ohio University in Athens. And paleontologist Stephen Brusatte of the University of Edinburgh says, "This was a dinosaur that hunted sharks, which is about as cool as it gets."

The original fossils of *Spinosaurus aegyptiacus*, which had been in Munich's natural history museum, were destroyed during Allied bombing in April 1944.

In 2009, Ibrahim was stunned to visit researchers at the Natural History Museum in Milan and see recently

acquired *Spinosaurus* bones. The researchers had no information on where the bones had been excavated, so they weren't of great use to science. But the sight jogged Ibrahim's memory of a man in the desert with a cardboard box.

On one of Ibrahim's earlier expeditions to Morocco, a local man had shown him a box with some sediment-caked, hard-to-identify fossils, including one with the same cross section as some of the *Spinosaurus* bones in Milan. Ibrahim had had the stranger's fossils deposited in a Moroccan museum. But he didn't even know the name of the man who had approached him. Ibrahim could say only that the stranger was probably somewhere in the Sahara and had a mustache.

"An extinct animal that we already thought was kind of weird was actually even stranger."

LAWRENCE WITMER

Revisiting the town where he had met the fossil source and asking around yielded nothing. "I saw all my dreams going down the drain," Ibrahim says. Then, sipping mint tea in a café, he glimpsed the mustached man walking by.

Ibrahim persuaded the digger to reveal his site, where more *Spinosaurus* fragments turned up. The site lay in roughly 97-million-year-old rock in Morocco's Kem Kem region. A vast river network there had once nourished coelacanths, sharks, crocodile-like predators and dinosaurs.

The partial *Spinosaurus* skeleton from that site had dense limb bones, the researchers report in the Sept. 26 *Science*, like the bones of penguins, manatees and other aquatic animals that evolved from terrestrial ancestors. Having dense bones helps formerly land-dwelling animals control their buoyancy.

Also, the pelvis was small for the

Piece together A digital reconstruction of *Spinosaurus*, which could grow to some 15 meters long, suggests the dinosaur could swim. On land, it probably walked on all fours, as indicated by the animal's relatively forward center of mass (arrow). Red, orange and yellow bones are based on fossils from closely related species; green and blue are inferred from adjacent bones.

Spinosaurus' size and its hind limbs were short and muscular. Ibrahim compares them to bones of early whale species losing their adaptations for walking.

Spinosaurus still had the ability to move on land "and would have been a fearsome animal," says coauthor Paul Sereno, also at Chicago. Yet features such as the unusual hindquarters and a center of mass a bit more forward than in two-legged dinosaurs suggest *Spinosaurus* walked on all fours, the researchers say. (Brusatte cautions that it's not easy to estimate center of mass based just on a skeleton.) *Spinosaurus* would have been the only known dinosaur among the *T. rex*-style predator group of theropods to use four legs instead of two, the researchers say.

The arguments that *Spinosaurus* spent much of its time in water are "generally very compelling," Witmer says, though he's not fully convinced on some points. The researchers report *Spinosaurus* nostrils lying well back from the snout tip as a possible adaptation to a watery life. Yet, Witmer says, modern crocs, hippos and seals have nostrils at their snout tips despite their watery habits.

Hippos do much of their traveling in water by walking on the bottom, says paleontologist Casey Holliday of the University of Missouri in Columbia. So he wonders whether *Spinosaurus* mostly swam or walked. "The dino doggy paddle I'm not sure about," he says. ■

Digital recipe simplifies metamaterials

Analogy to electronic bits offers new way to manipulate light

BY ANDREW GRANT

Invisibility cloaks and superlenses could be improved by taking a page from the digital playbook, two scientists contend September 14 in *Nature Materials*. Their method, inspired by the 1s and 0s of digital electronics, involves arranging nano-sized blocks of just two materials to bend and focus light.

It's a new approach to making metamaterials — intricately engineered combinations of metal, plastic and other components with structural features small enough to manipulate waves of light. By developing metamaterials that bend those waves in just the right way, scientists have built rudimentary invisibility cloaks (*SN: 7/15/06, p. 42*) as well as superlenses that focus light.

Building those metamaterial devices can get complicated. Their components

need to be smaller than the wavelength of visible light, in the range of only hundreds of nanometers. And it's hard to find the right mix of materials to interact with light in the desired way.

Electrical engineer Nader Engheta and colleague Cristian Della Giovampaola of the University of Pennsylvania set out to simplify metamaterial construction, using electronics for inspiration. Computers and smartphones are complex devices that perform a variety of tasks, yet they work by simplifying electric voltages into collections of 1s and 0s, or bits.

Every material has a property called permittivity, which determines how it interacts with light. Engheta and Della Giovampaola realized that instead of seeking the perfect mix of multiple materials to make a cloak or lens, scientists can simply choose two materials with

opposite permittivities (one positive, one negative) to use as metamaterial bits. Arranging those bits in various combinations, called bytes, could then achieve the desired effect on incoming light waves.

Simulations showed that arrangements of two bits, silver and glass, can replicate the performance of metamaterial devices that required more materials or more complex engineering. "The biggest impact is the simplicity it offers in future nanofabrication," Engheta says.

Steven Cummer, an electrical engineer at Duke University, worries that the proposal doesn't offer any obvious shortcut for metamaterial researchers. "I find the high-level idea compelling and interesting," he says. "But I'm really struggling to come up with what's the big new thing here." He notes that some of the designs still require complex fabrication techniques, despite using only two materials.

Engheta says his work has drawn interest from researchers building metamaterials and can serve as a recipe for cooking up devices in a more efficient way. ■

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ATOM & COSMOS

Milky Way enigma explained

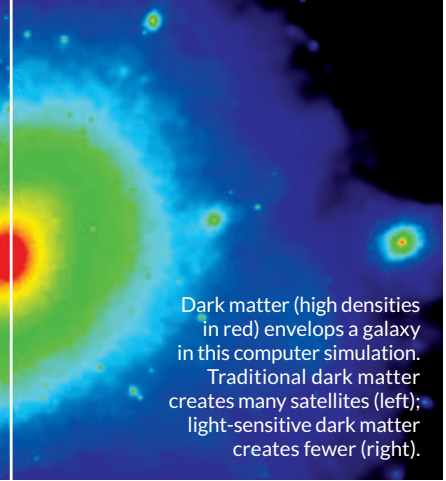
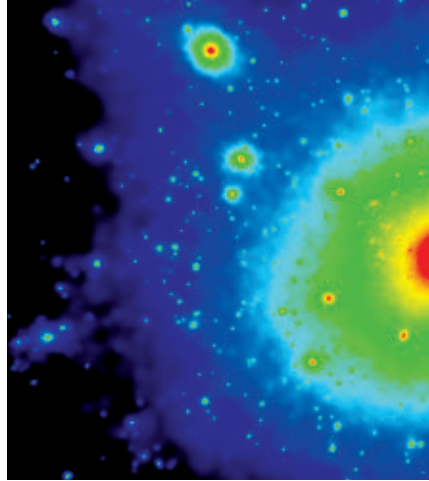
Lighter dark matter may have led to fewer satellite galaxies

BY CHRISTOPHER CROCKETT

Dozens of tiny “satellite galaxies” have been observed orbiting the Milky Way, but theorists predict there should be hundreds. Now a team of astronomers offers a resolution to this conflict: Maybe dark matter, the mysterious substance making up most of the matter in the cosmos, isn’t quite so dark. The researchers propose that radiation might have stirred up dark matter in the early universe, preventing the formation of satellites.

The mystery of the missing satellite galaxies has bedeviled astronomers for more than a decade. While dark matter has proven an exceptionally good tool to explain the formation of large galaxies and clusters, it routinely runs into trouble when attempting to describe tiny structures such as satellite galaxies.

Physicist Celine Boehm of Durham University in England and colleagues sought to reconcile this discrepancy



Dark matter (high densities in red) envelops a galaxy in this computer simulation. Traditional dark matter creates many satellites (left); light-sensitive dark matter creates fewer (right).

by tweaking dark matter theory. They propose that dark matter, long thought to be oblivious to light, actually interacts with photons in subtle ways. This interplay might have been important shortly after the Big Bang, when a smaller universe meant a much higher density of light, but it would be undetectable now because photons are spread thin after billions of years of cosmic expansion.

Boehm’s team ran computer simulations to see how interactions between dark matter and light might affect the formation of satellites around a galaxy like the Milky Way. Their results, appearing September 8 in the *Monthly Notices of the Royal Astronomical Society Letters*, indicate that dark matter weakly sensitive to light could reduce the number of predicted satellite galaxies.

In the case of the Milky Way, that reduction would bring the number much closer to what astronomers have observed.

No one has explored this particular idea before, says Erik Tollerud, an astrophysicist at Yale University. But he notes that the simulations by Boehm’s team predict more fast-moving satellites than are seen. And many other ideas have been put forth to fix the missing satellite problem, Tollerud says. It’s possible that supernova explosions may stir up the gas in nascent galaxies, preventing them from forming stars. Also, tiny galaxies may be torn apart as they fall toward the Milky Way.

“With quasi-reasonable explanations, you can get about the right number of satellites,” Tollerud says, without mucking around with otherwise successful theories about dark matter. ■

LIFE & EVOLUTION

Fossils push back origin of mammals

Common ancestor appeared in Late Triassic, study suggests

BY MEGHAN ROSEN

Modern mammals’ ancestors may have emerged millions of years earlier than scientists suspected — around the time early dinosaurs roamed the Earth.

Fossilized remains of six little, tree-dwelling animals push the lineage of mammals back to more than 200 million years ago, in the Late Triassic, researchers report September 10 in *Nature*.

“That’s really, really old,” says paleontologist Robert Asher of the University of Cambridge, who was not involved with the work. Scientists had thought that the common ancestor of those animals originated sometime in the Jurassic, he says.

The newly reported fossils were found in China and belong to three new species of haramiyid, a group of extinct mammals that researchers discovered more than a century ago. But most of the animals left only teeth behind, says study coauthor Jin Meng of the American Museum of Natural History in New York City. “We just couldn’t find any better material,” he says. “A generation of paleontologists has been looking everywhere.”

Without more complete specimens, scientists had trouble figuring out where to place this group in the mammalian family tree. It’s one of the most debated topics in early mammalian evolution,

says mammalogist Alexander Averianov of the Zoological Institute of the Russian Academy of Sciences in St. Petersburg.

The new specimens are the most complete haramiyid skeletons ever found. They reveal rodent-sized animals that might have looked like a cross between a lemur and a squirrel, with spindly fingers and long slender tails. Each species appears adapted for forest life. After studying the fossil teeth and bones, Meng’s team found that the animals fit within a branch of the mammalian family tree that includes all mammals living today.

Though the fossils are only about 160 million years old, previously discovered haramiyids trace back even further — to more than 200 million years ago. So the common ancestors of these animals and modern mammals must be at least that old, or older, Meng says. ■

BODY & BRAIN

Experimental herpes drug offers hope

Therapy effective for people, but side effects seen in monkeys

BY NATHAN SEPPA

An experimental treatment for genital herpes suppresses the viral infection better than the primary drug now used, a study shows. But whether the new compound will reach the market may depend on resolution of a recent disconcerting finding of anemia in animals given the drug.

About 16 percent of the U.S. population is infected with genital herpes, but more than two-thirds of those people don't know it: Their symptoms fall short of the blisterlike lesions that strike some patients. Even without symptoms, carriers of the herpesvirus can spread it.

The drug candidate, called pritelivir, has now cleared two hurdles. In a study of 156 people with genital herpes, those getting pritelivir had fewer lesions and were less infectious than those getting a placebo, researchers reported in January in the *New England Journal of Medicine*.

In the new study, scientists pitted pritelivir against the first-line herpes drug valacyclovir, marketed as Valtrex, in 91 patients. The volunteers were people beset by genital herpes symptoms, averaging four to nine outbreaks per year, said chemist Helga Rübsamen-Schaeff, the chief executive officer at AiCuris, a pharmaceutical company in Wuppertal, Germany, which is developing the compound.

Patients got valacyclovir or pritelivir for four weeks, neither compound for four weeks and then the other drug for another four weeks. Each day, participants swabbed their genitalia for lab analysis.

During the study, volunteers had a genital herpes lesion on 1.9 percent of days they were taking pritelivir and on 3.9 percent of days on valacyclovir, Rübsamen-Schaeff reported September 6. The analysis revealed virus in 2.4 percent of swabs from people taking

pritelivir and 5.2 percent of swabs from people on valacyclovir. That indicates that patients taking pritelivir are less likely to spread the virus, she said.

If approved by regulators, pritelivir might serve as a daily preventive for people who experience frequent herpes outbreaks, Rübsamen-Schaeff said. "For people who only have it once a year, you would wait, and when you start to feel a tingling, then treat that episode" with pritelivir, she said.

Pritelivir should work equally well on oral herpes, which causes cold sores or fever blisters, because the compound targets a viral enzyme that is integral to both kinds of herpes infections, she said. Valacyclovir targets a different enzyme and works only in infected cells, whereas pritelivir has the advantage of protecting healthy cells while thwarting virus replication in infected cells, Rübsamen-Schaeff said.

"Having a drug with a different mechanism of action is long overdue," said Khalil Ghanem, an infectious disease physician at Johns Hopkins University. "This is really what everyone was waiting for."

But the study was halted after only 56 of the 91 participants had completed the 12-week regimen. A separate unpublished test in monkeys showed that some of the animals getting pritelivir had developed anemia. The researchers made those data available to the U.S. Food and Drug Administration, which considers serious adverse effects with caution. The monkey data are being analyzed now, Rübsamen-Schaeff said. No such serious side effects showed up in either study of pritelivir in people. Meanwhile, the company is working on a topical version of the drug for use on cold sores, she said.

That's welcome news, Ghanem said. "The topical antivirals we have don't work very well. This is an exciting paper." ■

MEETING NOTES

Viruses can zoom through workplaces in hours

A virus on an office door handle can spread to more than half the people working there within a few hours. But hand sanitizers and disinfectants can cut transmission sharply, researchers at the University of Arizona in Tucson reported September 8.

Microbiologist Charles Gerba and colleagues planted an innocuous virus on a doorknob or tabletop in three settings — a health care facility, an office and a conference room. The virus showed up on 40 to 60 percent of employees within two to four hours and was found on bed rails, in a coffee break room and on phones and computers.

When Gerba and his colleagues offered participants wipes to disinfect hands and surfaces, only about half used them. But that was enough to reduce virus presence by 80 percent overall. — *Nathan Seppa*

Speedy test could aid treatment of urinary tract infections

A new test can quickly diagnose drug-resistant urinary tract infections, potentially reducing delays in treating thousands of UTIs per year.

Antibiotics are the first line of defense, but microbes are rapidly evolving to resist standard drugs.

Current diagnosis of drug-resistant infections is costly and time-consuming. The new exam costs \$2 to \$3 and requires just 20 minutes. If bacteria make certain antidrug enzymes, the acidity of a dye used in the test increases and the sample turns from red to yellow. In 450 samples, the test's 98 percent accuracy rivaled slower methods.

The diagnostic may help doctors choose sooner to use antibiotics that work against drug-resistant *E. coli*, said test codeveloper Laurent Dortet of Bicêtre Hospital in Le Kremlin-Bicêtre, France. — *Nsikan Akpan*

GENES & CELLS

Source of coffee's kick found

Coffee's caffeine jolt evolved independently from that of tea and chocolate, a genetic analysis reveals. Researchers deciphered the genome of *Coffea canephora*, the second-most cultivated species of coffee. Within the plant's 11 chromosome pairs, the team found many duplicated genes, including ones that produce caffeine. Such duplications may let organisms make more of those genes' products and evolve new or better-functioning proteins. The genes that encode caffeine-synthesizing enzymes in coffee are in a distinct group from those in tea and cacao plants, France Denoeud of the French Alternative Energies and Atomic Energy Commission and colleagues report in the Sept. 5 *Science*. That finding indicates caffeine production evolved at least twice. — *Tina Hesman Saey*

LIFE & EVOLUTION

Human interference does not cause chimpanzees to kill rivals

Chimpanzees gang up on and kill stray members of nearby chimp communities to eliminate competitors for food and mates, whether or not people have intruded on the animals' territories. Chimps have not killed each other over dwindling resources as loggers have cut down the apes' forest, nor have chimps turned on each other when encountering animals given bananas by tourists, report Michael Wilson of the University of Minnesota in Minneapolis and colleagues in the Sept. 18 *Nature*. The scientists examined data

collected over the last 50 years from 18 communities of chimps. In 15 communities, the team documented 152 killings that were observed or inferred. Killings clustered in communities with high numbers of males and relatively large populations. Males were the most frequent attackers and victims. The most violent community inhabited a largely undisturbed area, whereas another exposed to intense logging and tourism experienced no killings. The new study fits the idea that lethal clashes have a long pedigree in chimps and humans (*SN*: 8/10/13, p. 10). — *Bruce Bower*

BODY & BRAIN

More than 1 million Ebola cases may hit West Africa by January

The Ebola epidemic could cause more than 1 million cases unless improved isolation and treatment of patients are put in place, new projections suggest. In less than six weeks, the number of infections could surpass 20,000, World Health Organization officials and others report September 23 in the *New England Journal of Medicine*. Experts from the U.S. Centers for Disease Control and Prevention predict that the 20,000-case mark might be reached even sooner. If the epidemic continues unabated, the reported number of cases in Liberia and Sierra Leone could reach 550,000 within four months. That would translate to an estimated 1.4 million cases when underreporting is taken into account, the scientists say in the Sept. 26 *Morbidity and Mortality Weekly Report*. The WHO report also

suggests that Ebola in the region might never be fully eradicated and become endemic. — *Nathan Seppa and Janet Raloff*

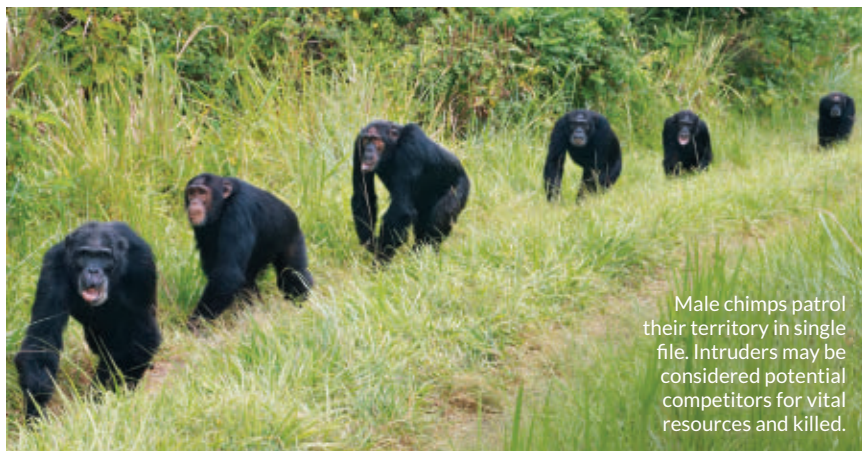
The brain sorts words during sleep

A soundly sleeping brain still monitors and responds to its surroundings, researchers report September 11 in *Current Biology*. The finding, that a person's snoozing brain correctly sorts words into categories, represents the latest feat the brain achieves while sleeping (*SN*: 12/29/12, p. 28). Researchers led by Sid Kouider of CNRS in Paris recorded brain signals from awake people as they classified spoken words as either animals or objects. In some trials, participants pushed a button with their right hand when they heard an animal name and a button with their left hand when they heard an object. After nodding off, the participants heard a different set of words. EEG recordings revealed that their brains continued sorting the words into their proper categories. When participants heard "horse," their brain activity looked as if they were preparing the right hand, not the left, to hit a button. The results may help explain how meaningful sounds, such as a baby crying, creep unconsciously into the slumbering mind and wake a person more readily than other sounds. — *Laura Sanders*

HUMANS & SOCIETY

More signs emerge of New World settlers before 20,000 years ago

New finds support the controversial idea that people inhabited South America before Clovis hunters reached North America around 14,000 years ago. Two sets of simple stone tools excavated in Brazil were made by small groups of settlers, one that lived about 24,000 years ago and another from around 15,000 years ago, researchers say. The site lies near other proposed pre-Clovis camps (*SN*: 4/20/13, p. 9), a team led by Eric Boëda of Université Paris Ouest Nanterre La Défense reports in the September *Antiquity*. Microscopic marks on 294 unearthened stones indicate that humans had sharpened the rocks. Radiocarbon dating of burned wood and soil analyses yielded ages for those stones. — *Bruce Bower*



Male chimps patrol their territory in single file. Intruders may be considered potential competitors for vital resources and killed.



Simple stone tools unearthed in Brazil suggest that people were living in South America as early as 24,000 and 15,000 years ago.

ATOM & COSMOS

Mystery of the missing lithium extends beyond the Milky Way

Stars in the Milky Way don't have as much of the element lithium as predicted. New observations of distant stars confirm that the problem isn't unique to our galaxy. The missing lithium confounds astronomers because it may require rethinking of how stars operate or of conditions in the early universe (*SN: 8/9/14, p. 6*). In the first three minutes after the Big Bang, the universe created mostly hydrogen and helium with a smattering of lithium. Observations of hydrogen and helium

in the early universe match theoretical predictions. But there's only about a third as much lithium in the atmospheres of old stars as there should be. Until now, most lithium measurements were made in stars born in the Milky Way. To expand the search, Alessio Mucciarelli of the University of Bologna in Italy and colleagues turned the Very Large Telescope in Chile toward old stars in Messier 54, a star cluster roughly 90,000 light-years away. The results, published in the Oct. 21 *Monthly Notices of the Royal Astronomical Society*, show that stars in M54 have just as little lithium as stars in the Milky Way, suggesting that the lithium problem is universal. — *Christopher Crockett*

MATTER & ENERGY

Three photons get entangled

A process that works once in every quadrillion attempts has produced trios of entangled photons. Particles with properties that are entangled share an extraordinary connection: Measuring the properties for one particle immediately determines the

properties for the others (*SN: 11/20/10, p. 22*). Physicists routinely create entangled pairs of photons. But confirming the entanglement of more than two photons can be done only after measuring the particles, which destroys their entanglement. Deny Hamel of Canada's University of Waterloo and colleagues have removed this limitation by using crystals that split one photon into two. The photons that emerge are entangled by their polarization, the horizontal or vertical orientation of the light's vibration. The team sent a beam of blue photons toward a crystal; for every billion or so photons that passed through, one transformed into two entangled red photons. A red photon from each pair then passed through a second crystal. One in a million of those split into two entangled infrared photons. When this sequence of events occurred, three entangled particles emerged: one red and two infrared. The result, reported September 14 in *Nature Photonics*, could shape plans for future quantum cryptography and computers. — *Andrew Grant*

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A 2013 fire in the western Santa Monica Mountains left parts of the landscape charred and a rare plant species on the brink of extinction.

Resurrecting LIVEFOREVERS

Saving a native plant from extinction
after a devastating fire **By Nsikan Akpan**

Protruding from a cliff face, a diminutive desert plant peered across a sapphire channel as flames charred the earth hundreds of feet below. The remote pinnacle should have protected the onlooker, as it had in the past, but the blaze was too hot. This time, the mountain burned, and the tiny succulent, known as Verity's liveforever, wilted and died.

As the May 2013 Camarillo Springs fire cooked 98 square kilometers of coastal valley just northwest of Los Angeles, it almost wiped out the Verity's liveforever, a dudleya succulent once abundant among the western Santa Monica Mountains.

This wasn't the first time human actions caused problems for a dudleya (pronounced like the name Dudley with an "uh" on the end). Of the 45 or so dudleya species spread across the western United States and Mexico, nearly a quarter are threatened or endangered. The destruction has assumed many forms, from classic threats such as suburban development to imported colonies of hungry bunnies.

As their name suggests, however, liveforevers are survivors,

subsisting for decades where most other plants can't. With pointy yellow flowers and low, thick leaves arranged like a star, Verity's liveforever (*Dudleya verityi*) inhabits rocky, nutrient-poor outcrops. The munchkin liveforever (*Dudleya gnoma*), boasting stubby, pinkish leaves, survives on a gusty mesa on the Channel Islands offshore of Southern California, where 40 mile per hour winds are too much for most plants to take root.

Good thing liveforevers are tough. They provide sustenance for a bevy of pollinators, from bees to wasps to hummingbirds. The jewel beetle *Chrysobothris dudleyaphaga*, as its name suggests, survives on dudleya. As with other rare and endangered plant species, dudleya's loss would be felt.

"Remove enough bricks and the whole house collapses," says Mark Elvin, a U.S. Fish and Wildlife biologist based in Ventura, Calif. Elvin and his team of botanists keep tabs on plants located in the Santa Monica Mountains that are protected by the Endangered Species Act. Several dudleyas are under their watch.

"All of the ESA-listed species help maintain ecological



Dudleya verityi



Dudleya linearis



Dudleya traskiae



Dudleya cymosa ovatifolia



Dudleya gnoma

Liveforevers, succulents known for their thick leaves that retain water in arid climates, produce vibrant flowers from spring to summer. Members of the *Dudleya* genus, the plants come in myriad shapes and sizes, but one characteristic — scarcity — unites them. All but the *Dudleya gnoma* pictured above are federally listed as threatened or endangered.

balance in the world, and consequently, productivity for humans,” Elvin says.

Dudleyas are one beacon exposing how human behaviors, even seemingly inconsequential ones, can erode nature. The Camarillo Springs fire is a marquee illustration. After an undetermined spark, perhaps a discarded cigarette, ignited the blaze along California Highway 101, a contaminant in the soil, a by-product of a successful state campaign to improve air quality, likely encouraged grass overgrowth that fed the fire.

This extra punch urged the nine-day inferno toward the Verity’s liveforever’s secluded habitat on Conejo Mountain (in the Santa Monica range), suspects Stephen McCabe, a botanist at the University of California, Santa Cruz. In 2009, the liveforever population on Conejo numbered 3,450. “In less than two weeks, the fire wiped out 93 percent of what was already a rare species.” Fewer than 300 remain today, according to McCabe and Elvin.

The situation calls for a daring rescue, and this fall, Elvin, McCabe and a group of botanists are planning such a feat. They will creep along vertigo-inducing ledges to rebuild the dudleyas’ cliffside homes. With an invaluable stockpile of seeds squirreled away inside McCabe’s greenhouse, the climbers hope to ensure that the Verity’s liveforever survives a bit longer.

Back from the brink, again

Dudleyas don’t actually live forever, though killing them takes effort. The plants earned their nickname in the 1800s after naturalists transported some home from California to Europe. “They would smash the dudleyas inside plant presses, take the long boat ride back to England, open up the plant press, and the dudleyas were still alive,” McCabe says.

Their resilience stems from an ability to store and conserve water in their plump succulent leaves for extensive periods of time. The skill comes in handy in their mostly arid habitats. Though a few inhabit Nevada and Arizona, most liveforevers pepper sea-hugging hills and coastal mountains from southern

Oregon through California and down into Mexico. The plant’s range is predominantly characterized by a Mediterranean climate, where rain sporadically falls during the winter, while the rest of the year is dry with occasional fog.

The succulents also sprout on the island chains along the West Coast, which is where they first encountered major trouble with humans. The San Benito Islands, an archipelago off Mexico’s Baja California, are uninhabited, except for some fishermen who camp overnight and a sole lighthouse keeper on the westernmost isle. Yet this modest intrusion was enough to endanger native plants.

European rabbits arrived on West Benito Island in 1991, perhaps brought as hunting game by the lighthouse keeper or the fishermen. The critters gorged on the native flora, including the resident liveforever (*Dudleya linearis*).

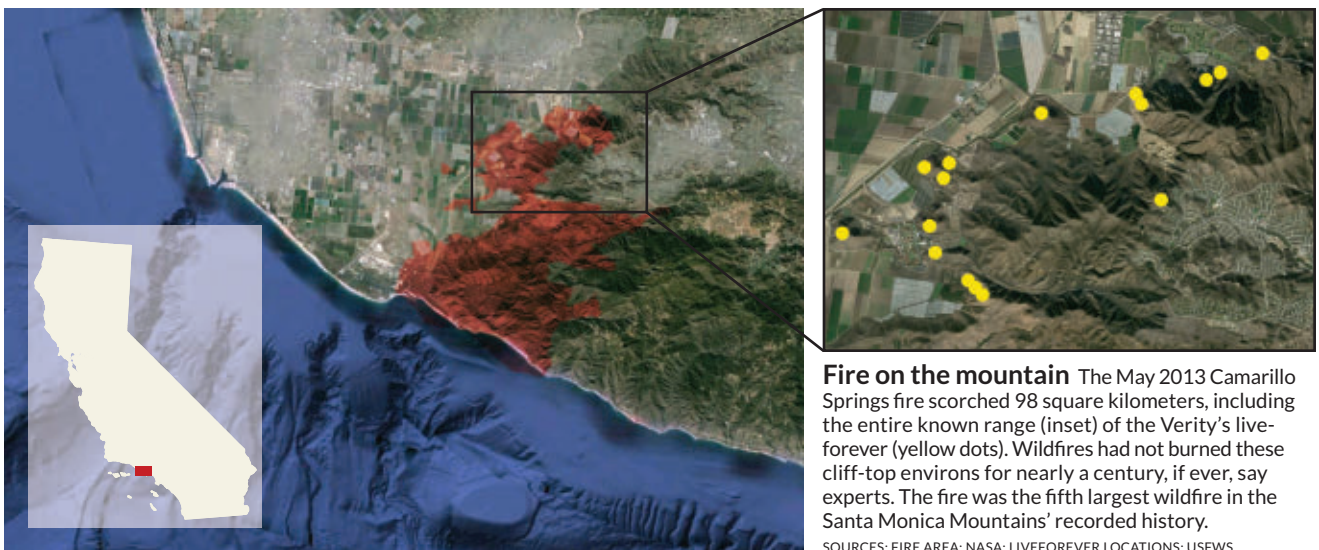
“The rabbits skewed the whole plant community,” says ecologist Josh Donlan, who studied the region in the late 1990s while working for Island Conservation, an ecological agency that aims to prevent extinctions of island life. Donlan and his colleagues found that the rabbits voraciously consumed certain species, such as *D. linearis*, while leaving others untouched.

So in 1998, Donlan and Island Conservation decided to rid the islands of nonnative herbivores.

“They hired a trained Jack Russell terrier named Freckles that rooted out rabbit burrows,” says Steven Junak, a botanist with the Santa Barbara Botanic Garden. “The dog single-handedly eliminated the rabbits from West San Benito Island.”

With the 400 or so rabbits gone, the dudleyas rebounded, which Donlan attributes to leftover seeds in the soil and the arrival of El Niño rains.

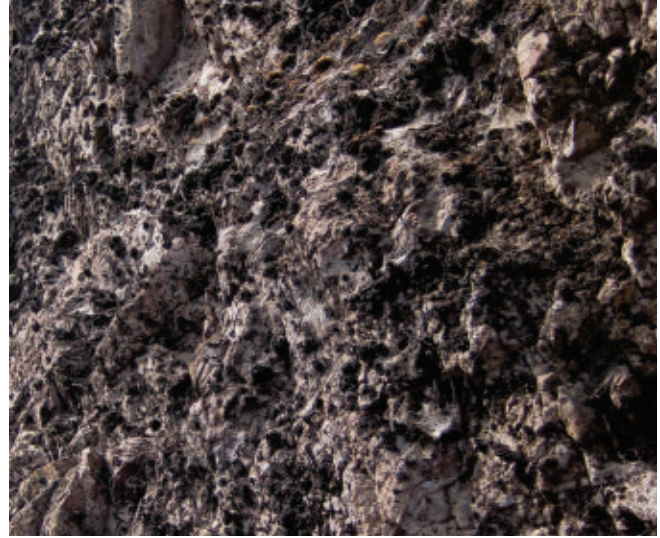
The success reminded Junak, an expert on the flora of Californian and Mexican islands, of a close call on another coastal island, this time due to Belgian hares introduced by farmers in 1942. By 1970, the Santa Barbara Island liveforever (*Dudleya traskiae*) had been decimated; experts deemed them extinct



Fire on the mountain The May 2013 Camarillo Springs fire scorched 98 square kilometers, including the entire known range (inset) of the Verity’s liveforever (yellow dots). Wildfires had not burned these cliff-top environs for nearly a century, if ever, say experts. The fire was the fifth largest wildfire in the Santa Monica Mountains’ recorded history.

SOURCES: FIRE AREA: NASA; LIVEFOREVER LOCATIONS: USFWS

CALIFORNIA INSET: U.S. CENSUS BUREAU/WIKIMEDIA COMMONS; LARGER MAPS: GOOGLE EARTH PRO, ADAPTED BY E. OTWELL



Yellow-flowered Verity's liveforever bloomed among green puffs of lichen on Conejo Mountain (left) until the 2013 fire. The blaze killed both the succulents and the lichens that supported them. More than a year later, the mountainside has still not recovered (right).

in the wild. Once the animals were removed in 1981, however, the liveforevers bounced back. The herbivores had left gnawed stubs of the hardy plants in the ground, giving rise to a new generation of the succulents. A tenuous population of about 1,000 Santa Barbara Island liveforevers inhabits the island today.

Lifesaving lichens

An identical happy ending for the Verity's liveforever of Southern California seems unlikely.

"Many of the plants were outright destroyed by the fire," says John Tiszler, a plant ecologist with the U.S. National Park Service and a partner in the restoration project. Tiszler and company noted a fair number of seedlings last winter, but all subsequently died as California entered its third year of a crippling drought, making a natural revival unlikely.

Facing such devastation, McCabe, Elvin, Tiszler and colleagues aim to rebuild the plants' habitat from scratch.

Many regard Stephen McCabe as the premier expert on dudleya taxonomy and cultivation, with his greenhouse at the UC Santa Cruz arboretum harboring almost every known species.

"People say if you give Stephen a pencil and he plants it, he can get it to grow," remarks Elvin.

McCabe will cultivate Verity's liveforevers in his outdoor laboratory, a kind of island of Doctor Moreau for plants. Strange genetic hybrids cover every table. Some hybrids spill open like peeled artichokes with tentacle-like stems shooting out the sides. Others are blood red with bulbous leaves shaped like snap peas. Each was spawned over years, sometimes decades, by classic breeding techniques.

To retain the integrity of the species, however, only true Verity's liveforevers will be reintroduced at Camarillo. Tiszler has tracked down geneticists at UCLA and UC Berkeley who will confirm which specimens represent pure breeds.

McCabe's nursery also contains specimens of the Verity's succulent that were collected from the cliffs before the fire. Given that this dudleya species is threatened with extinction, a few plants will be transferred to backup locations at Tiszler's laboratory in Thousand Oaks, Calif., and at another location

at the Channel Islands National Park. If anything happens at one location, Elvin says, "we don't want to lose all the replacement strains."

The succulent's cliff-hanging lifestyle won't make the project any easier. "The big question is how to establish nursery beds under these extreme conditions," Tiszler says. The Verity's liveforever can sprout from rock walls, but like any plant, they require a soil bed, moisture and adequate sunshine.

Two lichens — *Niebla ceruchoides* and *Niebla homalea* — could be the key. Both resemble tumbleweeds cemented to boulders, though they are actually a partnership between microscopic algae and fungus clinging to the rock. Verity's liveforevers primarily grow alongside and on top of the *Niebla* lichens. Bits of falling dirt and clay lodge behind the lichens' perch, creating a serene microhabitat for sprouting liveforevers, says Kerry Knudsen, who is curator of lichens at the UC Riverside herbarium.

As Pacific fog rolls over the coastal mountains, dew collects on the lichens' blades. Water trickles into the nuggets of soil, where dudleya seeds take root. "The lichens appear to be essential for the reproductive success of *Dudleya verityi*," says Elvin.

The lichens at Camarillo were well established, but like the dudleyas, they perished in the fire, says Knudsen, who surveyed the area before the fire. "Based upon the size of the lichens there, that area hadn't burned in maybe a hundred years," he says. No previous fire had been as intense as the Camarillo Springs fire, the fifth largest in the Santa Monica Mountains' recorded history, which dates back to the early 1900s.

From the frying pan

The ongoing drought undoubtedly contributed to the inferno's fury. But a soil contaminant described in a 2010 paper in the *Journal of Environmental Management* by Mark Fenn and colleagues at the U.S. Forest Service, also inadvertently may have stoked the furnace.

For almost half a century, the United States has tried curbing harmful NO_x — nitrogen oxides — from its air. And California has led the way. After 1975, all new cars had to have catalytic converters for their exhaust, which convert NO_x into other

nitrogen-based gases. The state's strict emissions standards for cars and trucks cut local NO_x pollution by 40 percent between 1990 and 2010.

An overlooked by-product of the catalytic converters is ammonia, which is not regulated, says conservation biologist Stuart Weiss of the Creekside Center for Earth Observation in Menlo Park, Calif. Recent estimates suggest that ammonia now constitutes 20 to 30 percent of nitrogen-based vehicle emissions in California.

Ammonia deposition occurs mainly near high-traffic roadways. Nonnative, or invasive, grasses gobble up the extra ammonia as it settles. (Ammonia, a major component of fertilizer, is rich in nitrogen, which all plants need to grow.) As the contaminant takes root, the long grasses prosper, blotting out the sun for smaller wildflowers. The invasive plants require year-round hydration, and when groundwater runs dry in the summer, the plants become kindling. The grasses tend to sprout on formerly barren or low-growing land, which helps wildfires spread in sparse scrub or desert environments.

"It just builds up a fine fuel load, and you get a more intense fire," Weiss says. This scenario probably influenced the Camarillo blaze, he says. Invasive grass growth was robust near the freeway where the fire began.

Two-step rebirth

With the mountainside scorched and desolate, the reintroduction of the Verity's liveforever must start from scratch. Step one of the proposed plan involves moving *N. ceruchoides* and *N. homalea* lichens from the Channel Islands off Santa Barbara to the liveforever's charred habitat on the mainland.

"Lichens damaged in the fire continue to fall off the cliff," McCabe says. Even with intervention, he estimates it will take 80 to 100 years before the Verity's liveforever will reach its pre-fire numbers.

The burned zone was the only mainland location for *N. ceruchoides* for about 112 kilometers, according to Knudsen. But lichens flourish on the nearby Channel Islands. "On the islands, *N. homalea* numbers in the millions. The other species is less common, but still fairly abundant," Knudsen says.

The plan could work because of the lichens' unusual biology. *Niebla* lichens lack roots and do not sap nutrients from the ground. Instead, they sport a stemlike thallus with tiny grappling hooks on the bottom called rhizines. Algae pack the thallus, which draws moisture from the air to supply these tiny tenants. The algae, in turn, feed the lichens' fungal cells. Rhizines adhere the lichens to rocks, but freeing the attachments shouldn't harm the lichens, Knudsen says.

Before winter, the group proposes to transfer 400 lichens to the Santa Monica Mountains, gluing them by their bases to rock walls. Over the next two years, the researchers would monitor the lichens' survival.

Once the lichens settle, the group will climb high and broadcast Verity's liveforever seeds across the rock wall, hoping that a few will catch in the lichen roosts. In some spots, adult



Starting over

A long-shot proposal aims to re-establish Verity's liveforever in the charred western Santa Monica Mountains.

1. Lichens (top) from nearby islands will be transported to the liveforever's cliff-face habitat and glued to the rock walls.
2. Once the lichens are established, climbers will broadcast dudleya seeds onto the rock walls (center), with hopes the seeds will collect and grow in the lichen.
3. Cultivated dudleyas in pots may be placed overhanging the cliffs as well, so their seeds will fall into the lichen roosts and germinate.
4. If the plan works, new liveforevers (bottom) will take root from the seeds and sprout on the lichen.

liveforevers might be placed in special pots overhanging the ledge, so that their seeds will naturally fall into the cliff-hanging lichen beds. "Those seeds that tend to stick and germinate should be genetically predisposed to surviving in that habitat," Elvin notes.

The continuing drought is going to make this hard, Knudsen says. Last winter, California had the lowest rainfall in recorded history and the state's signature fog has rolled in less frequently than in the past. Fog helps maintain the lichens and the dudleyas, in particular as the liveforevers grow from the tiny seedling stage to flowering size, McCabe says.

New human-made threats are sprouting too. A quarry has purchased much of the land on Conejo Mountain where a large patch of Verity's liveforevers formerly grew.

But the resurrection marches on. "Right now we want to ensure that the Verity's doesn't go extinct. We're spending our resources mostly on keeping it alive," says Elvin with a whisper of exhaustion. "Humans are responsible for this species' current status. It is our responsibility to keep it from falling over the precipice." ■

Explore more

- University of California, Santa Cruz Arboretum: www.arboretum.ucsc.edu
- Jenn M. Yost *et al.* "Phylogenetic relationships and evolution in *Dudleya* (Crassulaceae)." *Systematic Botany*. December 2013.

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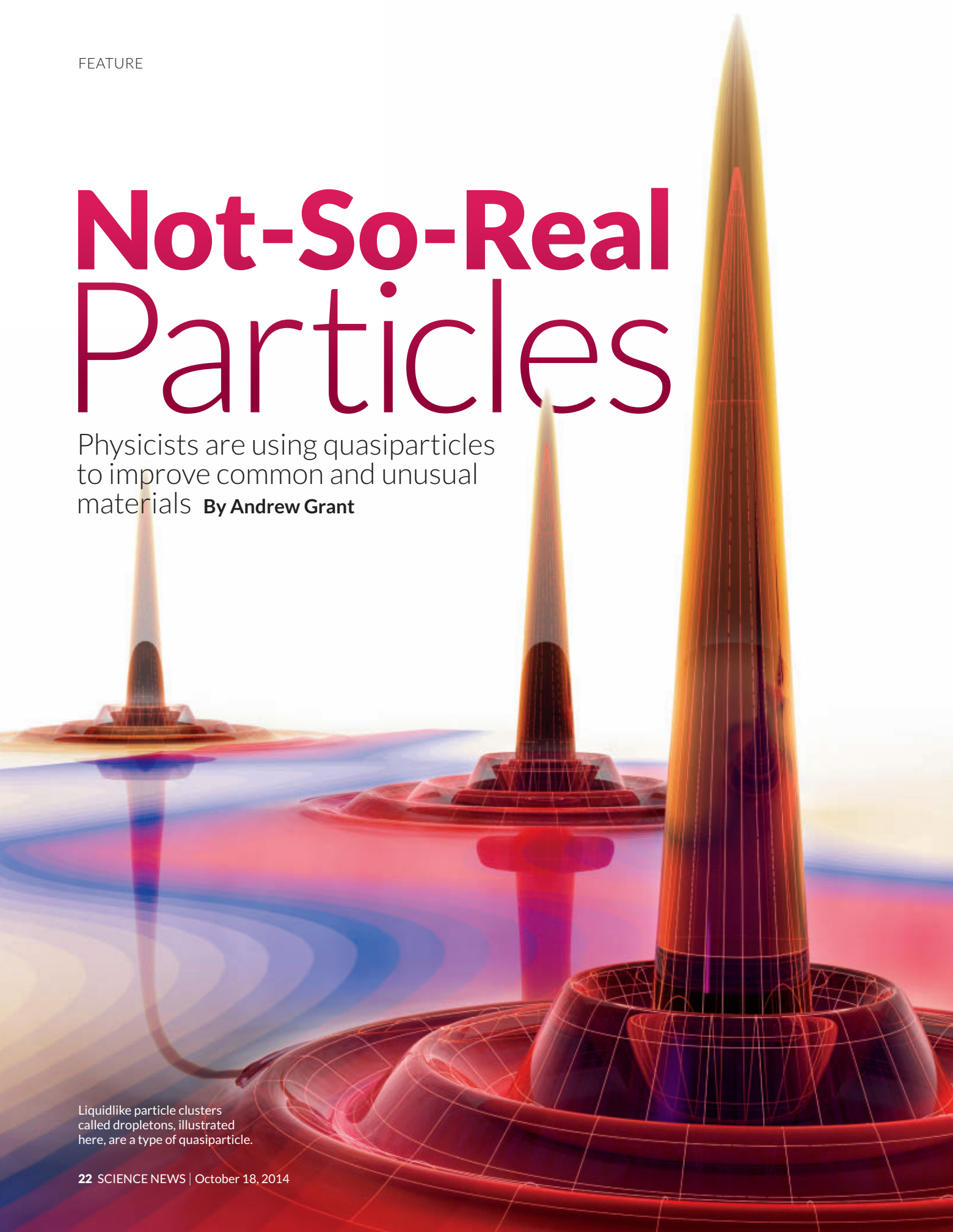
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Not-So-Real Particles

Physicists are using quasiparticles to improve common and unusual materials **By Andrew Grant**

The background of the page is a 3D illustration of three droplet-like particles, known as dropletions, on a surface. Each droplet is a tall, narrow, conical shape with a dark, rounded base. The droplets are arranged in a line, with the largest one in the foreground and two smaller ones behind it. The surface they sit on is a flat plane with a grid of red and blue lines. The droplets cast long, soft shadows on the surface. The overall color palette is dominated by reds, oranges, and yellows, with a gradient from dark red at the bottom to bright yellow at the top.

Liquidlike particle clusters called dropletions, illustrated here, are a type of quasiparticle.

Steven Cundiff wasn't sure what would happen when he fired a laser at a target last year.

The condensed matter physicist wanted to see how the electrons inside a material used in solar panels and DVD players would behave when hit with an energy boost.

To deliver the energy, Cundiff and his team at JILA, a joint institute of the National Institute of Standards and Technology and the University of Colorado Boulder, fired a quick pulse of red laser light at a strip of gallium arsenide, a material similar to silicon. Trillionths of a second later, they followed up with a weaker pulse. Once through the target, the second laser beam struck a detector, which helped the researchers determine what kinds of particles had absorbed the light from the first pulse.

The laser barrage seemed to cause strange clusters of electrons to form inside the strip. The electrons weren't bunched rigidly as they would be in a solid, nor were they jetting around randomly as they would in a gas. Rather, the particles clumped together as if they were nanosized droplets of water.

Cundiff and his team had discovered the dropleton, or quantum droplet (*SN Online*: 2/26/14). They published their finding February in *Nature*.

A dropleton looks like a particle and acts like a particle. But it's not really a particle. Each dropleton exists for just a few trillionths of a second after the laser-energy injection, and it can't be extracted from the material and isolated as an electron or an atom could be.

As unreal as it is, the dropleton offers an unprecedented probe of the inner workings of a commercially important material. The dropleton is a quasiparticle, a theoretical construct that helps physicists make sense of the jungle of particles and forces within the materials we use every day.

Instead of trying to calculate all the complex interactions taking place inside a given material, physicists can simplify the problem by envisioning these made-up particles moving through.

"Quasiparticles can be the key to understanding a particular material or system," says Ross McKenzie, a condensed matter physicist at the University of Queensland in Australia.

Over the last 75 years, physicists have been making sense of incomprehensible things by identifying and exploiting more than a dozen quasiparticles (see partial list, Page 24). And now, scientists have the engineering skills to tinker with materials at the nanoscale and introduce quasiparticle-inspired changes that lead to useful devices.

After studying the characteristics of quasiparticles in a variety of materials and conditions, scientists are designing new material combinations that efficiently transform

sunlight into electricity or convert electricity into laser light. Plus, quasiparticles may eventually enable long-promised technology that revolutionizes the way the world delivers and uses electricity.

A horse and its dust cloud

For physicists, understanding the behavior of a single electron floating in space is easy. But most electrons in everyday life are not dancing around freely. Take a coil of copper wire, like the ones that carry electricity through buildings. It contains roughly as many electrons as there are stars in the observable universe. Until the 1920s, physicists thought of each of those electrons as minuscule charged pinballs. Negatively charged electrons would repel their fellow electrons and attract positively charged copper nuclei as they bounced around inside the wire.

The introduction of quantum theory revealed that this already complicated picture was way too simple. In 1924, Louis-Victor de Broglie theorized that matter can behave as both particles and waves. As a wave, an electron can interfere with other matter. Then in 1927, Werner Heisenberg proposed with his uncertainty principle that it is impossible to determine both a particle's position and its velocity at a given moment.

Suddenly those electrons in the wire transformed from pinballs to fuzzy part-particle, part-wave entities that have no definite location or velocity and that can subtly influence each other with their mutual negative charge. Making sense of even a couple of those electrons, let alone a trillion trillion, "very quickly becomes an intractable problem," Cundiff says. In the 1992 edition of his book *A Guide to Feynman Diagrams in the Many-Body Problem*, physicist Richard Mattuck compares the dilemma to trying to describe a galloping horse and all the grains of dust that it kicks up.

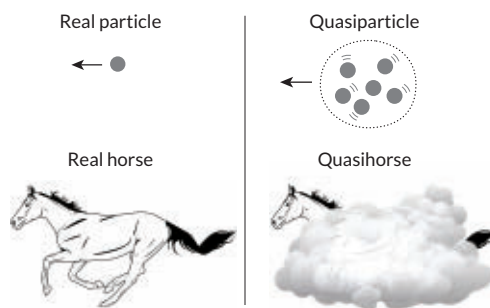
In the late 1930s, Soviet physicist Lev Landau, just released from prison for holding anti-Stalinist views, found a way to simplify the problem. Instead of trying to sum up the complex interactions of each particle with its neighbors, physicists could combine a particle and its interactions into one composite quasiparticle. In other words, instead of trying to describe

the horse and account for all its effects on its surroundings, Landau proposed the formulation of a quasi-horse: a single entity that includes the horse and its accompanying dust cloud.

"It was a brilliant idea by Landau," McKenzie says. "It works amazingly well."

A simple example of Landau's proposal is an electron quasiparticle, the most common quasiparticle, according to Cundiff. Because of interactions with its neighbors, an electron moving through a

On the move Just as a galloping horse kicks up dirt, a particle disturbs its surroundings as it travels through a material. To simplify the interactions, physicists combine a particle and its perturbed neighbors into one entity — a quasiparticle. SOURCE: RICHARD D. MATTUCK, *A GUIDE TO FEYNMAN DIAGRAMS IN THE MANY-BODY PROBLEM*, DOVER PUBLICATIONS, 1992.



semiconductor, a type of material used in most electronic circuits, behaves differently than an electron moving through free space. Following Landau's approach, physicists found that an electron in a semiconductor such as silicon or gallium arsenide actually does behave as if it were a noninteracting free electron — just one with a larger mass. That adjusted-mass electron is called an electron quasiparticle.

A hole is another common quasiparticle. When an electron absorbs energy and jumps to a new position, it leaves behind a positively charged vacancy. That hole behaves as if it were a positively charged electron even though there is no physical particle there. Further, the positively charged hole often gets attracted to the energized electron, leading the electron and hole to bind and form another quasiparticle called an exciton.

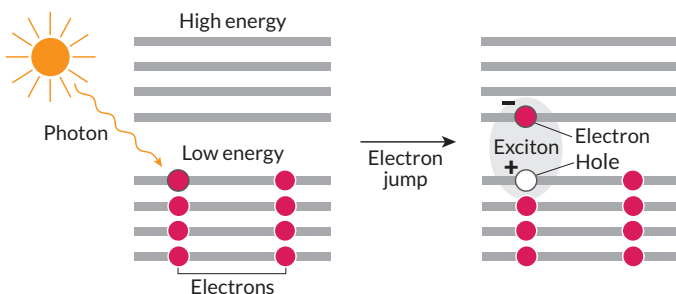
In April, researchers led by physicist Vladimir Bulović at MIT's Center for Excitonics reported in *Nature Communications* that they had imaged excitons traveling through an organic crystal called tetracene in real time. Bulović's team fired a laser to inject energy into the crystal, which caused electrons to jump and then bond to their vacated holes to form excitons. The excitons appeared to race outward from the spot where the laser deposited energy.

In reality, an electron and a hole don't move through the material; rather, electrons are simply passing on energy to their neighbors, and the energy cascades outward. But for Bulović and other researchers, it's far simpler to think of those energy cascades as quasiparticles with well-defined properties such as mass and charge. "You can't directly see what's going on at the nanoscale," Bulović says. "But you can infer what's going on at the nanoscale with quasiparticles."

Although they are, in a sense, just made-up entities for the

Inside a solar cell In a silicon solar cell, when an electron absorbs photons from the sun it jumps to a higher energy level (result shown at right). The negatively charged electron attracts the positively charged hole it leaves behind, creating an exciton. Harvesting electrons from excitons is essential for producing efficient solar panels.

SOURCE: LOS ALAMOS NATIONAL LABORATORY



A quasi-lineup

Electron quasiparticle Essentially an electron with altered mass; accounts for all the interactions of electrons as they move through a material

Hole Positively charged spot where an electron once resided; used to understand behavior of electrons when they absorb energy

Exciton An electron attracted to a hole; leading to new kinds of solar cells and light-emitting diodes in electronic displays

Polariton An exciton or similar particle coupled to a photon; leading to energy-efficient lasers

Dropletion A liquidlike cluster of electrons and holes; offers insight into commercially important semiconductors

Phonon A vibration that moves through a material's atoms as if it were a particle; may play a pivotal role in inducing superconductivity

Plasmon A wave of free-flowing electrons in a metal or plasma; essential for understanding how materials interact with light

sake of physicists' sanity, quasiparticles describe reality well enough to lead to technological advances. Excitons figure prominently in the development of improved solar cells. When light strikes certain materials, it frees up electrons, which can be siphoned off as electricity. Einstein discovered this phenomenon, called the photoelectric effect, in 1905. But to truly understand solar cells and improve their capacity to convert sunlight into electricity, physicists apply the Landau treatment.

At the Center for Excitonics, Bulović and colleagues are working to control the propagation of excitons in certain types of solar cells. When a photon strikes a material such as silicon, an electron jumps up in energy and binds to its hole to form an exciton. The problem, Bulović says, is that most of the time the exciton doesn't get very far before it dissipates and gives back its energy. To produce more effective solar cells, excitons have to travel far enough to reach a second layer of material, which splits up the exciton and creates an electric field that drives the flow of electricity. Bulović and other scientists are crafting materials that maximize the lifetime of excitons. The aim is to increase

the rate that cells convert solar energy into electrical energy from the single digits to nearly 20 percent.

See-through power source

Studying the properties of excitons and how they move is also leading to solar cells with unique properties. Bulović's group has teamed with a group from Michigan State University to develop transparent solar cells. Conventional solar cells are opaque so they can absorb visible light to generate electricity. But these new transparent cells trap only infrared and ultraviolet light to trigger the formation of excitons; visible sunlight passes right through. Bulović envisions future generations of the device placed over an e-reader screen to keep it charged indefinitely, or on eyeglasses, for example, to charge a hearing aid.

Other quasiparticle-inspired technologies may soon find their way into electronics and medical devices. In June, a team led by electrical engineer Pallab Bhattacharya of the University of Michigan in Ann Arbor reported the development of a laser that requires a mere 0.4 percent of the electricity of a conventional laser. Its light is produced by the decay of quasiparticles (*SN: 7/12/14, p. 20*).

Commercially available lasers require a lot of electricity to energize atoms, which then emit laser light when the atoms drop back to lower energies, Bhattacharya explains. But his team's device, built with the semiconductor gallium nitride,

runs differently. A small jolt of energy creates excitons, which then absorb photons to form light-matter hybrid quasiparticles called polaritons. When the short-lived polaritons break apart, they release a beam of ultraviolet laser light made of photons that all have the same color and direction.

Game-changing materials

But not all materials can be so easily understood with quasiparticles. Superconductors are one example. These compounds can shuttle electricity around with no resistance as long as they are frigid — close to the coldest possible temperature, absolute zero, or -273°C . In 1986, IBM researchers Johannes Bednorz and Karl Müller discovered the first “high-temperature” superconductor: a compound containing copper and oxygen that maintained zero electrical resistance at temperatures as high as -238°C . In this case, high temperature is still awfully cold. A flurry of discoveries of similar materials with even higher superconducting temperatures followed, helping Bednorz and Müller snag the 1987 Nobel Prize in physics. Although superconducting electromagnets are used in hospital MRI scanners, for example, superconductors have been limited in their applications by their requirement for very low temperatures.

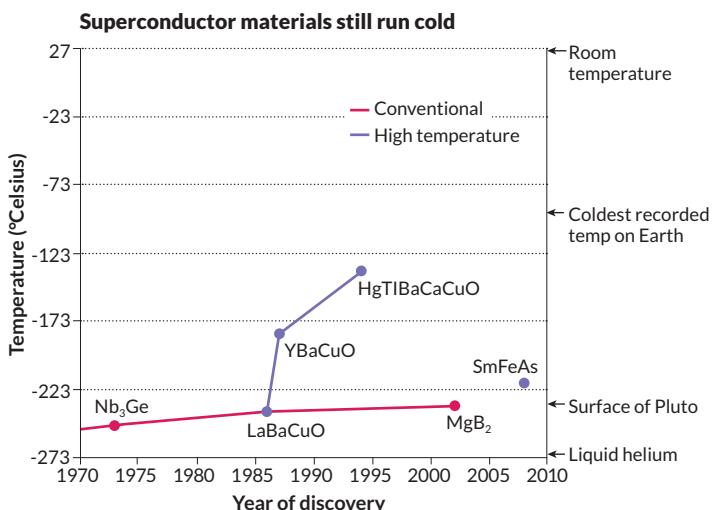
The Nobel Prize-winning discovery immediately raised hopes that physicists could develop superconducting materials at much higher temperatures, ideally room temperature, a technological breakthrough that would enable high-speed transport of electricity across the power grid with almost no loss of energy. The United States loses about 6 percent of its generated electricity during transmission, according to the U.S. Energy Information Administration. Those losses translate to a roughly \$20 billion annual hit to the economy.

In its 1987 Nobel Prize announcement, the Royal Swedish Academy of Sciences noted that the “details of how superconductivity arises in the new materials are still unknown.” Nearly 30 years later, the same holds true. The interactions within these compounds are so complicated that they defy simplification even by quasiparticles.

Drawn in by the quest for a new, game-changing material, many physicists are trying to understand the inner workings of high-temperature superconductors by looking for patterns in the movement and interactions of electrons. “For each electron moving through the material, you have to understand what’s the influence on its neighbor and vice versa,” says J. C. Séamus Davis, director of the Center for Emergent Superconductivity at Brookhaven National Laboratory in Upton, N.Y. In a sense, he is looking for quasihorses.

Davis and his team recently used a specially designed microscope to analyze a superconductor made of cerium, cobalt and indium. They determined that magnetism is the

Getting hotter The maximum temperature at which certain materials called superconductors can transport electrons with no energy losses has slowly but steadily risen, especially after the Nobel Prize-winning discovery of high-temperature superconductors in 1986. Yet the goal of superconductors at or near room temperature is still a long way off. SOURCE: ADAPTED FROM U.S. DEPARTMENT OF ENERGY



crucial force that steers electrons through the material in its superconducting state, a finding that starts to simplify the complex interactions at work. To simplify things further and start to work toward room-temperature superconductivity, physicists hope to find some structure in the migrating electrons in the form of a quasiparticle — much like the clusters

known as dropletions. The goal has real-life ramifications: For example, room-temperature superconducting cables could create the very powerful magnets needed to make high-speed levitated trains a viable means of transportation.

For McKenzie, the importance of quasiparticles in physics leads to a more philosophical question: What does it take for something to qualify as a real particle? All physicists would agree that fundamental entities like electrons and protons are particles. But McKenzie argues that excitons, polaritons and dropletions should

join the club. “I would say they’re just as real as an electron,” he says. If it looks like a particle and quacks like a particle, then it might as well be a particle.

McKenzie seems to be in the minority opinion. Yet nobody doubts the importance of quasiparticles, particularly if they aid the search for room-temperature superconductivity. For now, researchers just hope that a not-so-real particle is hiding in the insanity of trillions of trillions of electrons, waiting to bring clarity and resistance-free electricity. ■

Explore more

■ Gleb M. Akselrod *et al.* “Visualization of exciton transport in ordered and disordered molecular solids.” *Nature Communications*. April 16, 2014.



Clear solar cells may one day harvest energy from the invisible components of sunlight while allowing visible rays to pass through.



Empowering possibility

The Society's new leader, Maya Ajmera, has a habit of making things happen

Spend an hour with Maya Ajmera, and you begin to see opportunity everywhere. As she tells her life story, it becomes clear she has been seizing opportunities since she was a kid. Through the global organization she founded when she was only 25, she's been creating opportunity for millions of young people around the globe for decades. She frames every venture in her life, including her new role as president and CEO of the Society for Science & the Public and publisher of *Science News*, as an opportunity just waiting to be developed.

As Ajmera sees it, these are exciting times in science education and science journalism. "Momentum is building — from universities, the business sector, even the White House — that we must aggressively engage young people in science, technology, engineering and math fields," says Ajmera, who took

the reins of SSP in August. With its long history of student science competitions and its 92-year-old magazine, SSP is poised to play an important role in fostering interest in and an understanding of science in people of all ages, she notes.

"Here at SSP, we have an incredibly strong foundation," Ajmera says. "What's next is to grow, to build our capacity so that we can reach even more people. We also need to ensure that the *Science News* family of media properties can continue to tell stories from the frontiers of science — something that's increasingly rare in an age in which most newspapers have severely cut back on science coverage and few magazines have staff reporters able to do the type of in-depth, regular coverage *Science News* does. I really do see all of these challenges as opportunities for SSP to evolve and become a 21st century organization."

The Intel International Science and

Engineering Fair, the largest of the youth competitions run by SSP, is already global in reach. The competition brings in kids from over 70 countries. So it's no surprise that Ajmera sees a global focus as a new opportunity for *Science News* as well. "People around the globe should be reading *Science News*, bringing science and scientific thinking into their lives."

This appreciation of the possibilities, matched by the drive needed to bring those to fruition, is apparently a life-long habit born of "your typical, hard-charging family," she says. Ajmera's parents moved to the United States from India when her father enrolled in an electrical engineering Ph.D. program at the University of Iowa. Born in Iowa City, she grew up in North Carolina, where her father joined the physics faculty of East Carolina University. Her mother became one of the top-selling Avon representatives on the East Coast.

When a 13-year-old Ajmera needed to ask her father for a ride at night, it wasn't for a sleepover, or a trip to the movies or any other typical teen activity. She needed to get to the lab, to turn the lights on over a pool of duckweed. She worked in the ECU lab of Prem Sehgal, a botanist exploring the life cycle of the duckweed Lemnoideae. Long considered a nuisance, duckweed is surprisingly high in protein and starch, giving it potential as both a food and biofuel.

"I had to count the duckweed three times a day, to measure the growth," she recalls. "If I had failed to turn on the lights, I would have had to start again."

It was the beginning of a love for science, says Ajmera, who also learned her first lessons in mentorship, scientific integrity and the scientific method in the botany lab. She became fascinated with the possibilities of science. That turned her into what she calls "a science fair junkie." She participated in the North Carolina Science Fair and the NASA Space Shuttle competition.

Her passion for science also earned her a spot at the prestigious North Carolina School of Science and Math, a two-year high school boarding program. As a junior, Ajmera again created her own

opportunity — she went to the west campus of Duke University and “started knocking on scientists’ doors.” Molecular biologist Vickers Burdett took a chance on her. With Burdett, Ajmera looked at the genetic determinants of tetracycline resistance in certain bacteria.

Ajmera’s work with Burdett led to her first introduction to Society for Science & the Public. At 17, she entered her research project into the Westinghouse Science Talent Search, a competition run by SSP and now known as the Intel Science Talent Search. She became the first woman from North Carolina to make it to the honors group.

As an undergraduate at Bryn Mawr College in Pennsylvania, Ajmera continued to pursue a career in science, studying with developmental neurobiologist Margaret Hollyday, who was well-known for her investigations of cell death. After earning a bachelor’s degree in biology, Ajmera’s path took a turn in 1989 when she won a fellowship from Rotary International.

The prize funded a year of study at St. Xavier’s College in Mumbai, India, and Ajmera used the opportunity to travel throughout South Asia. “I had professors who told me, ‘If you want to understand people, get a backpack and start traveling,’” she says.

Those travels had an impact. “I saw home-grown innovations in people’s backyards. I saw adaptations we never heard about in the classroom or the lab, particularly in the social and environmental sector.”

Then came what she calls her “moment of obligation.” As she hustled through a crowded platform at the train station in Bhubaneswar, Ajmera saw a group of children sitting in a circle. At their center: a teacher, leading a class. “There were 50 kids, all learning to read and write,” she recalls. “They were obviously poor. They would work, beg, eat and sleep at the station; they had no time to go to school. So this social

entrepreneur decided to bring the school to them, where they were, on the train platform.” Ajmera asked the teacher what it cost: \$400 per year. In addition to their education, the children were also given clothing and food.

“I suddenly saw the world in a new way,” she says. “I asked, ‘How come I don’t see more train platform schools all over India?’ I imagined what a difference this would make. I imagined what a difference it would make if I could make this happen.”

Ajmera went on to earn a master’s degree at the Sanford School of Public Policy at Duke. While still a graduate student, she raised \$25,000 in seed capital and incubated the Global Fund for Children, a nonprofit designed to bring

small amounts of capital to innovators focused on improving the lives of children “living on the edges of society.” Among its targets: refugee children, child laborers and trafficked children. Officially launched in 1997, GFC was one of the first nongovernmental organi-

zations to foster scalability and sustainability in local community groups.

Today, GFC is a well-respected organization that has invested more than \$37 million in 614 grassroots organizations in 79 countries.

At GFC, Ajmera founded an innovative children’s book publishing imprint. She also became a children’s book author, writing 20 of the more than 35 award-winning books put out by the organization. The books, which have a combined readership of 4 million, take children inside diverse global cultures with titles such as *Children from Australia to Zimbabwe*.

Since founding GFC, Ajmera has received many honors, including the Henry Crown Fellowship at the Aspen Institute in 2011, and this year the Rotary Foundation Global Alumni Service to Humanity Award. In 2011, after 18 years at the helm of GFC, she decided the organization needed fresh leadership.

“I needed time to reflect and decide what I was going to do next.”

For the last three years, she has served as a visiting scholar at the Paul H. Nitze School of Advanced International Studies at Johns Hopkins University and was named a visiting professor of the practice in public policy at Duke.

As an alumna of the Science Talent Search and an early reader of *Science News* at the local library, Ajmera kept up with SSP over the years. “Every six months I would go online and see what was happening,” she says. That’s how she learned about the search for a new leader for the organization of more than 60 people.

It’s no surprise that Ajmera was attracted by the opportunities of the job. “It’s an incredibly challenging time in the world of publishing and media, but I think of it as a time of innovation. There are great opportunities. I’m quite ambitious — I want to see more readers of *Science News* in every age group.”

With deep respect for the organization’s traditions, Ajmera also sees the potential for new programs, such as adult competitions. “I want to build on what we are known for,” she says.

Still, she recognizes that getting to the magazine’s 100th anniversary in 2022 will not be easy. “I was brought into SSP at a very challenging time for *Science News*. Doing high-quality science journalism is expensive, and my charge is to figure out how to make it sustainable, so we have another 100 years. I need our readers, alumni, partners and supporters to give me ideas, to find new ways to support this crucial part of our mission. We don’t want to cut back — we want to do more. That’s the challenge.”

If anything, Ajmera seems energized by such lofty goals. It helps that she feels she has landed in the perfect place to blend her love of science and her dreams of educating and improving lives. “I feel privileged and honored to be here. As Steve Jobs said in his famous Stanford graduation speech, you can’t connect the dots looking forward, but you can look backwards. Somehow this all makes sense.” — *Monika Guttman*

“It’s an incredibly challenging time in the world of publishing and media, but I think of it as a time of innovation.”

MAYA AJMERA



BOOKSHELF

Planet of the Bugs

Evolution and the Rise of Insects

Scott Richard Shaw

The 165-million-year-long era when dinosaurs roamed the Earth shouldn't be called the Age of Reptiles. Nor should the era that followed, which extends to the present, be christened the Age of Mammals. Just ask an insect guy.

In *Planet of the Bugs*, Shaw, an entomologist at the University of Wyoming, makes a good case that Earth has long been dominated by insects. The six-legged creatures have adapted to almost every ecological niche imaginable, from the icy heights of the Himalayas to the deserts of Death Valley to the scalding springs of Yellowstone National Park. Within a couple broad ecosystems, the biomass of insects outweighs that of all vertebrates combined, including humans.

So far, almost 1 million insect species have been identified — Shaw alone has discovered almost 200 — and perhaps tens of millions more await the honor. Shaw highlights some of the keys to insect diversity, including tiny size, which lets insects take advantage of even exceedingly small ecological niches. Prolific reproduction and short life spans both enable rapid evolution.

In a chapter-by-chapter march through time, Shaw engagingly chronicles the evolutionary innovations that have rendered insects so successful for the last 400 million years or so. One triumph was the ability to fly; insects were the only critters to do so for more than 150 million years. Another was the evolution of multistage life cycles, which limited competition for resources between adults and their offspring. Yet another was insects' coevolution with flowering plants, which explosively fueled biodiversity for at least 120 million years.

Drawing from field studies and the fossil record, *Planet of the Bugs* is a fascinating look at the rise and proliferation of creatures that shape ecosystems worldwide. — *Sid Perkins*
Univ. of Chicago, \$27.50

BOOKSHELF

The Big Ratchet

How Humanity Thrives in the Face of Natural Crisis

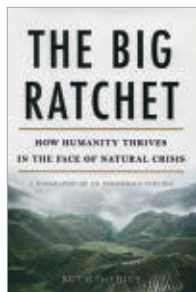
Ruth DeFries

The second half of the 20th century witnessed “the Big Ratchet.” That’s what DeFries, an environmental geographer at Columbia University, calls the massive surge in food production that accompanied the world’s skyrocketing population growth. Her book looks back much further to survey the technological innovations that transformed humans from nomadic hunter-gatherers threatened with starvation into farmers and then into urban-dwelling specialists whose sustenance is usually produced far away by a relative few.

This evolution has been fraught with ups and downs: More food leads to more humans, more humans leads to scarcity and scarcity forces the invention of new ways to cope. DeFries sums up the cycle in the pithy catchphrase “ratchet, hatchet, pivot.”

As she details, the road to food abundance is littered with unintended conse-

quences of what seemed like good ideas at the time. DDT wipes out insect pests but can wreak havoc on wildlife. Fertilizer improves crop yields, but nutrients in runoff can cause algal blooms. But for DeFries, such overshoots are opportunities to regroup and excel. Her writing percolates with a bubbly optimism as she recounts the “extraordinary” pivots humans have found to “hijack nature to feed ourselves.”



The phrase “natural crisis” in the book’s subtitle is puzzling since most of the crises that DeFries presents are environmental disasters, which is to say, human-made. In scanning all of human history, she largely ignores how geopolitics, ignorance and greed trigger or exacerbate such disasters. Meanwhile, she chides the shortsightedness of both doomsayers and Pollyannas who “fail to grasp that there is no endpoint to this interplay between human ingenuity and nature.” Still, even DeFries concedes that it’s just a matter of time before a mighty hatchet falls. “New pivots,” she writes, “enabling us to sidestep the blow are far from assured.”

— *Laura Fisher Kaiser*
Basic Books, \$27.99

BOOKSHELF



The Quantum Moment

Robert P. Crease and Alfred Scharff Goldhaber

A philosopher and a physicist explore the development of quantum mechanics and how the jargon of the field has influenced art, architecture, literature and pop culture.
W.W. Norton & Co., \$29.95



Your Atomic Self

Curt Stager
Follow the journeys that oxygen, carbon, hydrogen, nitrogen and other atoms found in the body

can take over time and around the planet, everywhere from the atmosphere and oceans to forests and rocks.
Thomas Dunne, \$25.99

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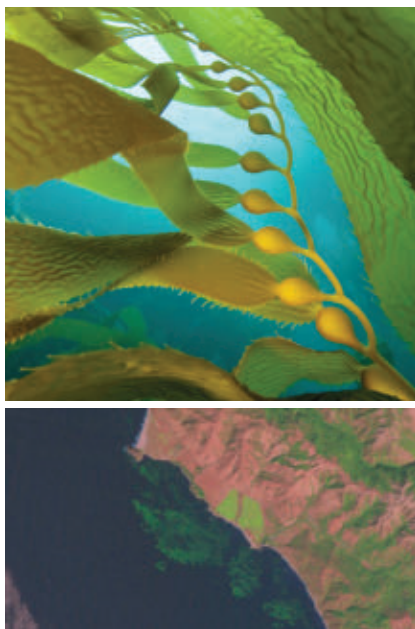
SCREENTIME

Help scientists find kelp

Although some kelp beds are vast enough to be visible from space, scientists lack long-term data on these forests of seaweed and how their abundance has changed over time. Researchers — from the Kelp Ecosystem Ecology Network, the Santa Barbara Coastal Long-Term Ecological Research Project and the National Center for Ecological Analysis and Synthesis — have designed a citizen science project called Floating Forests to help.

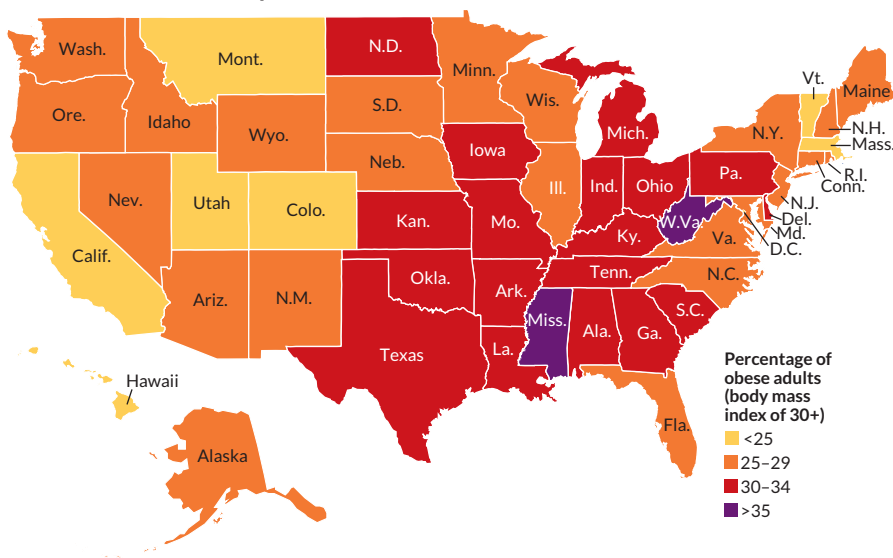
It's a website that relies on volunteers

Beds of kelp (top) are dense enough to be seen from space. The green smear off Carmel, Calif., in the satellite image (bottom) is what Floating Forests volunteers look for.



to search through images taken over the last 30 years by NASA's Landsat satellites and identify kelp beds. The task requires a human eye. Project member Jarrett Byrnes of the University of Massachusetts in Boston says computers just aren't sensitive enough to spot green blurs in a blue ocean. Sometimes clouds obscure the view and many pictures go by with no sign of kelp. But once you see the telltale green masses and outline them carefully with your computer mouse, you've just got to find more. Marked images will help scientists monitor kelp, which serve as both food and home for a plethora of marine creatures. The data may also offer insights on everything from kelp fisheries to how ocean circulation affects the seaweed. — *Bethany Brookshire*

2013 U.S. adult obesity rates



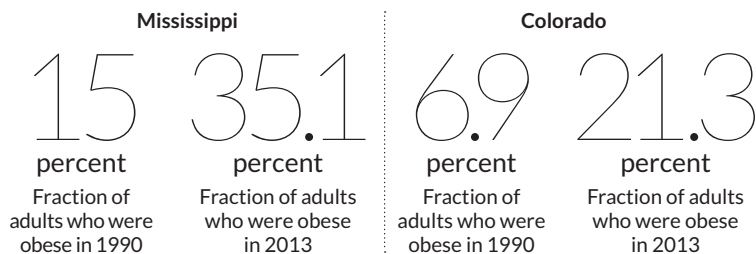
SCREENTIME

Get the facts about the obesity epidemic

There's no hiding a bulging waistline. And thanks to a new interactive U.S. map, there's no concealing the state-by-state status of the obesity epidemic. Moving a cursor across the map at the website stateofobesity.org exposes the track record of each state and lights up line graphs that trace that state's obesity rates back to 1990. The upward trend is unmistakable. Highlighting that fact is an aim of researchers from the Robert Wood Johnson Foundation and the Trust for America's Health who wrote the report that serves as the source of the website.

While a rise in obesity is evident in all states, the graphics make clear that some regions have more work cut out for them. West Virginia and Mississippi fare the worst, with obesity prevalence now at 35.1 percent; Colorado gets a gold star for coming in at 21.3 percent. Switching to maps from past years reveals that the weightiest states have jostled for the dubious honor of being at or near the top. Clicking on a state reveals more details, such as where it ranks in obesity-related areas such as rates of diabetes and hypertension. — *Nathan Seppa*

The rise of obesity



FROM TOP: NATALIEJEAN/SHUTTERSTOCK; WWW.FLOATINGFORESTS.ORG; RWJF. ADAPTED BY S. EGTS



SEPTEMBER 6, 2014

SOCIAL MEDIA

Mummies inspire health care humor

New research on mummies from around the world shows that heart disease is an ancient affliction. What caught readers' attention in **Tina Hesman Saey's** story (SN: 9/6/14, p. 6), however, was a photo of a mummy prepped for a CT scan.



"It's amazing how long it takes to get a CT scan these days. Must have had an HMO"

Matt Cummins on Facebook

"Thank goodness for expanded health care coverage or he would need all those treasures for the copay."

@JLRoose on Twitter

"I think this patient is beyond saving."

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In defense of jellies

Jellyfish may not be as lovable as some other animals, but they do more for their ecosystems than most people realize. **Susan Milius** explained that gelatinous creatures provide food for some ocean dwellers, homes for others and more in "Seeing past the jellyfish sting" (SN: 9/6/14, p. 16). Scientists wrote in to show support for often-maligned jellyfish. Evolutionary biologist **Casey Dunn** of Brown University in Providence, R.I., has frequently been frustrated by what he calls "Jellies are scary" articles, which treat gelatinous animals as a sign of unhealthy ecosystems. "Your article shows that there is no reason to resort to fear tactics to get people engaged and interested in these incredible animals. Their beauty and unique biology are far more compelling," he wrote. "This is refreshing, and provides a much better framework for informing the readers."

Neurologist **Oliver Sacks**, who has written eloquent books about human nervous systems, e-mailed to express his appreciation of gelatinous ones. "Until the latter part of the 19th century, it was assumed that jellyfish (of all kinds) were simply passive masses of jelly, but in 1880, Darwin's young friend George Romanes was able to demonstrate that jellyfish had quite complex nervous systems, with upwards of 1,000 nerve cells." Now biologists recognize that box jellyfish have nerve ganglia and even eyes with retinas and lenses. Comb jellies, with well-developed sensory cells and rapidly reacting ion channels, may be the most ancient surviving branch on the animal genealogical tree, the sister lineage to all other animals. "It is pleasing to think that these beautiful, misunderstood creatures are our ancestors, and have been around for nearly 600 million years," **Sacks** wrote.

No guessing in goalkeeping

Flawed guesswork leads soccer goalies astray when diving to block a penalty kick. **Nsikan Akpan** reported in "Goalkeepers deceive themselves" (SN: 9/6/14, p. 15) that goalies expect to see patterns in kickers' shots that just aren't there.

In an online comment, **Jared** argued that goalie-kicker dynamics aren't that simple. "The researchers assume that goalies are guessing because of a pattern from kicker to kicker. This is rarely the case," he wrote. "Most goalies attempt to read, not guess, where a shooter is going just before the ball is kicked. Sometimes this is done consciously and other times subconsciously. Of course, then shooters can deceive goalies with false cues. These duels are far more about game and chaos theory than about lucky guessing."

Anton Szautner agreed, adding that the skill and experience of the goalie also comes into play. "There is a significant success rate amongst good goalkeepers who do anticipate which way a shooter is likely to send the ball, based on their observation of body language, face and direction of gaze."

Off-kilter planets

In "Stars' tilted disks clarify odd orbits" (SN: 9/6/14, p. 10), Christopher Crockett described the misaligned disks of gas and dust circling a pair of nearby stars. The cockeyed duo may provide insight into the peculiar orbits of some exoplanets. Online commenter **Inquisitive** observed that the odd exoplanets may have something in common with a planet closer to home: "Our planet also shows a tilt in its orbit around the sun."

That's true, **Crockett** says. "While the planets' orbits line up pretty closely with each other, the entire solar system is tilted by about 7 degrees relative to the sun's equator. Caltech astronomer **Konstantin Batygin** says that, although there are several plausible ideas about what caused that tilt, it could be a hint that our sun once had a star companion that has since drifted away. Pretty remarkable!"

Correction

"Forecast: Cloudy, 100% chance of ash" (SN: 10/4/14, p. 32) incorrectly stated that the Yellowstone volcano erupted 1,000 cubic kilometers of ash 640,000 years ago. The volcano produced roughly 330 cubic kilometers of ash.

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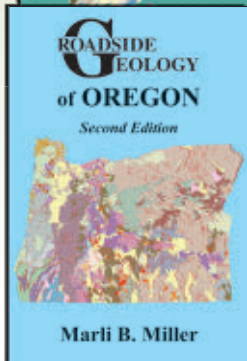
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15a. Total Number of Copies (Net press run)		Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
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Automated art history

Computers have become budding art historians. A new program can figure out a particular painting's style — whether it's abstract, impressionist or Baroque, for example — and tease out possible influences on the artists.

Program designers started with a close look at 1,710 paintings. For each work, the program logged the everyday items depicted, such as chairs and stoves, as well as features including color, composition and brushstroke. By comparing lists of these features with lists made from reference paintings, the program figured out the style of unknown paintings about 70 percent of the time, computer scientist Ahmed Elgammal and colleagues at Rutgers University in Piscataway, N.J., report August 19 in *Multimedia Tools and Applications*.

The program's analyses could offer historians a new way to look at artists' influences, Elgammal says. Among other links, the program proposed a connection between French impressionist Frédéric Bazille and American painting icon Norman Rockwell. Bazille's 1870 *Studio 9 Rue de la Condamine* (top left) and Rockwell's 1950 *Shuffleton's Barbershop* (top right) look alike to the program. The two paintings have similar compositions (red lines) and objects (circled), along with a similarly positioned window (blue rectangles).

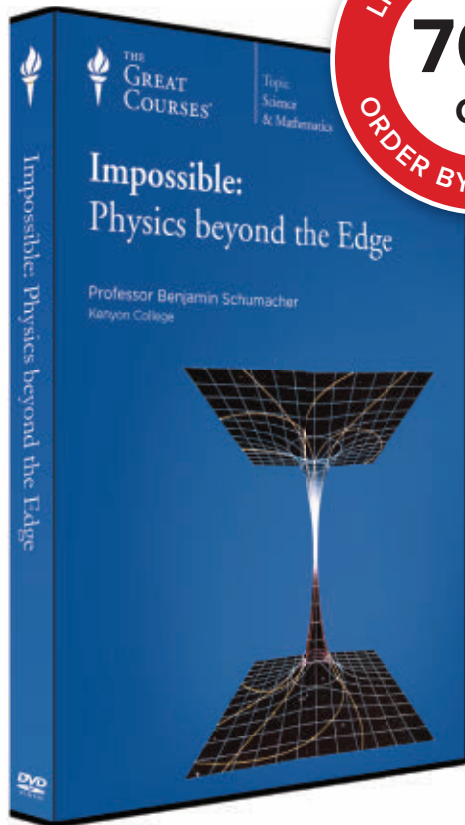
But the likeness may just be a coincidence, says Princeton art historian Emily Spratt. Two stylistically similar paintings don't ensure the artists are historically related, she says. Still, she can imagine a program that looks at a painting and spits out information about the image and its place in history: "Maybe in the future, with computer vision technology, you could actually have a pocket art historian." — *Meghan Rosen*



Identifying influences As the titles suggest, Diego Velázquez's 1650 *Portrait of Pope Innocent X* (left) figured prominently in Francis Bacon's 1953 *Study After Velázquez's Portrait of Pope Innocent X* (right). A new computer program was able to detect this connection. The program also suggested a less obvious link between paintings by Frédéric Bazille (top left) and Norman Rockwell (top right).



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