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JUNE 23, 2018

The 411 on Ancestry Testing

Bonobos Buddy Up for Births

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COVER Emmy Noether had a lasting impact on her colleagues and students, and on the fields of mathematics and physics. *Sam Falconer*

FROM TOP: MATTHEW RAKOLA; ANNA HOYCHUK/SHUTTERSTOCK; SERGEY URYADNIKOV/SHUTTERSTOCK

So what do you know about Emmy Noether?

Emmy Noether may be the most influential mathematician you've never heard of.

In 1918, she solved a puzzle in Albert Einstein's general theory of relativity. To do that, she created a mathematical theorem that changed forever how scientists study the universe, one that remains a guiding star for theoretical physics.

Not only was she a scientific pioneer, Noether was by all accounts a delightful person, known for the festive gatherings at her home in Göttingen, Germany, where wine flowed amid spirited scholarly debate. She led students and colleagues on long walks through the countryside, talking math all the while.

But Noether had one big problem: She was a woman, in an era when science remained largely closed to women. A gifted student, she quickly earned her Ph.D. once women were allowed to enroll. But at the University of Göttingen, she taught for years without being paid. She was forced out of the university in 1933 by the Nazis because she was Jewish, leaving for the United States to teach at Bryn Mawr College in Pennsylvania. Less than two years later, she died of complications from surgery at age 53.

Physicists today still rely on "Noether's theorem." They include *Science News* staff writer Emily Conover, who holds a Ph.D. in physics from the University of Chicago and who wrote this issue's cover story on Noether (Page 20). Conover explains how Noether divined a link between two key concepts in physics — conservation laws and symmetries. Every conservation law, such as energy conservation, has a matching symmetry that holds no matter how far you move in space or time. In addition to Noether's importance in physics, Conover writes, "in mathematics her ideas are so prominent that her name has become an adjective."

Emily Conover

Conover says her own experiences as a scientist have been much different than Noether's, though the number of women in her classes did dwindle as she advanced in academia, where she studied the weird ways of neutrinos (see Page 7 for more on these subatomic particles). Like many women in science, at times she questioned her abilities, even though she was honored for the quality of her work. I'm grateful that we have Conover's deep understanding of the science to illuminate a field that can be a tough go for us nonphysicists. Noether would have approved.

Despite the advances since Noether's day, women are still underrepresented in science, especially in the physical sciences. In 2010, just 14 percent of physics faculty members in the United States were women, according to a survey by the American Institute of Physics. A study published in April determined that based on the current rate of change it would take more than 100 years for women to achieve parity as authors in physics journals (*SN: 5/26/18, p. 32*).

Here at *Science News,* we'll continue to track the trends that reflect modern science in all its diversity. — *Nancy Shute, Editor in Chief*

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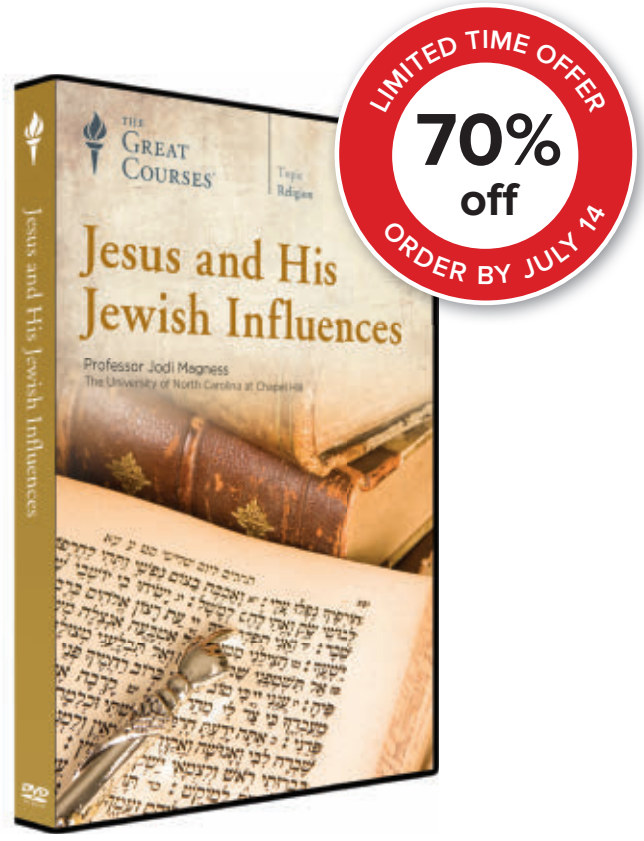

Unearth the Jewish Roots of Jesus's Teachings

For anyone interested in the profound impact Jesus had on the world, it's important to realize that his actions and teachings didn't emerge from a vacuum. Rather, they were the product of a fascinating dialogue with—and reaction to—the traditions, cultures, and historical developments of ancient Jewish beliefs. In fact, early Judaism and Jesus are two subjects so inextricably linked that one cannot arrive at a true understanding of Jesus without understanding the time in which he lived and preached.

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Excerpt from the June 22, 1968 issue of *Science News*

50 YEARS AGO

Gravity waves evidence

The long search for gravitational waves ... may be in the final lap.... Rotating binary stars or, perhaps, other galaxies like the Milky Way but far beyond it, or the center of the Milky Way itself, are likely sources for gravitational radiation.

UPDATE: Although Joseph Weber, a physicist at the University of Maryland, announced a gravity wave detection in 1969, no one could verify his claim. It took almost another 50 years for researchers to directly detect gravitational waves (*SN: 3/5/16, p. 24*). Those spacetime ripples from two merging black holes, glimpsed by the Advanced Laser Interferometer Gravitational-Wave Observatory, or LIGO, confirmed Einstein's theory of gravity. Scientists have since spotted more gravitational waves from black holes (*SN: 10/28/17, p. 8*), as well as from colliding neutron stars (*SN: 11/11/17, p. 6*). A trio of spacecraft called LISA, slated to launch in 2034, will continue the search from space (*SN Online: 6/20/17*).

SOAPBOX

Telomere testing is not a good age indicator

Test kits for telomere length come with advice for maintaining the ends of your chromosomes.

Stay younger, longer. Great idea. But direct-to-consumer test kits that promise to gauge a person's biological age by analyzing a drop of blood are not worth the $100 or so investment, says oncologist Mary Armanios. The tests measure the length of telomeres, the bits of DNA that cap and protect the ends of chromosomes. But the consumer tests are unreliable and can be misinterpreted, Armanios says.

"These kinds of tests can do harm, suggesting there is something wrong when there isn't," says the Johns Hopkins School of Medicine researcher, who uses a clinical test of telomere length to diagnose and treat people with certain rare disorders.

Armanios gets calls from people who panic when they get their results from consumer tests. One man in his 40s was told his telomeres were those of an 80-year-old. He sold his house and quit work to make the most of the short time he was convinced he had left. Worse, she says, because he was under the misguided impression that surgeries shorten telomeres, he had decided to delay removal of a precancerous skin spot.

> "These kinds of tests can do harm, suggesting there is something wrong when there isn't."
>
> MARY ARMANIOS

Armanios trained in the lab of Carol Greider, who shared the 2009 Nobel Prize in physiology or medicine for discovering telomerase, the enzyme that controls telomere lengthening (*SN: 10/24/09, p. 14*). Today Armanios is clinical director of the telomere center at Johns Hopkins.

There is a wide range of "normal" when it comes to telomere length. Work by her team and others has shown that cells don't stop dividing or die because of telomere shortening unless the ends get very short, far from the median.

Yet, commercial testing companies will label clients as older than their birthday suggests if their telomeres are anywhere shorter than the median. Longer means younger. But excessively long telomeres are not a guarantee of a long life and may be associated with higher cancer risk.

The test many consumer companies use, quantitative polymerase chain reaction, or qPCR, has a 20 percent variability rate — tests on different days can yield different answers, studies by Armanios and others have shown. The clinical test Armanios' group uses is flow cytometry and fluorescent in situ hybridization, or flow-FISH, which has a lower, 5 percent, variability rate.

The researchers use the more precise test to study a small group of disorders united by telomere defects. For two of the illnesses, treatment decisions can change based on clinical telomere testing. A hereditary form of aplastic anemia, a failure of the bone marrow to make blood cells, can be treated with a stem cell transplant with immune suppression. People whose telomeres are short need less immune suppression with the transplant. In a study by Armanios and colleagues in the March 6 *Proceedings of the National Academy of Sciences*, telomere testing flagged nine of 38 patients who required a gentler approach.

Likewise, patients with short telomeres who are receiving lung transplants for idiopathic pulmonary fibrosis should get low immune suppression. In fact, traditional levels can be lethal. With this knowledge, the transplant can be done more safely.

"The telomere belongs in the clinic," Armanios says, "and should not be used as a form of molecular palm reading."

— *Cori Vanchieri*

ANNA HOYCHUK/SHUTTERSTOCK

FOR DAILY USE

Don't swallow the pool water

It's vacation season — time for swimming pools, hot tubs and water parks. But you might want to think twice before getting wet, says a new report from the U.S. Centers for Disease Control and Prevention.

From 2000 through 2014, public health officials from 46 states and Puerto Rico reported 493 disease outbreaks involving treated recreational water, resulting in more than 27,000 illnesses and eight deaths, researchers report in the May 18 *Morbidity and Mortality Weekly Report*. Hotel pools and hot tubs were the setting for about a third (32 percent) of the outbreaks, followed by public parks (23 percent), club/recreational facilities (14 percent) and water parks (11 percent).

Most of the infections were from three organisms that can survive chlorine and other commonly used disinfectants: *Cryptosporidium*, a parasite that can cause gastrointestinal problems; *Pseudomonas*, a bacterium that causes swimmer's ear; and *Legionella*, a bacterium that causes a pneumonia-like illness.

So, what to do? The CDC recommends a few steps before diving in: Don't swallow pool water. Don't let children with diarrhea in the water. And use test strips to measure levels of pH, bromine and chlorine in the water. — *Kyle Plantz*

TEASER

Precision choreography among self-driving taxis would ease traffic

Self-driving taxis that work together like a well-oiled machine because of an algorithm could someday cut down on city traffic.

Researchers have created a computer program that can continually analyze incoming ride-hailing requests sent from a smartphone app and plot the most efficient course for each car in a self-driving fleet (*SN Online: 11/21/17*). Unlike standard taxis, which pick up customers spotted on the side of the road, this algorithm assigns cars to customers based on traffic conditions as well as the pickup and drop-off locations of all ride requests.

Moe Vazifeh, a physicist at MIT, and colleagues tested this algorithm by feeding it information on more than 150 million cab rides taken in New York City in 2011. The program, described in the May 24 *Nature*, choreographed routes to pick up more than 90 percent of customers within five minutes of their ride requests.

That can be slower than flagging down a taxi. But the algorithm's method required only about 5,400 cabs on the street at once, on average, compared with the average 7,700 cabs cruising the city at any given time in 2011. By serving customers using far fewer cars, such precision-guided, self-driving fleets could help curb traffic pollution and congestion (*SN: 9/30/17, p. 18*).
— *Maria Temming*

SCIENCE STATS

Leaf-cutting ants pick up the pace

In Central America's rain-drenched forests, leaf-cutting ants collect pieces of leaves on which they grow fungi for food. But the rain can hit hard, especially for a small ant. When leaf-cutting ants sense an incoming shower, they hoof it back to their nests, says a study in the May *Insectes Sociaux*.

Researchers from Argentina, Mexico and Peru tested how one species of leaf-cutting ants, *Atta cephalotes*, in Costa Rica deal with rain. The scientists placed hollow boxes filled with wet cotton on ant trails in the forest. When *A. cephalotes* walked through the boxes, they experienced higher relative humidity, as if it were about to rain. In another experiment, the researchers poured water on plants beside the trail to simulate falling raindrops. Both situations caused the ants to scramble to their nest up to 30 percent faster than normal, from about 1.21 meters per minute to 1.49. The researchers think that leaf-cutter ants speed up to keep their cargo and themselves dry, with good reason: A wet leaf fragment weighs more than double a dry one. In the study, when the ants or leaves got wet, the insects readily dropped their harvest and returned to the nest. But by hurrying along at the first hints of rain, the ants could stay dry and hold onto the leaves. — *Yao-Hua Law*

30 percent
Pace increase among leaf-cutting ants when they sensed rain

Leaf-cutting ants carry hefty cargo, which gets heftier when wet.

LIFE & EVOLUTION

Fossil prompts reptile rethink

Specimen suggests an earlier evolution of snakes, lizards

BY SUSAN MILIUS

A little animal that washed out to sea 240 million years ago off the coast of what's now Italy turns out to be the oldest known fossil of a lizard.

The identification pushes back the fossil record of snakes and lizards by about 75 million years, says Tiago Simões of the University of Alberta in Edmonton, Canada. He and colleagues used details of the fossil, called *Megachirella wachtleri*, and of related living and extinct species plus genetic data to reconstruct the evolutionary history of squamates, the reptile group that today includes snakes and lizards. The team's findings are reported in the May 31 *Nature*.

"Understanding lizard and snake evolution has been a constant problem in paleontology," says vertebrate paleontologist Stephanie Pierce of Harvard University. The trouble comes largely from a lack of relevant fossils, she says. That dearth isn't just because little animals don't fossilize as readily as big ones do. "Things like giant dinosaurs — they're pretty easy to spot," she says. "But if you're looking for something that can fit in the palm of your hand, that makes it very challenging."

A collector found *M. wachtleri* almost 20 years ago in a part of the Italian Alps that had once been underwater. But scientists hadn't categorized it as a member of the squamate branch of reptiles until now. The sole specimen is partly embedded in rock, which obscured some of the creature's telltale features. Now a CT scan has revealed previously unknown squamate details in the palate, braincase, limbs and shoulder, Simões says.

M. wachtleri was a small, terrestrial animal with teeth appropriate for snapping up insects, he says. A catastrophe such as a tropical storm apparently swept the critter out to sea.

Besides taking a closer look at *M. wachtleri*, Simões and colleagues traveled to 17 countries to reexamine other known squamate fossils. Combining all of the new fossil measurements with DNA data from living animals, the researchers reconstructed the evolutionary tree of squamates. Among the conclusions: Geckos appear to be the most ancient of still-surviving lizards. And iguanas, a hard-to-place group on the tree, have a more recent origin than some other studies have found.

"The picture is coming together," says study coauthor Oksana Vernygora, an evolutionary biologist also at the University of Alberta.

Previously, the oldest known squamate fossils dated to about 168 million years ago. Adding *M. wachtleri* to the mix, along with the new evolutionary tree data, indicates that the squamates are so ancient that they probably arose before the mass extinction at the end of the Permian Period 252 million years ago, notes herpetologist and evolutionary biologist Jeff Streicher of the Natural History Museum in London. That cataclysm came the closest (yet) to wiping out life on Earth. How the ancestors of modern lizards and snakes made it is still a matter of debate. ■

SERGEY URYADNIKOV/SHUTTERSTOCK

LIFE & EVOLUTION

'Midwives' help pregnant bonobos give birth

Like humans, bonobos may treat birth as a social event with a serious purpose. In three recorded instances, female bonobos stood close by and provided protection and support to a bonobo giving birth to a healthy infant. Researchers filmed these incidents in 2009, 2012 and 2014 at two European primate parks where the apes roam freely through forested areas.

These observations — along with a 2014 report of wild bonobos behaving similarly — challenge the idea that, among primates, only humans receive birth assistance. Scientists had proposed that the perils of passing a baby through the relatively narrow human birth canal called for help from others. But bonobos can safely give birth on their own. Comparably high levels of sociability among female bonobos (wild bonobos with an infant shown above) and among women may instead explain why helpers assemble as a pregnant individual nears delivery, the researchers propose online May 9 in *Evolution and Human Behavior*.

Chimpanzees, close cousins of bonobos, however, go it alone. Female chimps are more competitive and maintain weaker social bonds than do female bonobos and humans. — *Bruce Bower*

ATOM & COSMOS

Fermilab finds hints of a new particle

Experiment's excess signals point to a fourth type of neutrino

BY EMILY CONOVER

Pip-squeak particles called neutrinos are dishing out more than scientists had bargained for.

A particle detector has spotted a puzzling abundance of the lightweight subatomic particles and their antimatter partners, antineutrinos, physicists report online May 30 at arXiv.org. The finding mirrors a neutrino excess found over two decades ago. And that match has scientists wondering if a new type of particle called a sterile neutrino — one even more shadowy than the famously elusive ordinary neutrinos — might be at large.

Such a particle, if it exists, would transform the foundations of particle physics and could help solve cosmic puzzles like the existence of dark matter, an unidentified inert substance that makes up the preponderance of the matter in the universe.

The new study was conducted with a neutrino detector called MiniBooNE, while the previous neutrino excess was found with a different apparatus, the Liquid Scintillator Neutrino Detector, which operated in the 1990s at Los Alamos National Laboratory in New Mexico. "We have two very different detectors ... and we have the same results," says MiniBooNE physicist En-Chuan Huang of Los Alamos National Laboratory.

Hints of excess neutrinos showed up in earlier results from MiniBooNE, operating since 2002 at Fermilab in Batavia, Ill. But the new research includes twice as much data, making the neutrino deluge too strong to ignore.

Still, some physicists question whether the excess signals are really from neutrinos. "The events ... are real. The question is, what are they?" says neutrino physicist Jonathan Link of Virginia Tech in Blacksburg. The apparent neutrino surplus could be a red herring. Other known particles can interact in ways that mimic neutrinos.

> "The events ... are real. The question is, what are they?"
>
> JONATHAN LINK

Neutrinos come in three known types: electron neutrinos, muon neutrinos and tau neutrinos, named after the electron and its two heavier cousins, muons and taus. Neutrinos can morph from one type to another: A particle born as a muon neutrino might later be detected as an electron neutrino (*SN: 1/26/13, p. 18*).

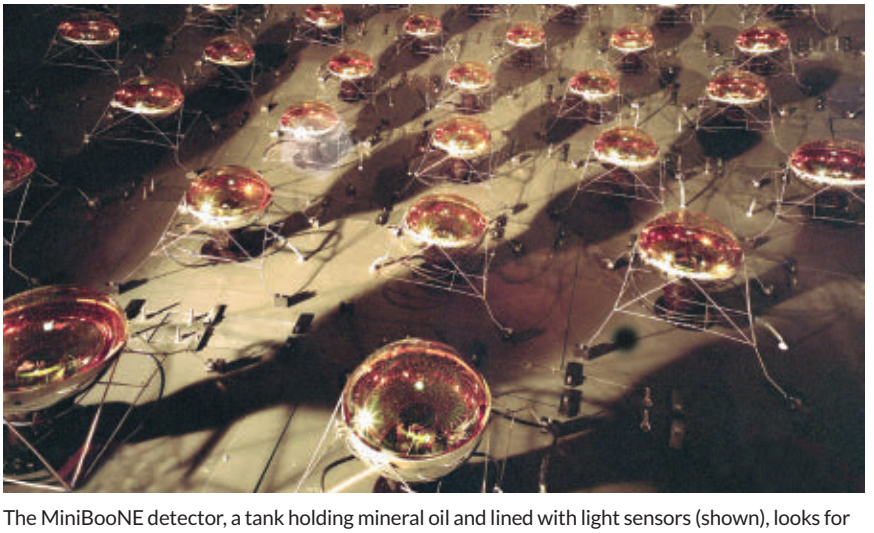
In the new experiment, scientists blasted muon neutrinos and antineutrinos at MiniBooNE and looked for particles that had morphed into the electron type. Using a large tank of mineral oil lined with sensitive light detectors, MiniBooNE looked for small flashes of light produced in electron neutrino and antineutrino interactions with atomic nuclei inside of the oil. The researchers saw 2,437 interactions, about 460 more than predicted.

That excess potentially hints at the existence of sterile neutrinos, which could alter the way neutrinos shift from one type to another, causing more muon neutrinos to morph into the electron type than otherwise expected. While ordinary neutrinos rarely interact with matter, sterile neutrinos wouldn't interact at all, except via gravity.

Sterile neutrinos have been proposed as a possible candidate for what makes up dark matter. But to explain the MiniBooNE results, the sterile neutrinos would have to be relatively lightweight — too puny to explain dark matter. Still, the existence of light sterile neutrinos might suggest that heavier ones are out there, too, says cosmologist Kevork Abazajian of the University of California, Irvine. "Sometimes people say they're like cockroaches: If you have one sterile neutrino, you have many."

Other neutrino misbehavior has shown up in experiments that measure electron antineutrinos produced in nuclear reactors. These experiments see fewer interactions than expected, a result that could also be explained by a sterile neutrino (*SN: 3/19/16, p. 14*). But there's an inconsistency: A sterile neutrino should cause a deficit of muon neutrinos in other experiments, but that hasn't been seen. That means the explanation is likely more complicated than there being a single type of sterile neutrino.

It's not yet clear how the various results from different neutrino experiments fit together. For now, the new study has physicists puzzled. "I actually don't know what to make of it," says Kate Scholberg, a neutrino physicist at Duke University. But theoretical physicists, she says, "will chew on this like crazy." ■



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The MiniBooNE detector, a tank holding mineral oil and lined with light sensors (shown), looks for flashes produced as subatomic particles called neutrinos interact with atomic nuclei inside the oil.

LIFE & EVOLUTION

How birds avoided mass extinction

Terrestrial lifestyle linked to surviving the dino apocalypse

BY SUSAN MILIUS

Nothing against trees. But maybe it's better not to get too dependent on them if you want to survive a big flaming space object crashing into Earth.

The asteroid impact that caused a mass extinction 66 million years ago probably also triggered the collapse of forests worldwide, a new investigation of the plant fossil record concludes. Needing trees and extensive plant cover for nesting or food could have been a fatal drawback for winged dinosaurs, including some ancient birds. Reconstructing the ecology of ancient birds suggests that modern fowl descended from species that survived because they could live on the ground, researchers propose in the June 4 *Current Biology*.

"You probably would have died anyway, regardless of habitat," says study coauthor Daniel Field, an evolutionary paleobiologist at the University of Bath in England. "But if you could get along on the ground, you at least had a shot at surviving across this devastated landscape."

The shock wave from the strike probably flattened trees within a radius of 1,500 kilometers, Field says. Wildfires ignited around the planet, and then came the acid rain. Clouds of ash and dust may have darkened the sky for several years, and researchers suspect that photosynthesis waned. Yet some lucky birds, but no other dinos, survived the hellscape.

For clues to what made a survivor, researchers turned to fossilized pollen from before and after the fiery impact. Abundant kinds of flower-bearing and cone-bearing plants left pollen just before the asteroid hit and again starting about a thousand years afterward. In between those times of diversity, however, ferns dominated, the team notes. A kind of "disaster flora," ferns (making spores instead of flowers and seeds) do well at recolonizing land. Seed plants, however, weren't thriving.

Analyzing evolutionary histories of modern birds supports the idea of tree dependence as a vulnerability for the earliest fowl, the researchers say. Specialists in bird evolution generally agree on the lowest, oldest branches of the bird family tree, Field says. The bottommost one includes such modern species as ground-dwelling ostriches and smaller, flight-capable birds called tinamous, which might be more like the ancient birds that dodged extinction than ostriches are.

Working backward along these low branches of the family tree, researchers used fossils and known bird traits

LIFE & EVOLUTION

Caterpillar thwarts corn's smelly SOS

Pest may co-opt plant's distress signal to avoid wasp attacks

BY SUSAN MILIUS

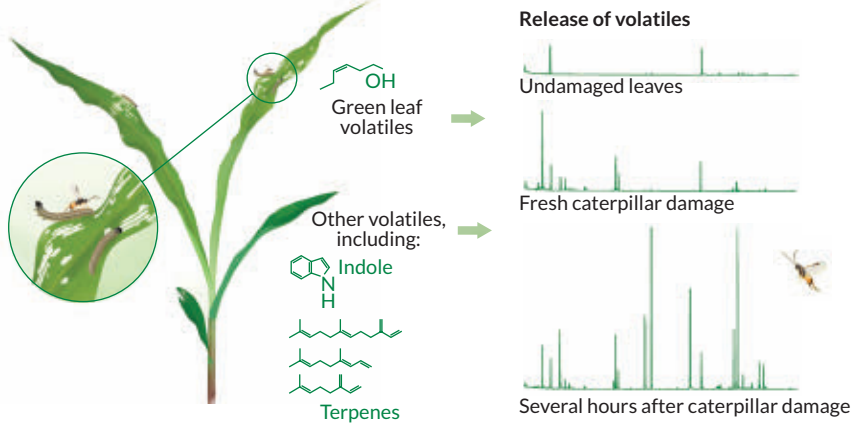
Here's the story of a caterpillar that foils gruesome violence orchestrated by corn.

No, that's not backward. Plants often look helpless to a human, but they fight with smells and other invisible chemistry. A growing body of evidence, for example, shows that plants under attack can waft out scents that attract help, such as tiny wasps that deal a lingering death to leaf-chewing caterpillars.

A dream for future farming is to boost such crop powers. Yet a tale, published May 16 in *Science Advances*, of how attacking *Spodoptera littoralis* caterpillars can escape a trap set for them by maize plants shows how complex a task that could be.

These attackers are "greenish, brownish, ugly caterpillars," says Ted Turlings of the University of Neuchâtel in Switzerland, who makes no secret of where his allegiance lies. The caterpillars damage maize, cotton and a variety of other crops in the Middle East, Africa and elsewhere. But maize fights back, of course. As the caterpillars crunch into a leaf, substances in their spit trigger a burst of furious plant chemistry, which causes the release of certain scents.

The first wave of odors from damaged plants, the cut-grass smell, comes just from ripped tissues spilling their innards. Then within hours, maize sends out new scents that can advertise the kind of pests attacking it. "You can actually smell it yourself," Turlings says. Or at least his trained nose can.



Smell the leaves Maize leaves don't normally give off much in the way of smells (top graph, each peak represents an airborne compound). When caterpillars bite into a leaf, though, a wave of leafy green volatile compounds rises (middle). In a few hours, the leaf synthesizes other volatiles (bottom), including indole and terpenes, that lure such caterpillar enemies as a female parasitoid wasp. New work suggests that caterpillars that bulk up on indole-rich foliage can repel wasps.

T.C.J. TURLINGS AND M. ERB/*ANNUAL REVIEW OF ENTOMOLOGY* 2018

Birds most likely to have survived a mass extinction 66 million years ago would have been small, able to fly and just fine living on the ground (as seen in this artist's depiction).

PHILLIP M. KRZEMINSKI

to reconstruct the most likely lifestyles of the earliest survivors. These probably weren't tree-dependent birds, the researchers conclude.

The glory days of dinosaurs had plenty of flying tree dwellers. So far, paleontologists have identified at least 80 kinds of what are called "opposite birds," the Enantiornithes (*SN: 2/4/17, p. 26*). "If you saw one flying around today, you'd say, 'Well, that's a bird,'" Field says. Their feet looked like those of birds that perch on tree limbs, so he's not surprised that a fossil of an opposite bird from this probably arboreal group has never been found in rock formed after the dino doomsday.

What did happen, however, was that when trees and forests came back after the disaster, birds quickly evolved arboreal lifestyles again, the team says.

Many people don't realize that birds almost died off during the mass extinction, too, says paleontologist Stephen Brusatte of the University of Edinburgh, who has studied bird evolution but was not involved in the new study. What let the few survivors squeak through, he says, has been a mystery for a long time. The whole scenario of a ground dweller's advantage and then a return to the trees "makes a lot of intuitive sense." ■

These telltale plant substances help female *Microplitis rufiventris* wasps track down a suitable species of caterpillar in which to inject an egg. "Out of that egg comes a little larva, and it starts eating the insides of the caterpillar — not a very pleasant thing," Turlings says. Caterpillars continue feeding for several days but then just passively stay alive longer as a source of fresh baby food.

What Turlings and colleagues have found, however, is that what the caterpillar eats makes a difference. Wasps were more interested in caterpillars grazing on maize that researchers genetically engineered not to produce a plant defense compound called indole. In contrast, wasps weren't very likely to inject eggs if this caterpillar species had been feeding on normal maize leaves.

Indole's "mothball-like odor [is] terrible in high dosages," Turlings says. Caterpillars didn't like it much either — except when female wasps were zinging nearby. Then the caterpillars fed willingly enough, a test showed. "It's almost like self-medicating," he says.

There's a cost to the caterpillars' choice to tolerate indole-rich foliage. "They grow fatter but not healthier," Turlings says. More die prematurely. On the plus side, wasp eggs don't flourish as well inside these caterpillars if a wasp does try to use them as zombified baby food. The odor of pure indole could attract the wasps, but caterpillars that bulked up on indole-rich leaves did not, the researchers found in lab tests. This caterpillar's foraging evolution had found a loophole in maize's defense strategy.

Just about every plant tested so far synthesizes special compounds that can lure in some kinds of natural enemies of pests, Turlings says. Yet he'd never run across a caterpillar with this bad-food strategy of avoiding the wasps.

Caterpillars evolving a work-around defense against a widespread plant defense isn't a shock to chemical ecologist James Tumlinson of Penn State. In these ornate biological systems of deceit and manipulation, "pretty much anything you can think of is possible," he says. "Once we get over our surprise, it nearly always makes evolutionary sense." ■

HUMANS & SOCIETY

Americans agree on 15 gun policies

But there's division over guns in schools, assault weapons

BY ERIKA ENGELHAUPT

Despite a public debate that grows more fractious with every school shooting, Americans actually agree on gun policy to a surprising extent.

According to a survey of more than 2,100 people, majorities of both gun owners and nonowners support 15 potential gun restrictions or regulations, researchers report online May 17 in the *American Journal of Public Health*.

"There's much more agreement than one would think given the rhetoric and the fighting," says David Hemenway, an expert on violence prevention at the Harvard T.H. Chan School of Public Health who was not involved in the study.

Two new questions in the survey, the third conducted by the Johns Hopkins Center for Gun Policy and Research, give a glimpse into where Americans draw their battle lines. More than 80 percent of both gun owners and nonowners support safe-handling tests for carrying concealed weapons, but these groups disagree on allowing legally concealed guns in schools. That idea got a thumbs-up from nearly 43 percent of gun owners but only 19 percent of nonowners.

Overall, the survey found little difference in each group's support for 15 policies, including universal background checks and improved reporting of mental illness records for background checks. There was less agreement on requiring owners to keep guns locked and banning military-style assault weapons and large-capacity clips. The study's authors suggest that policy makers can look to areas of agreement as a guide to developing regulations aimed at preventing gun violence.

But Hemenway points out that a dearth of firearms research makes it hard to predict the effectiveness of individual policies (*SN: 5/14/16, p. 16*). ■

ATOM & COSMOS

Sun's rain falls in unexpected places

Surprising plasma precipitation could help solve a solar puzzle

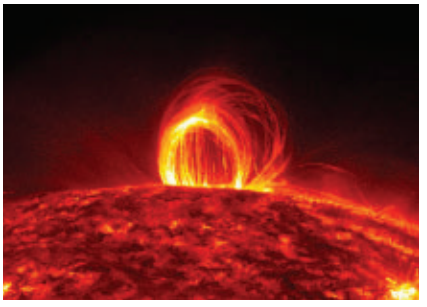
BY LISA GROSSMAN

LEESBURG, VA. — Coronal rain may have a finer grain.

A search for plasma precipitation in the sun's atmosphere reveals that the rain turns up in unexpected places. That discovery might mean the rain can fall as a fine mist as well as a shower. Ultimately, tracing the movement of this plasma may help solve the mystery of why the outer solar atmosphere, or corona, is so hot.

The sun has rainfall similar to Earth's, but with plasma instead of water. When hot plasma moves into a cooler part of the corona, it condenses and falls back toward the solar surface, just as warm air condenses into clouds that form water droplets that rain down on Earth. "The physics is literally the same," says solar physicist Emily Mason of the Catholic University of America in Washington, D.C., who presented new observations of coronal rain at the Triennial Earth-Sun Summit on May 22.

Scientists have seen coronal rain before, mostly as showers in solar regions associated with flares. But it can happen anywhere in the corona where temperatures go from higher to lower, Mason says. Theoretical studies by others suggested that tall streamers, which can stretch up to six solar radii above the sun's surface, could be hotter at their base than their tip and so should be full of rain.



Blobs of plasma can fall like rain in the sun's atmosphere, as seen in the center of this image of a solar flare. New observations suggest such rain can fall as showers or a fine mist.

"My job was to find it," Mason says. She searched for plasma blobs falling within tall streamers in videos recorded in extreme ultraviolet light by NASA's Solar Dynamics Observatory, but spotted none. But she did find rain showers in shorter loops that stretch only to about 0.1 solar radii above the surface. "These things rain like crazy," she says. Coronal rain fell in one of these loops for 30 hours.

The finding is surprising because shorter loops should have less of a temperature difference from bottom to top than the tall streamers, making such precipitation more difficult. Mason thinks the shorter loops don't actually rain more than streamers, but that the plasma blobs in small loops might be larger and thus easier to see. In tall streamers, because the temperature changes more gradually, blobs would end up being smaller — possibly as small as sand grains. "It's there, but it's invisible," Mason argues.

Mason later found much dimmer rain in midsize pseudostreamers, which supports her idea. Current telescopes can't see the smallest blobs, but the Daniel K. Inouye Solar Telescope under construction in Hawaii may be able to.

One long-standing solar mystery is that temperatures in the corona are millions of degrees higher than those at the sun's surface (*SN Online: 8/20/17*). Scientists think the extra heat may come from an unknown, continuous source — as if the corona were sitting on a hot stove — or from a bunch of small, short bursts of energy. The new rain results support the stove idea because that would set up the necessary temperature differences in the short loops, says Nicholeen Viall, a solar physicist at the NASA Goddard Space Flight Center in Greenbelt, Md.

"The fact that the rain is there puts limits on how coronal heating could have happened," Viall says. "The fact that [Mason] found it is pretty important." ■

ATOM & COSMOS

Odd asteroid may be an outsider

Backward-orbiting space rock could have alien origins

BY EMILY CONOVER

An asteroid that flouts the norms of the solar system might not be from around here.

The renegade asteroid travels clockwise around the sun — in the opposite direction of the planets and most other asteroids (*SN: 5/13/17, p. 5*). Now astronomers say that's because the space rock originated from outside the solar system.

Fathi Namouni of the Côte d'Azur Observatory in Nice, France, and Helena Morais of Universidade Estadual Paulista in Rio Claro, Brazil, used computer simulations to show that the asteroid, which shares its orbit with Jupiter, could have been traveling in reverse ever since the solar system's youth. Because asteroids in the infant solar system formed from one swirling cloud, they should have all been traveling in the same direction. So the best explanation is that the rock, called 2015 BZ_{509}, migrated here from another star's planetary system, the researchers argue in the June *Monthly Notices of the Royal Astronomical Society: Letters*.

In 2017, astronomers spotted the first known interstellar asteroid, dubbed 'Oumuamua, which cruised through the solar system and back out again. Asteroid 2015 BZ_{509}, however, appears to be a long-term inhabitant.

"It's certainly an interesting possibility," says astronomer Martin Connors of Athabasca University in Canada. But, he says, the study doesn't nail down whether the asteroid actually came from outside the solar system.

Such asteroids are hard to observe and hard to get information from, Connors says. "There isn't really a blazing sign saying, 'Hey, I'm not from here.'" ■

GODDARD SCIENTIFIC VISUALIZATION STUDIO AND SDO/NASA

Genetic genealogy could solve crimes

A new way to ID suspects with DNA raises privacy concerns

BY TINA HESMAN SAEY

Within the span of a month, DNA probes of family trees in a public database helped police catch two murder suspects.

On May 17, detectives in Washington arrested William Earl Talbott II, 55, of Seatac for the 1987 double murder of Jay Cook and Tanya Van Cuylenborg. A new DNA sleuthing technique called genetic genealogy led to Talbott's capture. His arrest came just weeks after police in California used the new approach to identify a suspect in the Golden State Killer case (*SN Online: 4/29/18*).

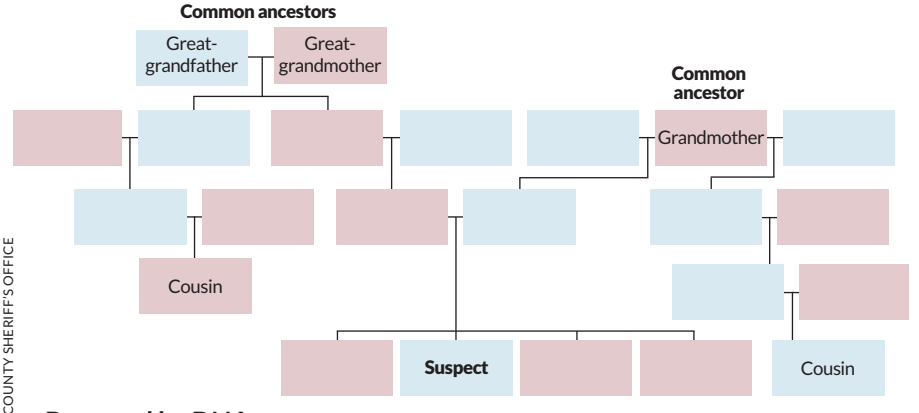
Arrests in both cold cases are probably just the beginning of the technique's use.

Parabon NanoLabs, a DNA-forensics company in Reston, Va., announced on May 8 that it has already used 100 genetic profiles generated from crime-scene DNA to search the public genealogy database GEDmatch. One of those profiles led investigators to Talbott. So far, the company says in about 20 percent of cases genetic genealogy alone could pick out a likely suspect.

Another 30 percent of cases may be solvable with a combination of genetic genealogy and additional police work, says genetic genealogist CeCe Moore, founder of The DNA Detectives, a genetic genealogy group that helps adoptees and other people find their biological families. Moore is working with Parabon to identify possible perpetrators in murder and rape cases.

Erin Murphy, a professor at New York University School of Law, acknowledges the satisfaction of "bringing to justice people who have evaded responsibility for pretty heinous crimes." But she and some other privacy experts are concerned that such cases are making innocent people the subjects of investigations just because those people happen to share DNA with a relative whom they may not even know. Digging through family trees and DNA of people without their knowledge and consent is akin to searching without a warrant or probable cause, Murphy argues.

What's more, police might extend such investigations to less-serious crimes. "There's no rule saying police can only do this sort of genetic sleuthing if it's a homicide or rape," she says. Or, while looking through financial or other records of possible suspects from family trees, detectives might start investigating people for another thing that they had never been under suspicion for. "That's something we haven't done in our country. We haven't said police should just investigate people randomly and see what they turn up," Murphy says.



SNOHOMISH COUNTY SHERIFF'S OFFICE

Betrayed by DNA To help identify a suspect in a murder case, genealogists used crime-scene DNA to probe a genealogy database called GEDmatch. Two people in the database shared DNA with the supposed killer (cousins). Reconstructing family trees led police to further investigate and arrest the suspect (relationships in the family trees are shown relative to the suspect).

In both the Washington and California cases, investigators created a genetic profile of a suspect from crime-scene DNA and uploaded the data to GEDmatch. The database allows people who do DNA testing through one consumer genetic testing company like 23andMe to find DNA matches with relatives who did testing through a different company (see Page 14 for more on these companies).

Parabon already had a DNA profile of the Cook–Van Cuylenborg suspect handy. It had been used to generate a sketch of what the suspected killer might look like at three different ages.

That profile also contained information that could be used to create the suspect's family tree. To build it, Parabon tested about 800,000 variable spots in the individual's DNA, says geneticist Ellen Greytak, the company's bioinformatics director. These spots — single nucleotide polymorphisms, or SNPs (pronounced "snips") — are places in the genome where people differ in one DNA letter. Scientists use SNP patterns to detect pieces of DNA shared by relatives.

Parabon, which was already using genealogy databases to identify Jane and John Does, had previously considered mining the data for clues about criminals. But, Greytak says, "we weren't sure what the public reception was going to be." Because the public's reaction to the Golden State Killer case was largely positive, Parabon moved ahead with its plans, Greytak says. "We now feel that people are aware, and if they continue to participate [in GEDmatch], they're OK with that usage."

DNA from Van Cuylenborg's murder scene matched two people in GEDmatch, who both shared amounts of DNA with the suspect typical of second cousins. That finding suggested that Moore would need to go back to at least each person's great-grandparents to build the suspect's family tree. Moore discovered one branch of the tree led to Talbott's mother and another to his father. Talbott, the couple's only son, became the prime suspect. Police tailed him and got DNA from a cup he threw away, which matched the DNA from the crime scene. ■

ATOM & COSMOS

Methane ice dunes spotted on Pluto

Wind, sublimation could explain the formations, scientists say

BY LISA GROSSMAN

Pluto's heart-shaped plains are striped with sand dunes, where the sand is made of methane ice, a new study finds.

Images from the New Horizons spacecraft's 2015 flyby of Pluto show 357 linear ridges that planetary scientist Matt Telfer of the University of Plymouth in England and colleagues interpret as dunes that have been shaped by a novel process.

The ripples lie parallel to a mountain range at the western edge of Sputnik Planitia, the wide plains of nitrogen and methane ice that form part of Pluto's famous heart-shaped region. Relatively strong winds, traveling about 1 to 10 meters per second, should blow from the mountains across the plains, Telfer's group reports in the June 1 *Science*.

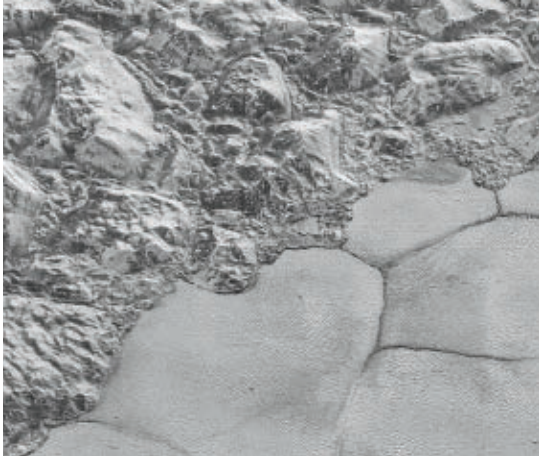
Computer simulations suggest that despite Pluto's thin atmosphere, these winds are strong enough to keep sand-sized methane ice particles moving once they become airborne. But the winds are probably too weak to lift the grains off the ground in the first place.

Instead, little puffs of air coming from Sputnik Planitia's nitrogen ice as the sun heats it could boost methane ice particles skyward and into the wind, the team suggests. That process, by which solids turn directly into vapor, is called sublimation.

"That's a novel, interesting idea," says planetary scientist Alexander Hayes of Cornell University, who was not involved in the work. But sublimation alone could explain some of the features, without the need for wind, he says.

Dunes are found across the solar system, including on Mars (*SN Online: 2/10/10*) and Saturn's moon Titan (*SN Online: 8/28/13*). These worlds have the ingredients for dunes: a supply of loose, grainy material and an atmosphere or fluid to carry grains around.

"When you look at dunes across the solar system, something that always strikes me is that they form the same patterns, regardless of the environment," Hayes says. Finding dunes on Pluto, too, suggests that the features may be ubiquitous. "If you have the material and a way to move it, you form dunes," he says. "That's what this is telling us." ■



On Pluto, dunes (ripples in the center bottom and right of this New Horizons image) form along a mountain range. The dunes are made of grains of methane ice, researchers report.

SWRI, JHU APPLIED PHYSICS LAB, NASA

NEWS IN BRIEF

BODY & BRAIN

Abiding by new blood pressure guidelines would save lives

The first estimate of how many deaths and heart problems could be avoided under new blood pressure guidelines suggests it's well worth it for Americans to get blood pressure under control.

The guidelines, announced in 2017, redefined hypertension as a blood pressure reading of 130/80 or higher (*SN: 12/9/17, p. 13*). The previous threshold was 140/90. As a result, 105 million U.S. adults are now considered to have hypertension, 31 million more than before.

An estimated 334,000 deaths could be prevented annually if people aged 40 and older keep their blood pressure below the new threshold, researchers report online May 23 in *JAMA Cardiology*. And 610,000 heart attacks, strokes and other consequences of cardiovascular disease could be avoided each year. The shift to the lower blood pressure target would prevent an additional 156,000 deaths and 340,000 cardiovascular-related illnesses compared with the previous target.

But adhering to the guidelines means doctors may recommend that 83 million adults, 11 million more than before, take blood pressure medications, epidemiologist Jiang He of Tulane University in New Orleans and his colleagues estimate.

Those drugs carry a risk of side effects, including kidney damage. More research is needed on whether kidney damage related to blood pressure drugs is long-term or temporary, He says. But taking the medication is far less expensive than dealing with a possible heart attack or stroke, he adds. — *Aimee Cunningham*

BODY & BRAIN

Colorectal cancer screening should start at an earlier age, experts say

Colorectal cancer screening should begin at age 45 rather than 50, according to new guidelines released May 30 by the American Cancer Society. The recommendation is a response to the steady rise in younger Americans' rate of colorectal cancer (*SN: 4/1/17, p. 5*).

For people at average risk for colorectal cancer — those without a personal or family history of the disease and who haven't had inflammatory bowel disease — the American Cancer Society suggests that regular screening begin at age 45 with either stool-based tests or visual exams, such as a colonoscopy.

Colorectal cancer is the second-most common cause of cancer death in the United States. Screening can catch precancerous polyps and early-stage cancers, when they may be more easily treated, according to the American Cancer Society.

"Overall rates of colorectal cancer have declined by more than 45 percent since the 1980s, owing in part to screening," says gastroenterologist Andrew Chan of Massachusetts General Hospital in Boston, who was not involved in the guidelines. "In sharp contrast, the rates of colorectal cancer have been increasing among all age groups between 20 and 49." Those groups have experienced

a 51 percent rise in the incidence of colorectal cancer since 1994.

Scientists aren't sure why the disease is increasing among younger Americans. But it's not just in relation to the older group; the absolute case numbers are going up, Chan says. "The increase we are seeing is not simply a reflection of the drop in cancer among older groups who are being screened." — *Aimee Cunningham*

EARTH & ENVIRONMENT

As carbon dioxide increases, rice loses B vitamins, other nutrients

By the end of this century, rice may not deliver the same levels of B vitamins as it does today. Protein and certain minerals will dwindle, too, new data suggest.

Testing higher carbon dioxide concentrations in experimental rice paddies in China predicts losses in four vitamins, B1, B2, B5 and B9, an international team reports May 23 in *Science Advances*. Adding results from similar experiments in Japan, the researchers also note an average 10.3 percent decline in protein, an 8 percent fall in iron and a 5.1 percent fall in zinc, supporting previous studies of rice and other crops (*SN: 4/1/17, p. 14*). Two exceptions to losses: Vitamin B6 levels remained unchanged and vitamin E increased.

In the experimental setups in China and Japan, researchers grew 18 varieties of rice. Piping exposed the rice to CO_2 concentrations elevated to 568 to 590 parts per million — higher than the current level of 410 ppm, but in line with the trend toward 570 ppm in this century.

Nine rice varieties grown in China and tested in their unrefined brown rice form differed in degree of vitamin loss. On average, B1 levels (thiamine) declined 17.1 percent; B2 levels (riboflavin), 16.6 percent; B5 (pantothenic acid), 12.7 percent; and B9 (folate), 30.3 percent.

Such declines could threaten the health of those who depend heavily on rice, now about 600 million people. B vitamins help with a range of bodily tasks, from maintaining a healthy brain to enabling normal fetal development. — *Susan Milius*

TOSHIHIRO HASEGAWA/NATIONAL AGRICULTURE AND FOOD RESEARCH ORGANIZATION OF JAPAN

Extra carbon dioxide can be piped into a section of a Japanese rice paddy to simulate a future atmosphere. Such tests suggest that rice will have lower levels of some B vitamins by 2100.

HUMANS & SOCIETY

A coastal route could have led humans into the Americas

Ancient colonizers of the Americas could have traveled down Alaska's Pacific coast in canoes or other sea vessels around 17,000 years ago, a new study finds.

At that time, toward the end of the Ice Age, glaciers had just receded from a cluster of southern Alaskan islands, say geologist Alia Lesnek of the University at Buffalo in New York and colleagues. Life-supporting habitats appeared soon after the ice melted.

The study, reported May 30 in *Science Advances*, is the latest to weigh in on the debate over how humans spread into the New World after arriving from Asia and reached as far as South America by 14,500 years ago. Previous work hinted that an inland, ice-free corridor from Alaska through what's now British Columbia may not have contained enough vegetation and wildlife to enable human travel before 12,600 years ago. New geologic evidence supports the coastal route idea, though Lesnek's team found no human bones or artifacts.

Measures of chemicals that accumulate in rock due to cosmic radiation once glaciers retreat provided age estimates for when four Alaskan islands lost their ice coats. A pathway for coastal travelers probably existed along the entire southeastern Alaskan coast about 17,000 years ago, the scientists say. Radiocarbon dates for a seal's bones found on a southern Alaskan island indicate the seal lived 17,000 years ago, suggesting the area was habitable soon after glaciers left. — *Bruce Bower*

ATOM & COSMOS

Dark matter is still in hiding

The largest particle detector of its kind has failed to find any hints of dark matter, despite searching for about a year.

Known as XENON1T, the experiment is designed to detect dark matter particles, which are thought to make up most of the matter in the cosmos. Physicists don't know what dark matter is. One of the most popular explanations is a particle called a WIMP, short for weakly interacting massive particle. XENON1T searches for WIMPs crashing into atomic nuclei in 1,300 kilograms of chilled liquid xenon. But XENON1T saw no clear signs of such collisions. The particles' absence further winnows down their possible hiding places by placing new limits on how frequently WIMPs can interact with nuclei depending on the mass of the WIMP.

Researchers described the results May 28 in two talks, one at Gran Sasso National Laboratory in Italy, where XENON1T is located, and the other at the particle physics lab CERN near Geneva. XENON1T had previously reported no hint of WIMPs using about a month's worth of data (*SN: 9/30/17, p. 17*). The new study was highly anticipated, as the longer search provided a better chance for spotting WIMPs.

As the WIMP window narrows, scientists are preparing to rev up the search, creating more-sensitive WIMP detectors and looking for other possible dark matter particles, such as axions (*SN Online: 4/9/18*). — *Emily Conover*

Finding Family

When your ancestry depends on the test you take

By Tina Hesman Saey

DNA testing helped Michael Douglas find his biological family in southern Maryland and his Irish roots.

MATTHEW RAKOLA

Michael Douglas, a new resident of southern Maryland, credits genetic testing for helping him find his heritage — and a family he knew very little about.

Douglas, 43, is adopted. He knew his birth mother's name and had seen a birth certificate stating his birth name: Thomas Michael McCarthy. Over the years, Douglas had tried off and on to find his birth family, mostly by looking for his mother's name, Deborah Ann McCarthy, in phone books and calling the numbers. "I think I must have broken up a lot of marriages," he laughs.

His search gained urgency in the last five years as he battled a life-threatening illness. "We planned my funeral three times," he says. Douglas has a genetic disease called Ehlers-Danlos syndrome, caused by a variant in a gene that helps build the body's connective tissue. His stretchy skin and hyperflexible joints are characteristic of the disease.

"As a kid, I was always dislocating something," he says. His blood vessels don't constrict properly to maintain his blood pressure, so Douglas sometimes faints when he stands up. For five years, he has had a constant migraine. Headaches are typical of about a third of people with Ehlers-Danlos. On top of that, he has B cell lymphoma. "I feel like I have the flu every day," he says. It was time, he decided, to track down his birth family and learn more about his medical history.

In June 2017, Douglas flew to Ireland on what he calls his "death trip." He wanted to see the land of his McCarthy ancestors. He chose Fethard, because the walled medieval town has a pub called McCarthy's. (Douglas learned later that he and the pub owner are related.) His health improved during the visit, which he attributes to Ireland's cool weather. When he returned to Phoenix, where he and his adopted family lived, he had new resolve to find his birth family.

"That's it," he decided. "I need my DNA run to find out who I am." He sent his DNA to three testing companies: Family Tree DNA, AncestryDNA and MyHeritage. With his results plus sleuthing

of genealogical records by some helpful strangers, Douglas found his biological family last November and dove headfirst into a new life.

In February, he moved from Phoenix to Maryland to help care for his biological mother as she recovers from a stroke. The new family dynamic hasn't been easy, but Douglas has bonded with one of his two biological brothers. "And I have a relationship with my ancestors that I did not know before." He is pleased to find that he resembles his great-grandfather Thomas Rodda, a bicycle maker. Douglas himself is a Star Wars costume maker.

Adoptees like Douglas and birth parents looking for children they gave up often use commercial DNA tests in hopes of reconnecting, says Drew Smith, a genealogical librarian at the University of South Florida in Tampa. Many states make it difficult for adoptees to get birth certificates or other documents that could help them track down birth families. DNA tests are "an end run around the documentation problem," Smith says.

But the pool of people looking for their genetic roots is much larger. AncestryDNA, the ancestry testing service with the biggest customer base, has persuaded about 10 million people to take its DNA test. 23andMe, Living DNA, Family Tree DNA, MyHeritage, National Geographic's Geno 2.0 and others also offer customers a chance to use genetics to connect with living relatives and with families' pasts. A few companies even give hints about ties that go back to Neandertals (*SN: 11/11/17, p. 10*). But such testing services may not be able to tell you as much about who you are and where your family came from as they claim.

False precision

I got my DNA tested for this multipart reporting project. My assignment was to investigate the science behind DNA testing (*SN: 6/9/18, p. 20*), but it was also a welcome excuse to learn more about my family's history.

I already knew a lot about three branches of my family tree. Based on birth and death records, plus census and other documents, most of my family stems from England and Germany. But I dreamed of connecting to relatives on the Hungarian branch, which I knew less about. So I sent saliva or cheek swabs to a handful of testing companies. (For a review of my experiences, see Page 26.)

My ethnicity estimates were all over the European map. Generally, estimates are most accurate on the broad continental scale. All of the companies agree that my heritage is overwhelmingly European. But that's where the consensus ends. Even the companies that limit their estimates to broad swaths of the continent told different stories. National Geographic's Geno 2.0 says that I am 45 percent Southwestern European. Veritas Genetics puts my Southwestern European heritage at only 4 percent and tells me I'm mostly (91.1 percent) north-central European.

The companies that try to dig down to the country level see their confidence in the results go down, but that doesn't stop them from making very specific estimates. In most reports, the main results given are at the lower end of the confidence scale. 23andMe, for instance, says it has 50 percent statistical confidence in the ethnicity results.

Along with the wide variations between companies, the estimates often didn't match what I know about my family tree. 23andMe says I'm 16.6 percent Scandinavian. When I sent raw data from 23andMe to MyHeritage to do its own analysis, that company reported no Scandinavian ancestry in my background; it said I'm 16.9 percent Italian. As far as I know, I have no ancestors from Italy or Scandinavia.

Only 23andMe called out my German heritage, though the company lumped it in with French for a total of 18.8 percent. Hungarian is not specifically identified in any company's estimates. I can only guess that 23andMe's 3.9 percent Eastern European and 0.3 percent Balkan findings cover that part of my ancestry. Both 23andMe and AncestryDNA say that I have Ashkenazi Jewish heritage. News to me.

Multiple companies agree that a sizable chunk of my heritage is from the British Isles. But even in that, estimates run from 23andMe's 26.6 percent British and Irish, to Living DNA's calculation that 60.3 percent of my DNA comes from Great Britain and Ireland, to MyHeritage's even higher 78.7 percent.

When I shared these inconsistencies with Deborah Bolnick, an anthropological geneticist at the University of Texas at Austin, I could practically hear her shaking her head over the phone.

"They present these very specific, precise numbers down to the decimal point. But it's a false precision," Bolnick says. "The tests that are available may

With this picture, Douglas learned he resembles his great-grandfather Thomas Rodda (center, holding the bicycle frame).

MATTHEW RAKOLA

Genetic testing goes mainstream

This feature is the final part of a series across three magazine issues on consumer genetic testing.

MAY 26, 2018
An Open Book
Getting a read on your DNA sparks more questions than answers

JUNE 9, 2018
Risks and Riddles
Apps that use raw DNA data to predict your chance of disease may get it wrong

THIS ISSUE
Finding Family
Ancestry results from consumer testing companies are all over the map

Review: Ancestry
Companies offer a mixed bag of results on family ties
Page 26

For these stories and more, visit *bit.ly/SN_DNAdeluge*

not be as nuanced, sensitive and fine scaled as they are presented."

Checking references

Ethnicity estimates come from comparing patterns of genetic variants — often called single nucleotide polymorphisms, or SNPs — in your DNA with the SNP patterns of pools of people from particular geographic locations. As a way to confirm that a pool solidly represents a place, companies generally require that the people in these pools, known as the reference populations, have four grandparents who were also born in that location. Many of the companies draw reference population DNA samples from people in large public databases compiled by the 1000 Genomes Project, a catalog of genetic variation of thousands of people around the world, and from other studies. Some companies supplement their databases by testing more people in particular parts of the world. So the mixes in reference populations differ across companies.

> "They may infer that you have French ancestors and not Italian because of who they do and do not have in their database."
>
> DEBORAH BOLNICK

Who the companies say you are depends in large part on those reference populations, Bolnick says. For instance, you may carry a pattern of SNPs found in people in both southern France and in Italy. If, by chance, the French people a company sampled had that SNP pattern but none of the Italians in the company's database did, "they may infer that you have French ancestors and not Italian because of who they do and do not have in their database," Bolnick explains.

Drilling down to tell customers which country or which part of a country their ancestors called home requires sampling many people in those countries, together with more sophisticated math to detect slight differences in the patterns. By looking at more than SNP patterns, Living DNA provides ethnicity estimates down to subregions of the United Kingdom and Ireland. The company analyzes how different stretches of DNA are connected to each other, says David Nicholson, the company's cofounder and managing director.

It's a bit like regional differences in the way people in southwest England assemble scones, cream and jam for cream teas. "In Devon you have a scone, cream and then you have jam," Nicholson says. "In Cornwall you have a scone, jam, cream, so you have them in a different order. Most DNA tests just tell you that you have a scone, jam and cream so you're from the U.K." But because his company looks at the order of the DNA ingredients, Nicholson claims his results can tell customers what part of the British Isles was their ancestral home.

Dividing lines

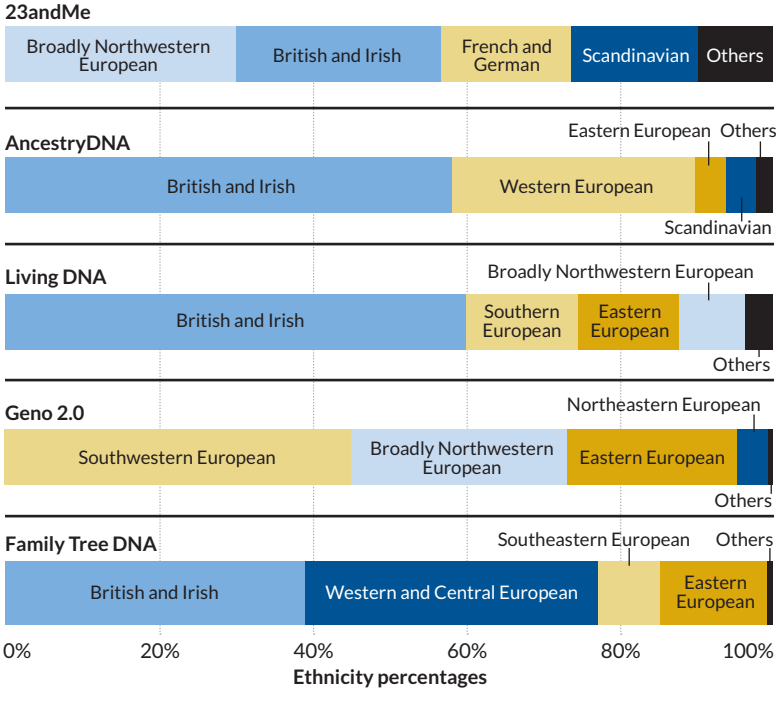
In reality, what the companies can say with certainty is that you share common DNA patterns with people living in those places today. But your ancestors may not always have lived where their descendants do now, Bolnick says. People move around, which muddies the waters.

For many Americans, some branches of their families may be recent immigrants, while other branches may have deep roots in American soil. Two branches of my family came to Massachusetts and Maryland from England in the 1600s. One branch moved from Germany to Nebraska in the late 1800s, and my Hungarian great-grandparents arrived in 1905.

Most Americans who get tested want to know about family from before the big move to the United States, says human geneticist Joe Pickrell, chief executive of DNA testing company Gencove. But the answer isn't simple. DNA is a record of thousands of ancestors stretching back deep in time, each from a slightly different place. How companies sort out time and place may produce different ancestry estimates, Pickrell says.

Take a stretch of DNA containing a particular SNP pattern. "Today it may be found in you in the United States and in relatives in England and

Mixed messages Five companies gave reporter Tina Hesman Saey a wide range of results about her ethnic makeup (results are shown below). Depending on the company, "others" included the Iberian Peninsula, South Asia and North Africa.



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Germany, but it could be that 500 years ago your shared ancestor lived in Italy," Bolnick explains. Going further back in time, that stretch of DNA may look like it came from Romania, Mongolia and Siberia. "As people move and the genes that they have move with them, it's going to change what those geographic ancestries look like," she says.

Given the timing of my family's migrations, I would have expected a much bigger percentage of my ethnicity to come from the newer immigrants. I thought my British ancestry would have been diluted after hundreds of years in America, but I guess not.

Further complicating matters, most people think of their ancestry as coming from particular countries, but genetics cuts across and transcends national borders, Bolnick says. In reality, those categories are not genetic, they're sociopolitical and historic.

Smith, in South Florida, agrees: "From a DNA perspective, it's hard to tell a French person from a German person."

Reference check Testing companies estimate ethnicity by comparing customers' DNA with the DNA of people in reference populations around the world. But companies have different reference populations and divide the world differently, as seen in this comparison of AncestryDNA's and MyHeritage's reference population maps.

Missing groups

And some groups, including aboriginal populations in Australia and big parts of Africa and Asia, are mostly absent from companies' databases. The same goes for Native Americans, whose samples in public databases are small, and in some cases, were collected by questionable means, says Krystal Tsosie, a geneticist at Vanderbilt University in Nashville.

Geneticist Krystal Tsosie says people's identities are composed of much more than their DNA.

She's talking about "vampire projects," in which geneticists swooped in to draw blood from native people, then disappeared. Some scientists have misused DNA samples taken from members of several indigenous nations, conducting studies the DNA donors didn't consent to and doing studies that contradicted the groups' cultural and religious beliefs.

In 2002, the Navajo (Diné) Nation — Tsosie's tribe — declared a moratorium on genetic research. Recently, tribal members have discussed lifting the moratorium, but for now it remains in place, Tsosie says. "We've been, for so long, used as research subjects and not really equitable partners in research," she says. "We're still waiting for the conversation to change to allow us to have our interests protected."

As a result of this mistrust of genetic research, there are not enough people from the 566 federally recognized tribes in the genetic databases to enable customers to learn about their tribal heritage from DNA tests. And even if a DNA test could establish that a person carries DNA inherited from a Native American ancestor, that doesn't make that person a member of the tribe, Tsosie says. Tribal memberships are based on family and community ties, not DNA.

As a volunteer for the Native American Indian Association of Tennessee, Tsosie gets a lot of questions. People get Native American results and want to know if they can share in gaming profits. "It's not enough to just call yourself a Native American," she says. "I tell them, you have to go through the genealogy" and document your ancestry. "Typically, the response is, 'Oh, that sounds like too much work.'"

That response baffles her. "If knowing this Native American past — this part of you — is so important, then undergoing the legwork and documentation should be important," she says. Equally puzzling is why people base their identities on randomly inherited SNP patterns, she says. "Our character, who we are, who we come from is a complex story of a variety of nonbiological factors. To reduce that to a test kit is actually going to ignore the beauty and complexity that is us."

Making connections

Some ads for testing companies reinforce the link between DNA and identity. An AncestryDNA ad features Kyle Merker, a real person, who says that he grew up thinking he was of German descent. He even danced in German folk groups and wore lederhosen. Merker's DNA suggests he's not German at all, but predominantly Scottish and Irish. He's swapped his lederhosen for a kilt.

TOP: ANCESTRYDNA; MYHERITAGE; MIDDLE: COURTESY OF VANDERBILT UNIVERSITY MEDICAL CENTER

The commercial makes it sound like Merker changed his entire culture because of a DNA test. Dig deeper, though, and you'll find that he researched his family through newspaper articles and government records. These traditional genealogical resources really told Merker the story of his family, Smith says.

"DNA by itself is rarely of any value," Smith says. "If you're really interested in researching your family, there's much more work to be done." He likens it to ads from Home Depot or Lowe's: "They make it look like, 'Oh my gosh, redoing a room is easy.'"

Similarly, to really confirm heritage, people have to follow paper trails composed of birth and death certificates, military forms, immigration records, census rolls, church baptism and marriage records, and more. "DNA is just one more type of record," Smith says. "You've got to pull it all together to build your case."

Michael Douglas found his Irish roots, but it took more than DNA to untangle his heritage. Douglas learned from a McCarthy lineage group on Family Tree DNA that his Y chromosome suggests he's a descendent of Donal Gott McCarthy, a 13th century Irish king. "Oh, my god, I'm royalty!" he says. The group helped him trace the McCarthy lineage from the 1200s to 1830s Cork County, Ireland.

AncestryDNA's and MyHeritage's DNA and genealogical records allowed Douglas and four people he calls his "ancestry angels" to connect him with his biological family. The angels were four strangers who friended Douglas on Facebook and helped him with his family research, using genetic connections Douglas had rejected because they didn't have the McCarthy last name. The helpers disappeared once he tracked down his mother.

Not all endings are happy. Smith has seen DNA testing split families. "You may discover things that are surprising or disturbing," he says. You could find out that your father isn't your father. Or matching to other relatives could uncover family secrets, such as an aunt who never told her family that she gave up a child for adoption or an uncle who knowingly or unknowingly fathered a child.

"It's fun to learn more about our ancestors and what our ethnicity is," Smith says. But, he warns, keep in mind that what you learn "may upend your personal life or the personal lives of members of your family." Don't do it if you're not prepared for the repercussions. ■

Mix and unmatch

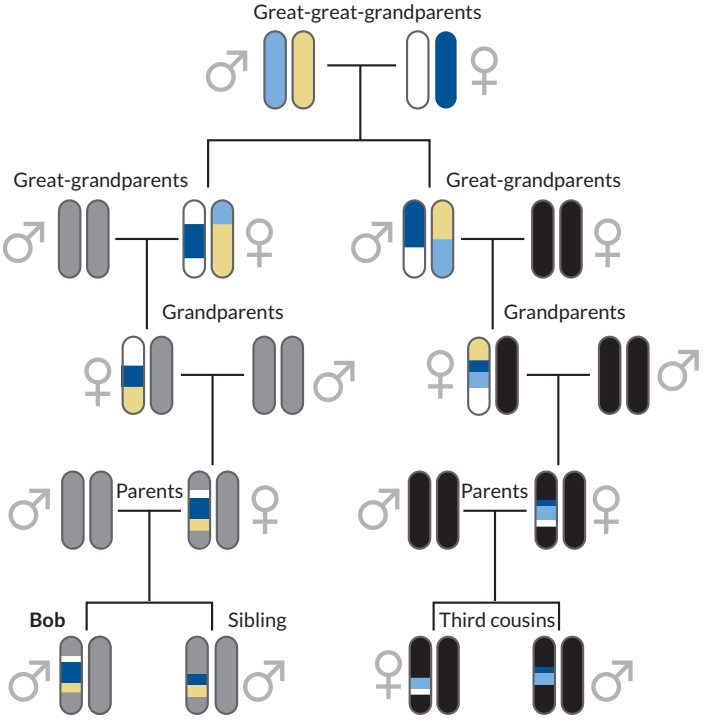
When genetic testing customers discover that they don't share DNA with people they thought were their cousins, assumptions can get dark quickly. Are there secrets in the family tree? Not necessarily.

DNA recombination — a reshuffling of bits of the parents' chromosomes in the cells that give rise to eggs and sperm — creates new genetic combinations, half of which each parent passes to a child. Siblings will share about 50 percent of their DNA. The recombination means children don't inherit the exact same mix from their parents (unless the kids are identical twins).

That mixing may lead to distant cousins inheriting completely different genetic legacies from their ancestors. The more distant the connection, the more likely relatives are to have no DNA in common. About 10 percent of third cousins (who share the same great-great-grandparents) and 45 percent of fourth cousins (descendants of the same great-great-great-grandparents) have no DNA in common, says Drew Smith, a genealogical librarian at the University of South Florida in Tampa.

"Don't get upset if you've got a documented third cousin and you don't share any DNA. It happens," he says. "On the other hand, if you've got a second cousin and you don't share DNA, there's a problem."

— Tina Hesman Saey



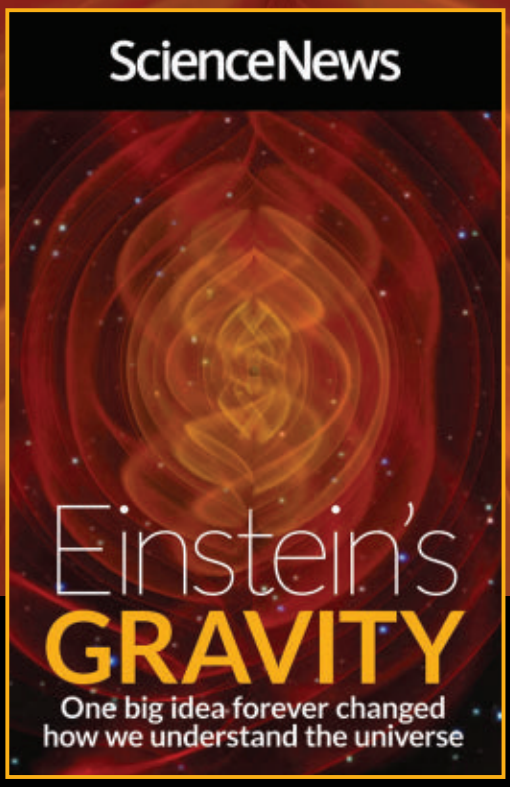
Relationships This tree shows how a set of chromosomes from one couple is recombined and passed down to their descendants. Here, Bob would share some DNA (dark blue strip) with a male third cousin but not with a female third cousin.

C. CHANG

Explore more

- Christine Scodari. "When markers meet marketing: Ethnicity, race, hybridity and kinship in genetic genealogy television advertising." *Genealogy.* December 7, 2017.
- Alondra Nelson. *The Social Life of DNA: Race, Reparations and Reconciliation after the Genome.* Beacon Press, 2016.

Einstein's BIG IDEA



Albert Einstein reinvented gravity.
Gravity has reinvented the cosmos.

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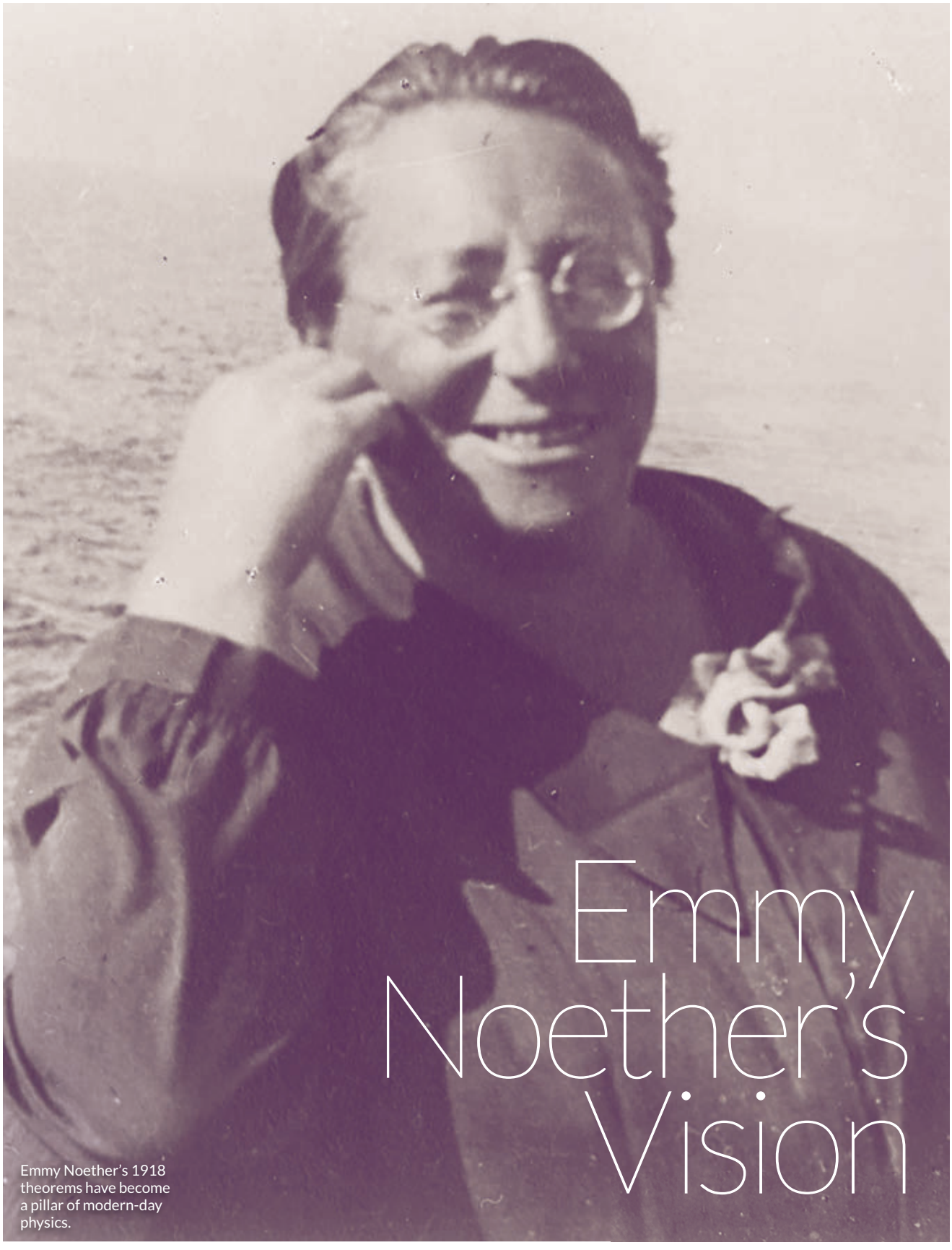


Emmy Noether's Vision

Emmy Noether's 1918 theorems have become a pillar of modern-day physics.

In her short life, the German mathematician changed the face of physics

By Emily Conover

On a warm summer evening, a visitor to 1920s Göttingen, Germany, might have heard the hubbub of a party from an apartment on Friedländer Way. A glimpse through the window would reveal a gathering of scholars. The wine would be flowing and the air buzzing with conversations centered on mathematical problems of the day. The eavesdropper might eventually pick up a woman's laugh cutting through the din: the hostess, Emmy Noether, a creative genius of mathematics.

At a time when women were considered intellectually inferior to men, Noether (pronounced NUR-ter) won the admiration of her male colleagues. She resolved a nagging puzzle in Albert Einstein's newfound theory of gravity, the general theory of relativity. And in the process, she proved a revolutionary mathematical theorem that changed the way physicists study the universe.

It's been a century since the July 23, 1918, unveiling of Noether's famous theorem. Yet its importance persists today. "That theorem has been a guiding star to 20th and 21st century physics," says theoretical physicist Frank Wilczek of MIT.

Noether was a leading mathematician of her day. In addition to her theorem, now simply called "Noether's theorem," she kick-started an entire discipline of mathematics called abstract algebra.

But in her career, Noether couldn't catch a break. She labored unpaid for years after earning her Ph.D. Although she started working at the University of Göttingen in 1915, she was at first permitted to lecture only as an "assistant" under a male colleague's name. She didn't receive a salary until 1923. Ten years later, Noether was forced out of the job by the Nazi-led government: She was Jewish and was suspected of holding leftist political beliefs. Noether's joyful mathematical soirees were extinguished.

She left for the United States to work at Bryn Mawr College in Pennsylvania. Less than two years later, she died of complications from surgery — before the importance of her theorem was fully recognized. She was 53.

Although most people have never heard of Noether, physicists sing her theorem's praises. The theorem is "pervasive in everything we do," says theoretical physicist Ruth Gregory of Durham University in England. Gregory, who has lectured on the importance of Noether's work, studies gravity, a field in which Noether's legacy looms large.

Making connections

Noether divined a link between two important concepts in physics: conservation laws and symmetries. A conservation law — conservation of energy, for example — states that a particular quantity must remain constant. No matter how hard we try, energy can't be created or destroyed. The certainty of energy conservation helps physicists solve many problems, from calculating the speed of a ball rolling down a hill to understanding the processes of nuclear fusion.

Symmetries describe changes that can be made without altering how an object looks or acts. A sphere is perfectly symmetric: Rotate it any direction and it appears the same. Likewise, symmetries pervade the laws of physics: Equations don't change in different places in time or space.

Noether's theorem proclaims that every such symmetry has an associated conservation law, and vice versa — for every conservation law, there's an associated symmetry.

Conservation of energy is tied to the fact that physics is the same today as it was yesterday. Likewise, conservation of momentum, the theorem says, is associated with the fact that physics is the same here as it is anywhere else in the universe. These connections reveal a rhyme and reason behind properties of the universe that seemed arbitrary before that relationship was known.

During the second half of the 20th century, Noether's theorem became a foundation of the standard model of particle physics, which describes nature on tiny scales and predicted the existence of the Higgs boson, a particle discovered to much fanfare in 2012 (*SN: 7/28/12, p. 5*). Today, physicists are still formulating new theories that rely on Noether's work.

$$\frac{d}{dt}\left(\sum_a \frac{\delta L}{\delta \frac{dq_a}{dt}}\delta q_a\right) = 0$$

Constant beauty Symmetries imply that certain quantities are conserved, according to Noether's theorem. The equation above expresses that concept: The quantity in the parentheses doesn't change over time.

OPPOSITE: PHOTO ARCHIVES/SPECIAL COLLECTIONS DEPARTMENT/BRYN MAWR COLLEGE LIBRARY

When Noether died, Einstein wrote in the *New York Times*: "Noether was the most significant creative mathematical genius thus far produced since the higher education of women began." It's a hearty compliment. But Einstein's praise alluded to Noether's gender instead of recognizing that she also stood out among her male colleagues. Likewise, several mathematicians who eulogized her remarked on her "heavy build," and one even commented on her sex life. Even those who admired Noether judged her by different standards than they judged men.

Symmetry leads the way

There's something inherently appealing about symmetry (*SN Online: 4/12/07*). Some studies report that humans find symmetrical faces more beautiful than asymmetrical ones. The two halves of a face are nearly mirror images of each other, a property known as reflection symmetry. Art often exhibits symmetry, especially mosaics, textiles and stained-glass windows. Nature does, too: A typical snowflake, when rotated by 60 degrees, looks the same. Similar rotational symmetries appear in flowers, spider webs and sea urchins, to name a few.

But Noether's theorem doesn't directly apply to these familiar examples. That's because the symmetries we see and admire around us are discrete; they hold only for certain values, for example, rotation by exactly 60 degrees for a snowflake. The symmetries relevant for Noether's theorem, on the other hand, are continuous: They hold no matter how far you move in space or time.

One kind of continuous symmetry, known as translation symmetry, means that the laws of physics remain the same as we move about the cosmos.

The conservation laws that relate to each continuous symmetry are basic tools of physics. In physics classes, students are taught that energy is always conserved. When a billiard ball thwacks another, the energy of that first ball's motion is divvied up. Some goes into the second ball's motion, some generates sound or heat, and some energy remains with the first ball. But the total amount of energy remains the same — no matter what. Same goes for momentum.

These rules are taught as rote facts, but there's a mathematical reason behind their existence. Energy conservation, according to Noether, comes from translation symmetry in time. Similarly, momentum conservation is due to translation symmetry in space. And conservation of angular momentum, the property that allows ice skaters to speed up their spins by hugging their arms close to their bodies, emerges from rotational symmetry, the idea that physics stays the same as we spin around in space.

In Einstein's general theory of relativity, there is no absolute sense of time or space, and conservation laws become more difficult to comprehend. It's that complexity that brought Noether to the topic in the first place.

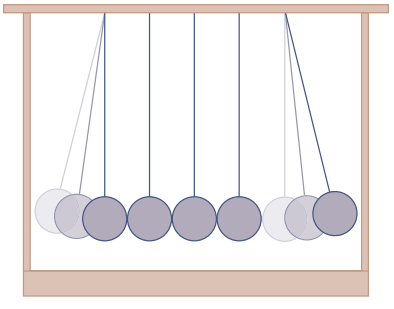
Gravity gets Noether'd

In 1915, general relativity was a fascinating new theory. German mathematicians David Hilbert and Felix Klein, both at the University of Göttingen, were immersed in the new theory's quirks. Hilbert had been competing with Einstein to develop the mathematically complex theory, which describes gravity as the result of matter curving spacetime (*SN: 10/17/15, p. 16*).

But Hilbert and Klein stumbled on a puzzle. Attempts to use the framework of general relativity

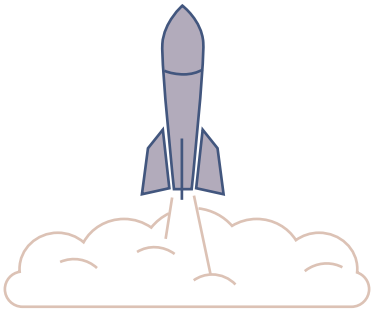
Unbreakable rules
The laws of physics are symmetric in space, time and rotation. According to Noether's theorem, those symmetries suggest that momentum, energy and angular momentum are conserved.

Conservation of momentum



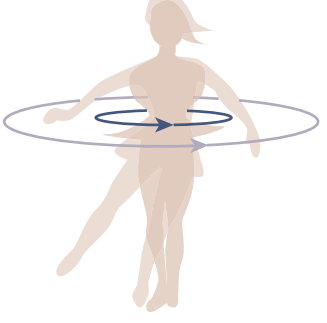
Newton's cradle
When one ball hits the row, a ball on the other end flies outward, conserving momentum. Why? Symmetry of space.

Conservation of energy



Liftoff
A rocket launch converts chemical energy in fuel into kinetic energy and potential energy. Total energy remains constant because of symmetry of time.

Conservation of angular momentum



Spinning ice skater
A skater's twirl speeds up when she pulls in her arms. That's because total angular momentum must stay the same, thanks to symmetry of rotation.

E. OTWELL

to write an equation for conservation of energy resulted in a tautology: Like writing "0 equals 0," the equation had no physical significance. This situation was a surprise to the pair; no previously accepted theories had energy conservation laws like this. The duo wanted to understand why general relativity had this peculiar feature.

The two recruited Noether, who had expertise in relevant areas of mathematics, to join them in Göttingen and help them solve the riddle.

Noether showed that the seemingly strange type of conservation law was inherent to a certain class of theories known as "generally covariant." In such theories, the equations associated with the theory hold whether you're moving steadily or accelerating wildly, because both sides of the theory's equations change in sync. The result is that generally covariant theories — including general relativity — will always have these nontraditional conservation laws. This discovery is known as Noether's second theorem.

This is what Noether did best: fitting specific concepts into their broader mathematical context. "She was just able to see what's right at the heart of what's going on and to generalize it," says philosopher of science Katherine Brading of Duke University, who has studied Noether's theorems.

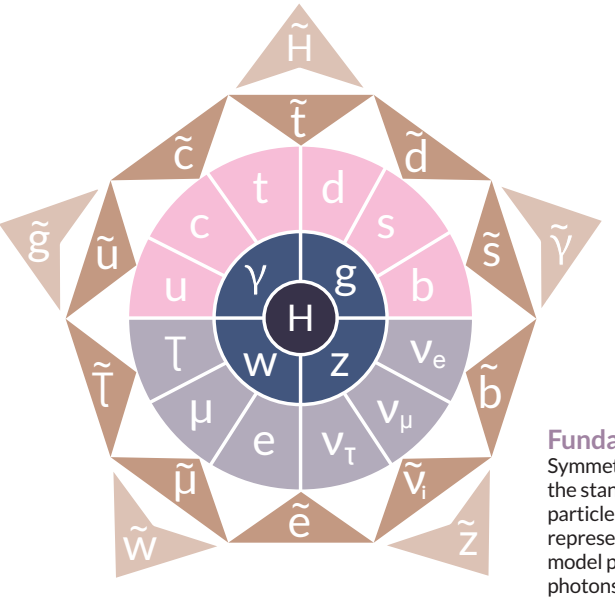
On her way to proving the second theorem, Noether proved her first theorem, about the connection between symmetries and conservation laws. She presented both results in a July 23, 1918, lecture to the Göttingen Mathematical Society, and in a paper published in *Göttinger Nachrichten*.

It's not easy to find quotes of Noether reflecting on the significance of her work. Once she made a discovery, she seemed to move on to the next thing. She referred to her own Ph.D. thesis as "crap," or "Mist" in her native German. But Noether recognized that she changed mathematics: "My methods are really methods of working and thinking; this is why they have crept in everywhere anonymously," she wrote to a colleague in 1931.

"Warm like a loaf of bread"

Born in 1882, Noether (her full name was Amalie Emmy Noether) was the daughter of mathematician Max Noether and Ida Amalia Noether. Growing up with three brothers in Erlangen, Germany, young Emmy's mathematical talent was not obvious. However, she was known to solve puzzles that stumped other children.

At the University of Erlangen, where her father taught, women weren't officially allowed as students, though they could audit classes with the permission of the professor. When the rule changed in 1904, Emmy Noether was quick to take advantage. She enrolled and earned her Ph.D. in 1907.



Fundamental order
Symmetries underlie the standard model of particle physics. In this representation, standard model particles, such as photons (γ) and electrons (e), are within the circle. Around the outer edge are hypothetical heavier particles proposed by a theory called supersymmetry.
SOURCE: *PARTICLE FEVER*, 2015

Although Göttingen finally began paying Noether in 1923, she never became a full-fledged professor. Hermann Weyl, a prominent mathematician at the university, said, "I was ashamed to occupy such a preferred position beside her whom I knew to be my superior as a mathematician in many respects."

Noether took these knocks in stride. She was beloved for her buoyant personality. Weyl described her demeanor as "warm like a loaf of bread."

She made a habit of taking long walks in the countryside with her students and colleagues, holding lengthy, math-fueled debates. When legs began to ache, Noether and company would plop down in a meadow and continue chatting. Sometimes she'd take students to her apartment for homemade "pudding à la Noether," conversing until remnants of the dessert had dried on the dishes, according to a 1970 biography, *Emmy Noether 1882–1935*, by mathematical historian Auguste Dick.

When she landed at Bryn Mawr, Noether continued her research and taught classes of

E. OTWELL



Noether's time

In an era when women weren't encouraged in math, Emmy Noether achieved a great deal.

March 23, 1882
She is born in Erlangen, Germany, to mathematician Max Noether and Ida Amalia Noether.

December 13, 1907
She earns her Ph.D. from the University of Erlangen.

April 1915
Noether begins working at the University of Göttingen at the invitation of mathematicians David Hilbert and Felix Klein.

July 23, 1918
She presents her theorems to the Mathematical Society in Göttingen, connecting symmetries and conservation laws.

June 4, 1919
Noether gets permission to teach under her name at Göttingen, where she helps launch abstract algebra.

1923
She finally gets a salary, but is not a full professor.

April 1933
The German government removes Noether from her post at the university.

October 1933
She leaves Germany to become a visiting professor at Bryn Mawr College in Pennsylvania.

April 14, 1935
Noether dies after surgery.

women — a change of pace from her previous students, who were known as "the Noether boys." She also lectured at the Institute for Advanced Study in Princeton, N.J. Her death, less than two years after her 1935 arrival, left the academic community grieving.

Russian mathematician Pavel Aleksandrov called Noether "one of the most captivating human beings I have ever known," and lamented the unfortunate circumstances of her employment. "Emmy Noether's career was full of paradoxes, and will always stand as an example of shocking stagnancy and inability to overcome prejudice," he said in 1935 at a meeting of the Moscow Mathematical Society.

Elusive partners

But Noether's theorems remained relevant, particularly within particle physics. In the minute, enigmatic world of fundamental particles, teasing out what's going on is difficult. "We have to rely on theoretical insight and concepts of beauty and aesthetics and symmetry to make guesses about how things might work," Wilczek says. Noether's theorems are a big help.

In particle physics, the relevant symmetries are hidden kinds known as gauge symmetries. One such symmetry is found in electromagnetism and results in the conservation of electric charge.

Gauge symmetry appears in the definition of electric voltage. A voltage — between two ends of a battery, for example — is the result of a difference in electric potential. The actual value of the electric potential itself doesn't matter, only the difference.

This creates a symmetry in electric potential: Its overall value can be changed without affecting the voltage. This property explains why a bird can sit on a single power line without getting electrocuted, but if it simultaneously touches two wires at different electric potentials — bye-bye, birdie.

In the 1960s and '70s, physicists extended this idea, finding other hidden symmetries associated with conservation laws to develop the standard model of particle physics.

"There's this conceptual link that — once you realize it — you have a hammer and you go in search of nails to use it on," Wilczek says. Anywhere they found a conservation law, physicists looked for a symmetry, and vice versa. The standard model, which Wilczek shared a 2004 Nobel Prize for his role in developing, explains a plethora of particles and their interactions. It is now considered by many physicists to be one of the most successful scientific theories ever, in terms of its ability to precisely predict the results of experiments.

At the Large Hadron Collider, at CERN in Geneva, physicists are still searching for new particles predicted using Noether's insights. A hypothetical hidden symmetry, dubbed supersymmetry because it proposes another level of symmetry in particle physics, posits that each known particle has an elusive heavier partner.

So far, no such particles have been found, despite high hopes for their detection (*SN: 10/1/16, p. 12*). Some physicists are beginning to ask if supersymmetry is correct. Perhaps symmetry can only take physicists so far.

That notion is leaving some physicists in a bit of a lurch: "If that's not going to be your guiding motto all the time — that more symmetry is better — then what will be your guiding motto?" asks mathematical physicist John Baez of the University of California, Riverside.

Holograms get symmetric

Despite such disappointments, symmetry maintains its luster in physics at large. Noether's theorems are essential tools for developing potential theories of quantum gravity, which would unite two disparate theories: general relativity and quantum mechanics. Noether's work helps

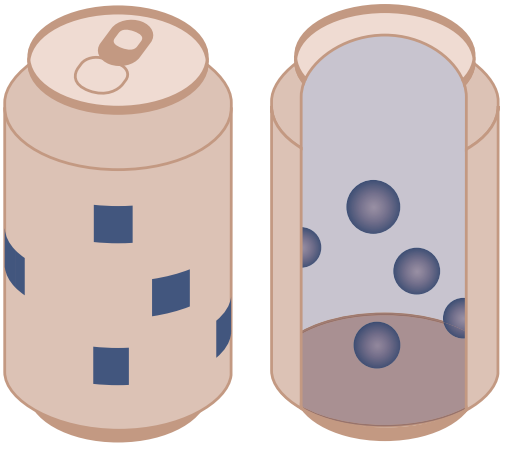
LEFT: WIKIMEDIA COMMONS; CENTER AND RIGHT: PHOTO ARCHIVES/SPECIAL COLLECTIONS DEPARTMENT/BRYN MAWR COLLEGE LIBRARY

scientists understand what kinds of symmetries can appear in such a unified theory.

One candidate relies on a proposed connection between two types of complementary theories: A quantum theory of particles on a two-dimensional surface without gravity can act as a hologram for a three-dimensional theory of quantum gravity in curved spacetime. That means the information contained in the 3-D universe can be imprinted on a surrounding 2-D surface (*SN: 10/17/15, p. 28*).

Picture a soda can with a label that describes the size and location of each bubble inside. The label catalogs how those bubbles merge and pop. A curious researcher could use the behavior of the can's surface to understand goings-on inside the can, for example, calculating what might happen upon shaking it. For physicists, understanding a simpler, 2-D theory can help them comprehend a more complicated mess — namely, quantum gravity — going on inside. (The theory of quantum gravity for which this holographic principle holds is string theory, in which particles are described by wiggling strings.)

"Noether's theorem is a very important part of that story," says theoretical physicist Daniel Harlow of MIT. Symmetries in the 2-D quantum theory show up in the 3-D quantum gravity theory in a different context. In a satisfying twist, Noether's first and second theorems become linked: Noether's first theorem in the 2-D picture makes the same statement as Noether's second theorem in 3-D. It's like taking two sentences, one in Japanese and one in English, and realizing upon translating them that both say the same thing in different ways.



E. OTWELL

Scratch the surface A theory of how particles act in two dimensions can serve as a hologram for quantum gravity in three dimensions. It's like being able to study the bubbles inside a soda can just by reading its label.

New directions for Noether

Everyday physics relies on Noether's theorem as well. The conservation laws it implies help to explain waves on the surface of the ocean and air flowing over an airplane wing.

Simulating such systems helps scientists make predictions — about weather patterns, vibrations of bridges or the effects of a nuclear blast, for example. Noether's theorem doesn't automatically apply in computer simulations, which simplify the world by slicing it up into small chunks of space and time. So programmers have to manually add in conservation laws for energy and momentum.

"They throw away all of the physics, and then they have to try and force it all back in somehow," says mathematician Elizabeth Mansfield of the University of Kent in England. But Mansfield has found new ways to make Noether's theorem apply in simulations. She and colleagues have simulated a person beating a drum inside a simplified Stonehenge, determining how sound waves would wrap around the stone — while automatically conserving energy. Mansfield says her method, which she will present in September in London at a Noether celebration, could eventually be used to create simulations that behave more like the real world.

In addition to Noether's importance in physics, in mathematics her ideas are so prominent that her name has become an adjective. References to Noetherian rings, Noetherian groups and Noetherian modules are sprinkled throughout current mathematical literature.

Noether's work "should have been a wake-up call to society that women could do mathematics," Gregory says. Eventually, society did awaken. In a 2015 lecture she gave about Noether at the Perimeter Institute for Theoretical Physics in Waterloo, Canada, Gregory showed a slide of herself with five female colleagues, then at the center for particle theory at Durham University. While women in science still face challenges, no one in the group had to struggle to get paid for her work. "That is Noether's legacy, and I honestly think she would have been really jazzed," Gregory says. "I think this would have been her real ... vindication." ■

Explore more

- Perimeter Institute for Theoretical Physics. Convergence public lecture. "Emmy Noether: Her life, work and influence." June 21, 2015. bit.ly/LectureonNoether
- Auguste Dick. *Emmy Noether 1882–1935*. Birkhäuser, 1970.

EXPERIENCES

A maze of genealogy results

Commercials abound for DNA testing services that will help you learn where your ancestors came from or connect you with relatives. I've been interested in my family history for a long time. I knew basically where our roots were: the British Isles, Germany and Hungary. But the ads tempted me to dive deeper.

Previous experience taught me that different genetic testing companies can yield different results (*SN: 5/26/18, p. 28*). So I sent my DNA to Living DNA, Family Tree DNA, 23andMe and AncestryDNA. I also bought the National Geographic Geno 2.0 app through the company Helix. Helix read, or sequenced, my DNA, then sent the data to National Geographic to analyze.

These companies analyze natural DNA spelling variations called single nucleotide polymorphisms, or SNPs. To estimate ethnic makeup, a company compares your overall SNP pattern with those of people from around the world. SNP matches also help companies see who in their database you're related to.

Some of the companies also analyze a person's Y chromosome or mitochondrial DNA. Y chromosome DNA traces a man's paternal line. In contrast, mitochondrial DNA traces maternal heritage, since people inherit mitochondria, which generate energy for cells, only from their mothers. Neither type of DNA changes that much over time, so those tests usually can't tell you much about recent ancestors.

Once I sent in DNA samples, my Web-based results arrived in just a few weeks. But my user experience, and results, were quite different for each company. — *Tina Hesman Saey*

National Geographic Geno 2.0

At $199.95, National Geographic's test is the most expensive, yet the least useful. The results are generic, and the ethnicity categories are overly broad. My results say that 45 percent of my heritage came from people living in Southwestern Europe 500 to 10,000 years ago. That doesn't tell me much and doesn't reflect what I know of my family history.

There's no relative matching, though Geno 2.0 shows which historical "geniuses" may have shared your mitochondrial or Y chromosome DNA. I don't know how National Geographic knows about the mitochondria of Petrarch, Copernicus or Abraham Lincoln. So I'm skeptical that I am actually related to those famous figures. The service also calculated the percentage of Neandertal ancestry that I carry. I take geeky pride that 1.5 percent of my DNA comes from Neandertals, topping the 1.3 percent average for Geno 2.0 customers.

Overall, Geno 2.0 has a nice presentation, but I learned more about my family history elsewhere.

Living DNA

Another expensive test ($159) came from Living DNA. When I saw the company's ad claiming to pinpoint exactly where in the British Isles a person's genetic roots stem from, I decided to give it a go. The company highlights ethnicity on a world map, then lets you zoom in from the continent level. I found that 22.5 percent of my heritage came from Lincolnshire in east-central England. I haven't yet traced any ancestors to Lincolnshire, but I did find through much genealogical sleuthing that one of my sixth-great-grandfathers came from

All in the family A variety of consumer genetic testing companies offer ancestry testing. Here's how five such services compare.

		National Geographic Geno 2.0	Living DNA	Family Tree DNA	23andMe	AncestryDNA
	Cost	$199.95	$159	$79; Y chromosome and mitochondrial DNA analysis costs extra	$99	$99
Services include:	**Ethnicity estimates**	✓	✓	✓	✓	✓
	Relative matching		Coming soon	✓	✓	✓
	Neandertal results	✓			✓	
	Y chromosome analysis	✓	✓	✓	✓	
	Mitochondrial DNA analysis	✓	✓	✓	✓	
	Family tree building			✓		✓
	Pros	Specialized for looking into the deep past	Offers detailed ethnicity estimates for people of British or Irish descent	Incorporates DNA results into family trees	Explains results well	Allows DNA results to be combined with traditional genealogical records
	Cons	Provides no ancestry information within the last 500 years	Can't link relatives to a family tree	Doesn't explain results well; website is hard to navigate	Can't link relatives to a family tree	Provides no information about ancient ancestry

Aberdeen, Scotland. Living DNA says that 3.1 percent of my DNA is from Aberdeenshire. Written narratives on the website provide a history of each reported region.

Using mitochondrial DNA and, if applicable, Y chromosome DNA, the company can trace your maternal and paternal lines back to human origins in Africa and show where and when your particular line probably branched off the original. My "motherline" probably arose in the Near East 19,000 to 26,000 years ago, Living DNA claims, and my ancestors were some of the first people to enter Europe.

I'm not sure the service would be worth the price tag for people whose ancestry doesn't contain a strong British or Irish tilt, though Living DNA says it is working to improve ethnicity estimates in Germany and elsewhere.

Family Tree DNA

The most no-frills of the bunch is Family Tree DNA. For $79, "autosomal" testing looks for genetic variants on all of the chromosomes except the X and Y sex chromosomes. Y chromosome and mitochondrial DNA analysis costs extra.

Family Tree DNA allows a user to build a family tree, incorporating personal DNA tests and matches from the site's relative-matching section. I found more than 2,400 potential relatives. A chromosome viewer lets me see exactly which bit of DNA I have in common with any particular relative. That feature also allows users to trace how they inherited DNA from a shared ancestor. But I found this tool difficult to use.

The website offers little explanation of results. For instance, I was excited to see that my DNA was compared with that of ancient Europeans, including Ötzi the Iceman, who lived 5,300 years ago (*SN: 9/17/16, p. 9*). I did get a breakdown of how different ancient groups contributed to my DNA. But when I saw Ötzi's dot on my ancestry map, it wasn't clear if that meant we share DNA or if the map was merely showing where he lived.

23andMe

23andMe ($99) offers one of the more complete packages of information. Most companies show a map of ethnic heritage. 23andMe does, too, but also presents an interactive diagram of all of a person's chromosomes, indicating which portions carry a particular ethnic ancestry. Because my parents also did 23andMe, I learned that my dad handed me a tiny bit of chromosome 15 that carries western Asian and northern African heritage. Playing with the chromosomes is fun. But I question the accuracy of these results (see Page 14 for more on why ancestry tests may miss the mark).

23andMe presents Neandertal heritage in terms of the number of genetic variants you carry. A family-and-friends scoreboard shows where you stack up. (I top my leaderboard with 296 Neandertal variants, more than what 80 percent of 23andMe customers have.) The report also explains what some of those Neandertal variants do, including ones linked to back hair, straight hair, height and whether you're likely to sneeze after eating dark chocolate.

Science News reporter Tina Hesman Saey tried out several consumer genetic testing companies to learn more about her ancestry.

Like Geno 2.0, 23andMe uses mitochondrial and Y chromosome DNA to trace the migration patterns of a person's ancestors, from Africa to the present day.

Relative matching is both interesting and frustrating. I could see the people I match, how we might be related and compare our chromosomes. But 23andMe doesn't provide a way to build family trees to further explore these relationships.

AncestryDNA

AncestryDNA ($99) doesn't give the variety of information other companies do. But it has useful genealogical tools, provided you link your results to a family tree that you can build with help from historical records via a paid subscription to Ancestry.com.

One interesting feature of my heritage report was that it went beyond spots on the map in Europe to also show a region of the United States called "Northeastern States Settlers." A match to that category tells me that my ancestors who came from Europe probably initially settled in New England or around the Great Lakes. They did. One branch of my family tree set roots in Massachusetts in the 1640s. Using birth, death and immigrant records from Ancestry.com, I could build a timeline to show when and from where individual ancestors immigrated to the United States.

AncestryDNA also matches you with relatives, but you can only see how you're related to those people if they have also chosen to make family trees.

Genealogy junkie

Although I've always been interested in family history, DNA testing has gotten me hooked on genealogy research.

23andMe and AncestryDNA were the most fun to use. 23andMe can tell me whether a relative is on my mother's or father's side of the family. But then I have to go back to AncestryDNA and comb through my family tree to learn how we're really connected. DNA can kick-start a genealogy hunt, but combing through marriage certificates, military rolls, census records, immigration documents, old photographs and other records — which Ancestry.com can provide — is what really tells me who my ancestors were. ■

MATTHEW RAKOLA

CONVERSATIONS WITH MAYA

KRISTINA JOHNSON
CHANCELLOR, THE STATE UNIVERSITY OF NEW YORK

Maya Ajmera, President & CEO of Society for Science & the Public and Publisher of *Science News*, sat down to chat with Kristina Johnson, Chancellor of The State University of New York and an alumna of the International Science and Engineering Fair. We are thrilled to share an edited version of their conversation.

You're an alumna of the 1975 International Science and Engineering Fair. How did the competition impact your life and are there any particular moments that still stand out for you?

It was an amazing experience. In 1975, I became fascinated by holograms — I just thought they were magic. Although holograms are everywhere now, at the time they were not that well known. [Note: Johnson's project title was "Holographic Study of the Sporangiophore of *Phycomyces*."]

I ended up building a little lab in our basement and was able to reproduce the lab in my physics classroom at school. That's the year I experienced my first all-nighter. I stayed up all night at my high school the night before the science fair. It was a little controversial to say the least.

My project did well, and it was exciting. As a result, I think competing at ISEF gave me confidence and enthusiasm about science.

At the time, I was really not aware that it was unusual to be a woman in science. It wasn't until I went to college that I realized that it was unusual. That's where doing well at ISEF gave me confidence. When I was told I didn't belong, I could just think back to succeeding at ISEF.

I understand your high school did not have a girls' lacrosse team so you practiced with the boys. At Stanford University, you started a women's lacrosse team that became the varsity team. We still experience a gender gap in a variety of fields, from athletics to engineering. What strategies do you think are working and not working to close the gender gap?

Obviously, the biggest improvement for gender equity in sports was passing Title IX, wherein it became important to open up these opportunities for girls and women. When I got to Stanford, I learned that we didn't have a lacrosse team and thought, well, we should start one. So, we did. Over the course of my nearly eight years at Stanford as an undergraduate and graduate student, it went from being a club sport to a club varsity sport. I think that's maybe part of the answer: Leaders need to take charge when they see an opportunity to build something new. [Note: On the 40th anniversary of Title IX in 2012, Johnson was recognized as a 40 For 40 honoree by espnW and other organizations. The 40 For 40 event honored "women who have made an impact" after participating in high school and college sports.]

When I went into science and engineering at Stanford, I didn't have any science or engineering faculty that were women. I only had two women professors in eight years. Only two, though I had terrific male faculty including my Ph.D. adviser, Joseph Goodman. When I graduated, I did not think that women were professors in science and engineering. I didn't really think too much about it. It just was the way it was. One of the things that I'm not as happy about today is that there hasn't been a significant increase in the number of women pursuing engineering. That needs to change.

Drawing on your experiences as chancellor of the SUNY system, dean of engineering at Duke University, an entrepreneur and a high-level government appointee in the Obama administration, what particular challenges do you think are keeping women in the sciences back?

In the early 1990s, the National Science Foundation did an interesting study that said women will pursue careers in science and engineering and stay in them if they can align their vocation with their avocation to help others.

I think the more that we humanize the field, the more attractive these careers will be to all individuals.

I also think part of it is that when women don't see role models in

STATE UNIVERSITY OF NEW YORK

their classrooms, they don't know they can do it. I'm very passionate about bringing underrepresented minorities and women into the professoriate and the academy so we can inspire a new generation of diverse leaders.

I think part of it really is when you are "other," it is important to feel welcome.

You've reportedly said that there are three things you would never do. One is be a dean, two is start a company and three is write a book. You've done two out of three. I'm curious as to what has motivated you to take different turns in your career.

So, it is true. I did say I never wanted to be a dean. I never wanted to start a company. I didn't want to write a book. I actually haven't written a book yet, but I have a title for a book. I was thinking just yesterday I probably need to write it. So, stay tuned on that one.

I wanted to become a dean because leadership to me is common sense. I felt that if I could make the lives better for my fellow faculty members, that I could have a bigger impact and just make it better for all.

When I was a young professor, we established an engineering research center. I helped cowrite the grant. As part of the grant, there was an expectation that we were going to create a new workforce and new industries. I took that mission very seriously, which led me to leave academia and try to create those new companies, products, processes and a different kind of educated workforce.

Did you enjoy your time as undersecretary of energy at the U.S. Department of Energy?

You know, I did like it. It was a very intense period of time. Maybe it was because we had to invest $37 billion in energy and environment investments from the American Recovery and Reinvestment Act in addition to the broad $11 billion energy and environment portfolio. It was an honor to work for the Department of Energy. Every single individual I worked with was committed. We worked every weekend, every evening, to try and get funding out, so that we could create jobs, put people back to work and lower our greenhouse gas emissions.

Chancellor Kristina Johnson visits the Institute for Advanced Manufacturing at Clinton Community College, a member of The State University of New York system.

STATE UNIVERSITY OF NEW YORK

While you were at Duke you created a fellowship that supported about a third of undergraduates so that they could spend 18 months doing research in labs. Are you thinking of similar things at SUNY, or are there any plans to partner with New York high schools to promote STEM education?

When I was at Duke, I saw that a lot of our engineering students were going to New York to join the financial industry, which is fine. But I thought it also would be great to introduce our students to a broader array of opportunities.

The program, called the Pratt Research Fellows, has students start work in research labs during the spring of their junior year, including the summer and all during their senior year. When those kids graduated, they were going to the financial sector, but they were also going on to graduate schools. It was exciting because they really caught the bug of innovation. So, yes, I'd like to start that at SUNY.

We're also very excited about trying to link SUNY with high schools. One of the exciting things about SUNY is it's the largest comprehensive university system in the country. We have high schools that we charter. We have 30 community colleges. We have 13 comprehensive, unique four-year institutions with master's programs. We have technical-focused two- and four-year schools. Then, we have 14 doctoral-granting degree institutions, including five medical schools and three hospitals.

During my first State of the University System Address, I discussed four themes across our broad intellectual ecosystem. First, innovation and entrepreneurship. The second, individualized education. Third, energy and sustainability, and fourth, partnerships. Creating programs where all of our students are doing research and innovation together — I think that is very exciting.

What advice do you have for young people just starting their higher education or careers?

Get everything you can out of it. I played sports. I "hashed" at the French house to keep up my French. I worked in the labs. When you start in higher ed, it's important to find an area that you can carve out outside the classroom. I recommend that students look up faculty with similar interests and make an appointment and ask to work with the faculty member as an independent study student.

What books are you reading now?

So, there's a book George Packer wrote called *The Unwinding*, which talks about Youngstown when Delphi left and the real estate crash in Tampa. It weaves through these characters that we all know that were living at the time in those communities. *Janesville* by Amy Goldstein is by my bedside along with *Seeing What Others Don't* by Gary Klein. ◆

APRIL 28, 2018 & MAY 12, 2018

Cutting remark

*Archaeologist **Nicholas Blackwell** built a version of a Bronze Age pendulum saw that may have been used to build Mycenaean palaces, **Bruce Bower** reported in "Making the cut"* (SN: 4/28/18 & 5/12/18, p. 32). Reader **Fredric Blum** argued that a pendulum saw's blade would have dulled too fast to completely cut through stone without having to be replaced, making for an impractical saw.

Ancient Mycenaeans could have used the blades along with crushed emery to cut stone, **Blackwell** says. Compared with the sand that **Blackwell** used in his experiment, crushed emery would have embedded in the blade and prevented it from wearing down as fast. But even in his experiment, the blades didn't completely wear down. "I could have made numerous additional cuts with a single blade before it wore away or became unusable," he says.

Blackwell adds that the ancient saws were probably selectively used. "It is not as if the Mycenaeans utilized the pendulum saw to cut every block on the citadel. That would have necessitated the continual switching of saw blades on a scale that is hard to comprehend," he says. Blades would have been changed occasionally, "but not at a rate that would have made the pendulum saw, given its restricted application in Mycenaean architecture and sculpture, unusable or inefficient."

Sticky subject

*Observations of a galaxy cluster called Abell 3827 show that interactions between clumps of dark matter don't force the stuff to abandon stars, as had been previously suggested, **Lisa Grossman** reported in "Dark matter shuns its brethren"* (SN: 4/28/18 & 5/12/18, p. 10).

Grossman "starts by saying that dark matter ignores all other kinds of matter, including itself, and ends by indicating that it sticks with its stars as expected," wrote perplexed reader **Hal Heaton**.

Dark matter doesn't actually stick to any stars, says physicist **Richard Massey** of Durham University in England. Dark matter stays with the stars "in the sense that two cars setting off at the same time from [the same place] and traveling at the same speed stay together," he says. "Neither is pushed out of the way or is slowed down by traffic any more than the other."

Two become one

*Researchers purposefully combined two specific atoms into a molecule for the first time, **Maria Temming** reported in "Using laser tweezers, chemists nudge two atoms to bond"* (SN: 4/28/18 & 5/12/18, p. 24). Reddit user **Praxada** wondered if the technique could make new molecules once thought impossible to exist.

"No, this doesn't allow us to make 'impossible' molecules," says **Lee Liu**, a physicist at Harvard University. "The usual rules of chemical bonding still apply." But the technique does increase the chances of making molecules that would be very unlikely to form under normal circumstances. "In this way, we used tweezer manipulation of single atoms to remove the chance element from chemistry," **Liu** says.

What's in a name?

One observant Science News *reader noticed a peculiar trend in two stories, "Some seals eat like their land ancestors"* (SN: 4/28/18 & 5/12/18, p. 20) *by **Laurel Hamers** and "Earliest known New World dogs ID'd"* (SN: 4/28/18 & 5/12/18, p. 22) *by **Bruce Bower**.*

"A researcher named Fish who studies seals and one named Perri (suspiciously like Spanish *perro*) who studies dogs? I haven't kept track, but it seems like this happens often in your magazine," reader **Henry Jones** wrote. "You're not making this up now, are you?"

"We aren't making it up, we swear!" says associate editor **Cassie Martin**, who fact-checked both stories. Some *SN* staff members have noticed the name trend, too. "We jokingly chalk it up to nominative determinism, a hypothesis that people gravitate to professions that fit their names," **Martin** says. "My favorite example is a paleontologist named Brianna McHorse who studies ancient horses" (*SN: 9/30/17, p. 12*).

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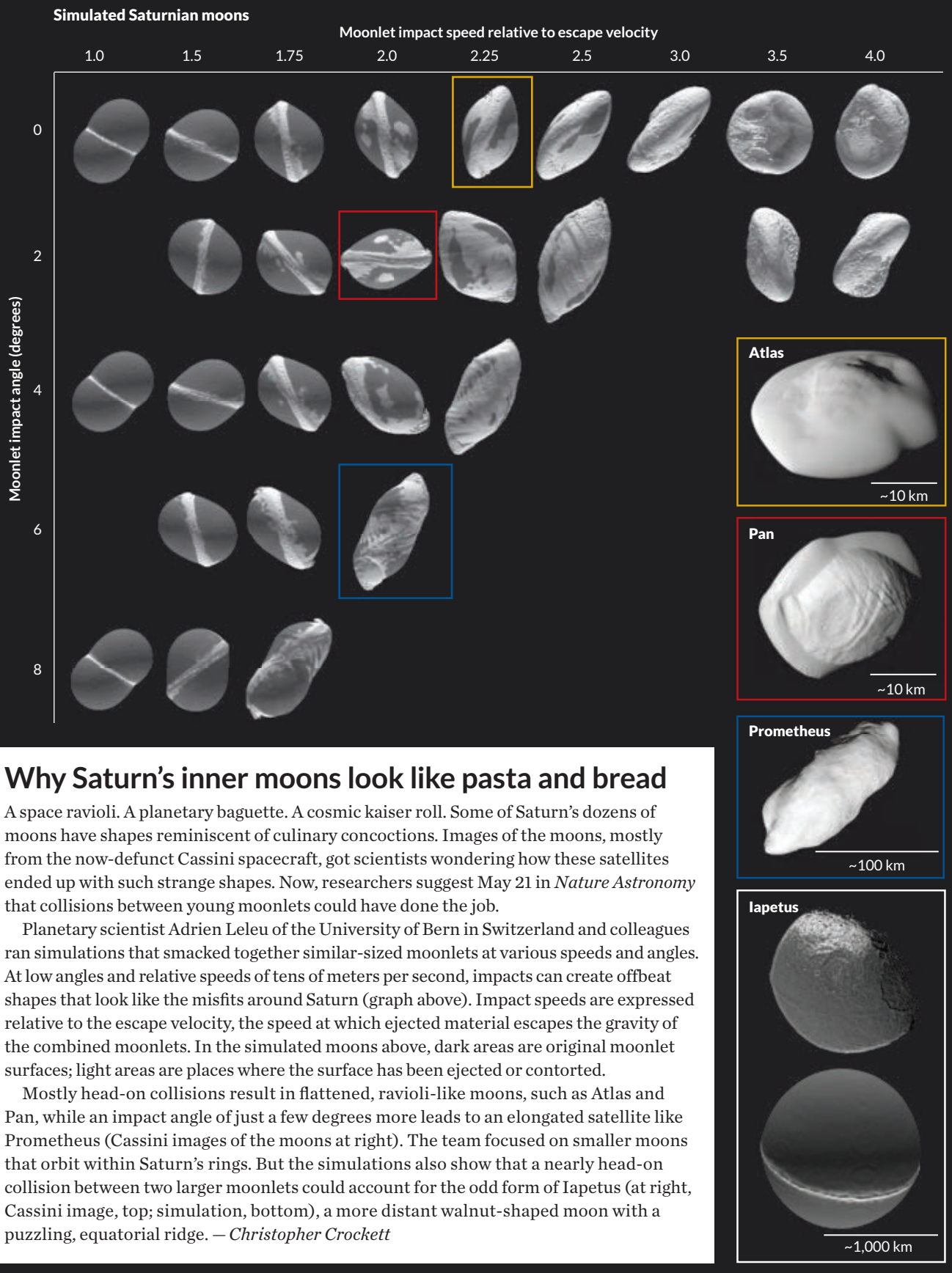

Why Saturn's inner moons look like pasta and bread

A space ravioli. A planetary baguette. A cosmic kaiser roll. Some of Saturn's dozens of moons have shapes reminiscent of culinary concoctions. Images of the moons, mostly from the now-defunct Cassini spacecraft, got scientists wondering how these satellites ended up with such strange shapes. Now, researchers suggest May 21 in *Nature Astronomy* that collisions between young moonlets could have done the job.

Planetary scientist Adrien Leleu of the University of Bern in Switzerland and colleagues ran simulations that smacked together similar-sized moonlets at various speeds and angles. At low angles and relative speeds of tens of meters per second, impacts can create offbeat shapes that look like the misfits around Saturn (graph above). Impact speeds are expressed relative to the escape velocity, the speed at which ejected material escapes the gravity of the combined moonlets. In the simulated moons above, dark areas are original moonlet surfaces; light areas are places where the surface has been ejected or contorted.

Mostly head-on collisions result in flattened, ravioli-like moons, such as Atlas and Pan, while an impact angle of just a few degrees more leads to an elongated satellite like Prometheus (Cassini images of the moons at right). The team focused on smaller moons that orbit within Saturn's rings. But the simulations also show that a nearly head-on collision between two larger moonlets could account for the odd form of Iapetus (at right, Cassini image, top; simulation, bottom), a more distant walnut-shaped moon with a puzzling, equatorial ridge. — *Christopher Crockett*

CASSINI IMAGES: JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE; SIMULATIONS: A. LELEU, M. JUTZI AND M. RUBIN/*NATURE ASTRONOMY* 2018

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