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SOCIETY FOR SCIENCE & THE PUBLIC

AUGUST 4, 2018

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ScienceNews



Features

16 Money's Murky Origins

COVER STORY Currency has ancient and mysterious pedigrees that trace back to more than one place. *By Bruce Bower*

22 Detecting Fake News

Algorithms that expose fake news are needed because there's just too much misinformation online for human fact-checkers to handle.

By Maria Temming

News

6 Astronomers finally pinpoint the source of a high-energy neutrino

7 Hominids' initial forays out of Africa began much earlier than thought

Clovis people were not the first toolmakers in Texas

8 Earth's electric field may cue some spiders to fly

Lab-made embryos could help save endangered northern white rhinos

9 HPV tests outperform Pap smears in screening for cervical cancer

10 Atomic engines take quantum shortcuts to maximize efficiency

Physics toy inspires quantum experiment

12 Foot fossil puts hominid kids upright 3.3 million years ago

Defective diamonds are a quantum internet's best friend

13 Turncoat cancer cells battle tumors

Dinosaur fossils expand story of how some species got so big

14 Some kids are waiting longer than ever in the marshmallow test

15 Virtual reality therapy helps people overcome a fear of heights

Nerve cells identified in mice might offer a way to control appetite



Departments

2 EDITOR'S NOTE

4 NOTEBOOK

Some outwardly male sharks can become pregnant; scientists snap a planet's baby pic

28 REVIEWS & PREVIEWS

Eager says beavers are a boon for the environment

30 FEEDBACK

32 SCIENCE VISUALIZED

See a star nursery shine in a stunning new image

SOCIETY UPDATE

Student's project provides alternative energy source

COVER Before paper bills, people paid debts with shells, cacao beans and textiles, at least in Mesoamerica.
alfexe/iStockphoto





What does fake news look like to you?

Journalists work hard to communicate science to the public, and we use more than words to do it. Visuals are vital tools in our journalistic kit, whether it's a graphic explaining the relationship between two datasets, as in the bar chart on Page 26 on how people share fake news on

social media, or the cover image of a wad of bills that clearly says "money."

I find the conversations we have about how to best illustrate a story endlessly enthralling, and one of the great pleasures of my job. For a feature story, those conversations start weeks, even months, before the story goes to press. A whole bunch of people cram into design director Erin Otwell's tiny office: the writer, features editor Cori Vanchieri, assistant art directors Chang Won Chang and Tracee Tibbitts, chief design officer Stephen Egts, digital director Kate Travis, associate digital editor Helen Thompson and yours truly. Much discussion ensues, whether it's over how best to convey symmetry in the laws of physics (a series of simple illustrations) or how the brain clears out waste while we sleep (a diagram of the flow of cerebrospinal fluid).

The biggest challenges come in explaining a concept; they're also, to my mind, the most rewarding. With this issue's "Detecting fake news" feature by technology writer Maria Temming, the debate continued for days. The article explains why it's hard to tell disinformation from fact on the internet, and how computer scientists are building algorithms to try to make that easier. How would you sum up that notion in a single image? Lying could be Pinocchio, sure, but then how do you convey the news part? And what about the detecting? A magnifying glass; a bloodhound? Illustrator Alex Nabaum e-mailed a series of sketches testing different concepts, all of them fascinating. We'd reply; Nabaum would draw; another series of sketches would pop up in the inbox.

In the end, we decided that his sketch of a polygraph machine with the needles scratching out our headline best fit the concept of the story. You can see the final version on Page 22.

Many artists share my obsession with science. In mid-July, I was fortunate enough to give the opening plenary speech at the 50th anniversary conference of the Guild of Natural Science Illustrators, a national association. Members' visualizations range from the design of the James Webb Space Telescope to the biochemical processes inside a brain to the odd structure of a flamingo's beak. All of this work embraces an essential conundrum of science communication — being accurate while being clear.

Though it's possible to name a few people famous for their depictions of scientific discovery (Leonardo da Vinci comes to mind), illustrators rarely get their due. Their work is usually credited in tiny agate type buried in the margin of a page, not sitting in large type atop the article like writers' bylines.

Yet without art, *Science News* would be a dreary place. And our ability to explain science would be sadly limited. Thank goodness illustrators take brush to paper (or these days, layering vector files in Adobe Illustrator) to help us see things we never could have envisioned without their help.

— Nancy Shute, Editor in Chief

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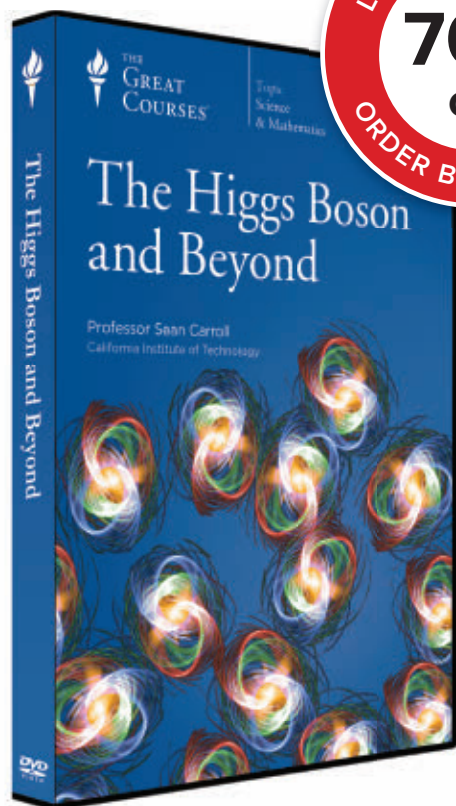
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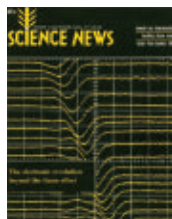
The recent discovery of the Higgs boson was celebrated around the world. The quest to pursue it cost 10 billion dollars; involved years of international collaboration among top physicists, engineers, and other experts; and led to the construction of the single largest and most complex device in the history of mankind. And yet, few people truly understand what the Higgs boson is or why it is so significant.

In *The Higgs Boson and Beyond*, award-winning theoretical physicist Sean Carroll, a brilliant researcher as well as a gifted teacher who excels in explaining scientific concepts to the public, leads you through this thrilling story. He clearly explains the necessary background of the basics of quantum mechanics, the Standard Model of particle physics, and more, helping you realize how the discovery of the Higgs boson validates and deepens our understanding of the universe.

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Excerpt from the
August 3, 1968
issue of *Science News*

50 YEARS AGO

Toward preselected sex

Robert Edwards and Richard Gardner of Cambridge University ... say they have been able to remove rabbit embryos ... then reimplant only the blastocysts destined to develop into the chosen sex. The implications are obvious and enormous. If this procedure could be extended easily to man there might, for instance, be imbalances, even fads, in the selection by parents of one sex of child over another.

UPDATE: Edwards helped pioneer in vitro fertilization, resulting in the first IVF baby in 1978 and a Nobel Prize in physiology or medicine in 2010. He also foresaw technology's potential for sex selection. With no sex selection, about 105 males are born for every 100 females worldwide. But in places where sex selection has been encouraged, through IVF and other methods, changes have resulted. In 1995, China's ratio was 115 boys per 100 girls, according to U.N. estimates. By 2015, men outnumbered women in China by more than 42 million. In 2017, China ended its one-child policy.



Male bigeye houndsharks use external claspers (inset) to impregnate females.

THE SCIENCE LIFE

The curious case of the pregnant male sharks

It's easy to tell a male shark from a female shark. Flip it over. If the shark has a pair of claspers — fingerlike extensions jutting from the end of the pelvic fins — it's male; no claspers means it's female. Like a penis, claspers deliver sperm inside the female.

That was marine biologist Alissa Barnes' understanding until she dissected seven bigeye houndsharks (*Iago omanensis*) with claspers and found a functional female reproductive system in each fish. None of the seven sharks had any internal male sex organs. Six were pregnant. Barnes, of the Dakshin Foundation in Bangalore, India, shared her findings June 25 at the International Marine Conservation Congress

MYSTERY SOLVED

Finally, a way to keep syphilis alive in the lab

For more than a century, scientists had no idea how to grow *Treponema pallidum*, the corkscrew-shaped bacterium that causes syphilis. The stubborn spirochete refused to thrive any place outside of a human or a rabbit for more than 18 days. That narrow window doesn't give researchers much time to study the bacteria.

"I've basically spent my entire career watching these organisms die," says Steven Norris, a microbiologist at the University of Texas Health Science Center at Houston. Until now. Norris and colleagues have cooked up a new recipe that keeps the bacteria alive in the lab for months, the team reports June 26 in *mBio*.

Being able to study syphilis bacteria long-term in a lab dish could lead to better treatments for the millions of people infected worldwide and pave the way for the development of a vaccine to prevent the sexually transmitted disease (*SN: 11/26/16, p. 5*).

The new recipe, adapted from a 1981 method, grew the bacteria for about two weeks, using rabbit epithelial cells. But it needed a secret sauce, a medium that would encourage the bacteria to grow within the rabbit cells. The team tried the kitchen sink approach, testing between 10 and 20 mixes of nutrients and additives. No luck.



Curly syphilis-causing bacteria (shown in a colored micrograph) infect millions of people worldwide.

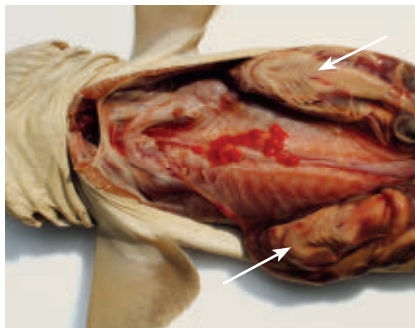
Then, inspiration — from the bacterium that causes Lyme disease — struck. Though *Borrelia burgdorferi* and *T. pallidum* behave differently, they have similar spiral shapes. Maybe they would grow in the same medium. They did. CMRL 1066, a brothy complex of sugars and vitamins favored by the Lyme spirochete, has kept *T. pallidum* bacteria alive for almost eight months, Norris says.

Each week, he gets a thrill as he moves the multiplying bacteria to a fresh batch of the medium. "It's still a surprise to us that the organisms are growing." — Leah Rosenbaum

in Kuching, Malaysia.

Barnes stumbled upon these hermaphrodite sharks at a port in Odisha in eastern India in 2017. She was surveying local fishers to see if changes in their practices might explain a decline in hauls of sharks and rays. When she checked what the fishing vessels brought in, Barnes noticed two oddities. Male bigeye houndsharks greatly outnumbered females. And though males of this deepwater species are smaller than females, she saw immature males as large as adult females. Sensing something was amiss, she took some sharks back to her lab for dissection.

“I was amazed,” says Barnes, who admits she squealed during the dissections. Even before opening the fish, she had pressed on the bellies of the “male” sharks and felt the pups inside.



Removing the digestive tract of this hermaphrodite shark, Alissa Barnes found ovaries (red disks) and pups (two shown at arrows). The shark had external male sex organs.

“Hermaphroditism is very uncommon in sharks,” says shark biologist Colin Simpfendorfer of James Cook University in Townsville, Australia. He calls Barnes’ seven hermaphrodite sharks “one of the most unusual cases

we have heard of” and says it’s an obvious developmental anomaly. Scientists can still use claspers to identify male sharks, Simpfendorfer assures.

Barnes’ finding isn’t the first among sharks. A 2005 study in the *Journal of Fish Biology* reported 68 hermaphrodites among 80 longhead catsharks (*Apristurus longicephalus*) from the Pacific and Indian oceans. And surveys in the 1990s of bigeye houndsharks found more than 20 hermaphrodites among more than 60 sharks down the coast from where Barnes found hers.

With these other finds, Barnes is convinced “there is something going on” with the sharks. She suspects it might be pollutants in the water or hormonal changes — human-caused or otherwise — and is keen to find out.

— Yao-Hua Law

SCIENCE STATS

Earth’s rivers are more abundant than thought

All of the world’s rivers and streams together cover more area than Texas.

A new estimate based on global satellite images shows that these waterways squiggle their way across about 773,000 square kilometers of land — or just over half a percent of Earth’s nonglaciated land surface. That’s roughly 44 percent more surface area than previous estimates, researchers report online June 28 in *Science*.

More river surface area means more contact between water and air. So rivers are probably exchanging more carbon dioxide with the atmosphere than assumed — releasing some to the air, carrying some from land to ocean.

— Laurel Hamers

773,000
square kilometers

Estimated global land surface covered by rivers and streams



The Very Large Telescope unveiled a still-forming exoplanet (the bright splotch to the right of its blacked-out star) about 370 light-years away from Earth.

FIRST

Astronomers snap a planet’s first baby pictures

Behold, the sharpest view yet of a planet-in-progress.

New infrared telescope observations reveal an exoplanet that appears to be growing inside the disk of gas and dust around a star about 370 light-years away from Earth. Astronomers have indirectly identified other exoplanet embryos by observing the paths that these young worlds cleared through the dusty disks around their parent stars (*SN Online: 11/6/14*). But pictures released July 2 of exoplanet PDS 70b give the first clear visual of a still-forming exoplanet itself, seen as a bright splotch of light to the side of its host star. This exoplanet-in-the-making, described in a pair of papers accepted to *Astronomy & Astrophysics*, could provide new testing ground for theories of planet formation (*SN: 5/12/18, p. 28*).

Miriam Keppler, an astronomer at the Max Planck Institute for Astronomy in Heidelberg, Germany, and colleagues spotted PDS 70b using the Very Large Telescope in Chile. The exoplanet is a giant, cloudy world about as far from its host star as Uranus is from the sun. The planet could be as cool as 730° Celsius or as hot as 1330° C, and its mass could be anywhere from twice to 17 times that of Jupiter.

PDS 70b has blazed a trail through the disk of planet-making material around its star by packing on the gas and dust in its orbital path. PDS 70b’s position inside this empty track and the young age of its star, just 5.4 million years old, indicate that the planet isn’t finished forming, Keppler says. — Maria Temming

ATOM & COSMOS

Elusive neutrino's homeland found

High-energy particle came from a distant blazar

BY EMILY CONOVER

A zippy little particle has been traced back to its cosmic stomping grounds: a flaring galaxy 4 billion light-years from Earth. The finding solves a cosmic whodunit.

Scientists have long puzzled over the sources of high-energy particles from space, which batter the Earth at energies that can outstrip the world's most advanced particle accelerators. Now, physicists have identified the source of an energetic, lightweight particle called a neutrino. The intergalactic voyager came from a type of bright galactic beacon called a blazar located in the direction of the constellation Orion, scientists report in the July 13 *Science*.

"This is super exciting news," says Angela Olinto, an astrophysicist at the University of Chicago who was not involved with the result. "It's marking the beginning of what we call neutrino astronomy," which uses the nearly massless particles to reveal secrets of cosmic oddities like blazars. While there may be additional sources for high-energy neutrinos, the detection indicates that at least some come from blazars.

The result also suggests that blazars emit energetic particles known as cosmic rays, which are produced in tandem with neutrinos. Until now, nobody had pinpointed a source of high-energy cosmic rays, says astrophysicist Francis Halzen of the University of Wisconsin–Madison, a leader of IceCube, the neutrino observatory that detected the particle.

IceCube, constructed within a cubic kilometer of Antarctic ice, uses thou-

sands of embedded sensors to measure light produced when neutrinos slam into the ice. On September 22, 2017, IceCube detected a neutrino with an energy of nearly 300 trillion electron volts. (For comparison, protons in the Large Hadron Collider near Geneva reach energies of 6.5 trillion electron volts.)

By tracing the neutrino's track backward, scientists zeroed in on a region of sky. Astronomers leapt into action, and telescopes around the world scoured the spot for light that could reveal the particle's source. The Fermi Gamma-ray Space Telescope spotted a flare of gamma rays coming from a blazar called TXS 0506+056, a bright source of light found in the center of a galaxy powered by an enormous black hole that launches a jet of energetic particles in the direction of Earth. Other telescopes observed the blazar's flare in other types of light, including X-rays and radio waves.

High-energy neutrinos with a well-defined incoming direction are rare. IceCube sent scientists only nine reports of such detections in the year and a half before this neutrino was found. This was the first time researchers were lucky enough to also spot the source's light.

Previously, scientists had identified the homes of lower-energy neutrinos: an exploding star (*SN: 2/18/17, p. 24*) and the sun. High-energy neutrinos have been more elusive, though there had been hints of high-energy neutrinos associated with blazar flare-ups (*SN Online: 4/7/16*).

After unmasking the neutrino's source, the IceCube scientists went back to their

data and looked for additional neutrinos that could have come from the blazar. Over seven months starting in September 2014, IceCube saw a neutrino flare, an excess of high-energy neutrinos, from that vicinity, the IceCube team reports in a second paper in the July 13 *Science*.

Blazars are poorly understood, including what kinds of particles they blast out. Because high-energy neutrinos can be produced only in combination with protons, the detection reveals that blazars are also a source of cosmic rays, which consist of protons and atomic nuclei.

Cosmic rays have been detected on Earth at ultrahigh energies, and it has been a mystery what kind of cosmic engine could rev particles up to those extremes. "This may be a clue to their origin," says astrophysicist Floyd Stecker of NASA's Goddard Space Flight Center in Greenbelt, Md. But it's not clear whether blazars can accelerate protons to the very highest energies observed, he says.

In general, cosmic rays leave few clues of their birthplaces: As they travel through space, their trajectories get twisted by magnetic fields, and therefore don't reliably point back to their sources.

Neutrinos, on the other hand, are electrically neutral, which means they are unaffected by magnetic fields, traveling in essentially a straight line from their origins to Earth. Since high-energy cosmic rays and neutrinos are produced together, the particles can help scientists understand cosmic rays as well, Olinto says. "What neutrinos gave us is a way through the fog." ■

The IceCube lab uses sensors embedded in Antarctic ice to detect high-energy neutrinos from sources outside of the Milky Way.



Stone tools push back hominid exodus

China's Shangchen is the oldest archaeological site outside Africa

BY BRUCE BOWER

Members of the human genus, *Homo*, left Africa far earlier than once thought, reaching China by around 2.12 million years ago, a study finds.

Some stone tools unearthed at central China's Shangchen site date to roughly 250,000 years before what was previously the oldest Eurasian evidence of *Homo*, say geologist Zhaoyu Zhu of the Chinese Academy of Sciences in Guangzhou and his colleagues. Toolmakers visited the Chinese spot on and off until as late as 1.26 million years ago, the scientists report online July 12 in *Nature*. No hominid fossils have been found at Shangchen.

Until now, the Dmanisi site in the western Asia nation of Georgia had yielded the oldest hominid remains outside Africa. *Homo erectus* fossils unearthed there date to 1.85 million to 1.77 million years ago (*SN: 11/16/13, p. 6*).

"An early form of *Homo* probably made the Shangchen artifacts, but it's too early to say if that was *H. erectus*," says study coauthor Robin Dennell, an archaeologist at the University of Exeter in England.

After learning how to make stone flakes sharp enough to slice meat off animal carcasses around 2.6 million years ago, African hominids may have had the survival skills to fan out into Asia and reach Shangchen by 2.1 million years ago, Dennell says.

Whatever species made that roughly 7,000-kilometer journey, Shangchen now stands as the oldest hominid site in China by some 400,000 years, says archaeologist Michael Petraglia of the Max Planck Institute for the Science of Human History in Jena, Germany. He did not participate in the research.

Between 2004 and 2017, Zhu's team excavated sediment layers stacked within a 74-meter-long slope in a mountainous part of central China. Digging revealed 96 artifacts that showed no signs of having shifted from their origi-

nal positions after being covered by soil, allowing for reliable dating. Implements included pieces of stone with sharpened edges or pointed tips, as well as chunks of rock with flat surfaces where toolmakers had pounded off cutting tools.

Shangchen lacks volcanic rock that can be used to estimate a site's age. Instead, the researchers identified ancient reversals of Earth's magnetic field recorded in minerals within the Chinese site's sediment. Dates for those geologic events came from published age estimates for ancient reversals of Earth's magnetic field documented at sites in Africa and elsewhere.

A previously dated magnetic reversal

that corresponds to the oldest one at Shangchen dates to at least 1.95 million years ago, not 2.12 million years, says archaeologist and geologist Reid Ferring of the University of North Texas in Denton. Even so, that quibble over dating isn't enough to change Shangchen's status as the oldest known hominid site outside Africa, says Ferring, who has participated in excavations and sediment analyses at Dmanisi.

"The most logical conclusion of this new discovery is that Dmanisi is not the earliest evidence of occupations in Eurasia," he says. Departures from Africa 2 million years ago or earlier must have led to hominids' presence at Dmanisi and Shangchen, he says. Perhaps, like nonhuman carnivores, early *Homo* traveled far and fast simply by trailing prey across the landscape, hunting them and reproducing along the way, Ferring suggests. ■



HUMANS & SOCIETY

Tools deepen debate over the first Americans

People inhabited what's now central Texas several thousand years before hunters from North America's ancient Clovis culture showed up, scientists say.

Excavations at Gault, a site about 64 kilometers north of Austin, produced a range of stone artifacts (some shown above) that date to between about 16,700 and 21,700 years ago, reports a team led by archaeologist Thomas Williams of Texas State University in San Marcos. An analysis of 184 of those finds identified 11 complete and partial spearpoints (including the four smallest artifacts shown above) unlike any others that have been found at ancient American sites, the scientists conclude July 11 in *Science Advances*.

Researchers have long argued about whether people reached North America before the rise of Clovis culture 13,000 years ago. Evidence from the Gault site joins other recent reports of humans venturing deep into North America far earlier (*SN: 6/11/16, p. 8*), which would take Clovis people out of the running for the title of first New World settlers. — Bruce Bower

LIFE & EVOLUTION

Electric field tells spiders it's liftoff time

A breeze alone isn't enough to send arachnids soaring, tests show

BY LAUREL HAMERS

Spiders may lack wings, but they aren't confined to the ground. Under the right conditions, some spider species will climb to a high point, release silk strands to form a parachute and float away on the breeze. Buoyed by air currents, some spiders have been known to drift kilometers above Earth's surface, and even to cross oceans to reach new habitats.

Now, research suggests that air isn't the only force behind this flight, called ballooning. Spiders can sense electrical charges in Earth's atmosphere, and the forces exerted by these charges might be a cue for the arachnids to launch, scientists suggest online July 5 in *Current Biology*. That signal could help explain why spiders' takeoff timing can seem a bit, well, flighty. Some days, arachnids balloon en masse; other days, they remain grounded despite similar weather conditions.

Spiders with atmospheric aspirations need a gentle breeze with speeds below about 11 kilometers per hour, past studies have shown. But those speeds alone shouldn't be strong enough to get some of the larger species of ballooning spiders off the ground, says Erica Morley, a sensory biologist at the University of Bristol in England.

So scientists have long wondered if some other force might be involved: Perhaps electrical charges in Earth's atmosphere push against the threads of airborne spiders' silk streamers to help them stay fanned out in a parachute. These electric charges form an electric

field that attracts or repels other charged objects or particles. The field varies in strength, becoming stronger around objects such as leaves and branches on trees and also fluctuating with meteorological conditions.

In the first experimental test of whether spiders can sense these electric charges, Morley and Bristol colleague Daniel Robert, a sensory biologist, blocked out naturally occurring electric fields in a lab. The pair then created an artificial field mimicking what would-be arthropod aerialists would experience, and placed tiny spiders into that faux field. Even with no breeze, the spiders perched on the tips of their legs, a ballerina-like behavior that precedes ballooning. When the researchers switched off the artificial electric field, the behavior, called the "tiptoe stance," subsided.

Spiders' hairs react to both moving air and an electric field's presence, but differently, Morley and Robert found. Hairs stood on end as long as air was blowing. But they stood on end most dramatically when the electric field was switched on and then gradually deflated to their resting position over about 30 seconds.

The study links the preballooning tiptoeing behavior to the presence of an electric field, but actually taking off might require something more, says Moonsung Cho, an aerodynamics researcher at the Technical University of Berlin. While some spiders in the study did incidentally float away, that liftoff behavior wasn't actually measured. ■

LIFE & EVOLUTION

Scientists make rhino embryos

The feat offers some hope for an endangered subspecies

BY LEAH ROSENBAUM

The nearly extinct northern white rhino may not be completely lost.

For the first time, white rhinoceros embryos have been made in the lab. Scientists injected preserved northern white rhino sperm into eggs of female southern white rhinos, a closely related subspecies. The embryos were incubated until the cells began to differentiate, a stage at which they can be implanted into a surrogate mother, researchers report July 4 in *Nature Communications*.

The feat is "one of the really crucial steps" to eventually producing rhino calves, says study coauthor Jan Stejskal, coordinator of northern white rhino conservation efforts at the Safari Park Dvůr Králové in the Czech Republic. Eventually, researchers hope to implant embryos into female southern white rhinos or hybrid northern-southern white rhinos.

If the technique works, it could provide hope for bringing back a species on the brink of extinction. The last male northern white rhino died in March. Only two females remain, both in captivity in Kenya and unable to reproduce naturally. In comparison, there are more than 20,000 southern white rhinos left.

The scientists used eggs from female southern white rhinos (*Ceratotherium simum simum*) and sperm preserved from two male northern white rhinos (*C. s. cottoni*) before they died. Creating hybrids is a way to save northern white rhino genes, says study coauthor Thomas Hildebrandt, a reproduction biologist at the Leibniz Institute for Zoo and Wildlife Research in Berlin.

Hybrid rhinos, if they are ever born, could serve as more compatible surrogate mothers for an eventual pure northern white rhino embryo since they will share more DNA with the babies. And theoretically, the hybrids could be selectively

Before ballooning into the breeze, spiders adopt the "tiptoe stance" seen here and release silk threads. New research suggests that spiders can sense electric fields and perhaps use them as a cue to balloon.



bred for northern rhino genes, eventually creating a pure northern white rhino—a process that would take many generations and span multiple decades.

In a potentially quicker way to birth a pure northern white rhino, researchers plan to harvest eggs from the two remaining females and combine them with preserved northern white rhino sperm. If successful, a northern white rhino calf could be born within the next three years, Hildebrandt says.

Stem cell technology may play a role in saving the rhinos, too. The team was able to derive pluripotent stem cells, which can turn into any cell in the body including eggs and sperm, from two southern white rhino embryos. There are 12 frozen cell lines from northern white rhinos; six are genetically distinct, which is important for avoiding inbreeding, Hildebrandt

says. Scientists could try to transform these cells into pluripotent stem cells and then into eggs and sperm to make a pure northern white rhino embryo.

Other scientists caution against too much optimism. “Saving a species or a subspecies takes a lot more than the science,” says Terri Roth, an animal reproductive physiologist at the Cincinnati Zoo and Botanical Garden. Africa is in the midst of a rhino-poaching epidemic, she says. In 2007, poachers in South Africa, for example, killed 13 rhinos; in 2017, over 1,000 were killed. Efforts to reestablish the northern white rhino population will need to address this crisis, she says.

Hildebrandt agrees: The northern white rhino isn’t nearly extinct because it failed at evolution. “It failed because it is not bulletproof.” ■

These two female northern white rhinos, seen here at the Ol Pejeta Conservancy in Kenya, are the only living members of their subspecies.



BODY & BRAIN

HPV tests could replace Pap smears

Switch would improve cervical cancer screening, study suggests

BY AIMEE CUNNINGHAM

Evidence continues to grow that screening for human papillomavirus infection bests a Pap test when it comes to catching early signs of cervical cancer.

In a clinical trial of Canadian women, pap tests more often missed warning signs of abnormal cell growth in the cervix than did HPV tests, researchers report in the July 3 *JAMA*. As a result, at the end of a four-year period, researchers found 5.5 new cases of severely abnormal, precancerous cervical cells per 1,000 women who got Pap tests and just 2.3 cases per 1,000 women who got HPV tests.

“We should be moving away from screening with Pap tests toward screening with HPV tests,” says L. Stewart Massad, a gynecologic oncologist at Washington University School of Medicine in St. Louis who wrote a commentary accompanying the study.

Pap tests, in which cells are scraped from the cervix and examined for abnormal growth, are the standard way to screen for cervical cancer. An HPV test,

which removes cells like a Pap test, checks for a viral infection in cervical cells. HPV, the most common sexually transmitted disease in the United States, causes nearly all cervical cancers. After a positive result, doctors then examine the cervix for abnormal cells.

Previous work found that HPV tests lead to increased detection of abnormal cervical cells before they become cancerous compared with Pap tests. A 2009 study reported fewer cases of advanced cervical cancers and fewer deaths among women in India tested for HPV (*SN*: 4/25/09, p. 11). The study supported HPV testing in poorer countries, where cervical cancer screenings aren’t widespread.

The new study suggests that HPV testing could also boost detection rates in countries with well-established screening programs, such as the United States. Since the 1950s, the number of U.S. cervical cancer cases and deaths has plummeted. (The American Cancer Society estimates there will be 13,240 new cases and 4,170 deaths in 2018.) The drop is primarily

due to Pap tests. But the test sometimes misses early signs of cancer.

In the clinical trial, roughly half of about 16,000 Canadian women in an established screening program got the HPV test and the remainder a Pap test. After four years, all got both tests to check for missed cases. For the HPV-negative women, three more cases of abnormal cell growth were discovered after a Pap test. For women whose Pap test didn’t report abnormal cells, 25 additional cases were found after HPV testing.

“When [an] HPV [test] is negative, women are significantly less likely in four years to have anything abnormal,” says study coauthor Gina Ogilvie, a public health physician at BC Women’s Hospital and Health Centre in Vancouver.

A switch to a screening system that starts with an HPV test will require education for patients and doctors. “Some women in their 40s and beyond in decades-long stable relationships may be alarmed to be identified with a new sexually transmitted infection,” which may have been contracted years before, Massad says. It will have to be emphasized that “the goal of cervical screening is to identify and remove HPV-infected cervical tissue from women at high risk.” ■

MATTER & ENERGY

Minuscule machines avoid friction

Quantum shortcuts make tiny engines maximally efficient

BY EMILY CONOVER

To evade friction, try taking a quantum shortcut.

Two teams of physicists are building tiny machines designed to operate with the maximum possible efficiency. According to thermodynamics, there's a limit to the efficiency of machines known as heat engines. These engines, including steam engines and car engines, convert heat into motion or other types of energy (*SN: 3/19/16, p. 18*). But real-world engines never reach that maximum efficiency, and often run well below it, because they lose energy to friction.

Now, quantum experiments are circumventing the limitations imposed by friction using specially designed shortcuts. Physicists Adolfo del Campo and Roberto Serra described two separate experiments June 25 and June 28. Del Campo and colleagues also reported their findings April 27 in *Science Advances*.

The shortcuts are “a kind of quantum lubricant,” says Serra, of the Federal University of ABC in Santo André, Brazil. Similar to the way that oil can decrease friction in a standard engine, these shortcuts eliminate the friction that is present on quantum scales.

Heat engines operate by cycling through a series of steps. For example, a car engine's cylinders execute a sequence that includes intake of fuel and air, compression, combustion, expansion and release of exhaust.

Normally, to avoid friction, it would be necessary to run these steps very slowly. That limitation increases a machine's efficiency but decreases its power, the amount of energy transferred in a given amount of time. “The idea of shortcuts is to have both simultaneously,” says physicist Masahito Ueda of the University of Tokyo, who was not involved with the research.

Del Campo's group reported first steps toward a simple frictionless engine, composed of a cloud of chilled lithium

atoms, which expands and contracts in a way reminiscent of a car engine's piston. To avoid friction, the team carefully controlled the cloud, allowing it to expand slowly at first and then speed up before slowing again. The technique results in frictionless operation.

“In principle, what this allows you is to have the best use of your energy resources,” says del Campo, of the University of Massachusetts Boston. To complete the engine's cycle, his group must also find ways to heat and cool the cloud, which future work will focus on.

Using very different technology based on the energy levels of carbon nuclei in molecules of chloroform, Serra and colleagues created another type of frictionless quantum engine. Thanks to a quantum property called spin, the nuclei are magnetic. When placed in a magnetic field, that results in two possible energy levels for the carbon nuclei — one in which the magnetic pole aligns with the field, and one in which it points in the opposite direction. Instead of a physical expansion and contraction, Serra and colleagues increased and decreased the magnetic field, which changed the separation between energy levels.

When Serra and colleagues operated the engine too quickly, friction drove its efficiency to zero. But by tweaking the oscillations of the magnetic fields applied to the molecules, the researchers eliminated friction and the machine reached an optimal efficiency of around 40 percent, Serra reported. Car engines, for comparison, typically run at around 20 percent efficiency.

Designing shortcuts isn't easy, and the technique works only for quantum systems that can be precisely controlled. The researchers can't yet use the engines for any useful process — any applications are far in the future. But such technology eventually might be harnessed to make efficient miniature refrigerators, for example, to cool quantum computers. ■

MATTER & ENERGY

Classic physics toy goes quantum

Atomic Newton's cradle gives clues to thermal equilibrium

BY EMILY CONOVER

A simple toy is helping scientists understand new details of a mysterious quantum process.

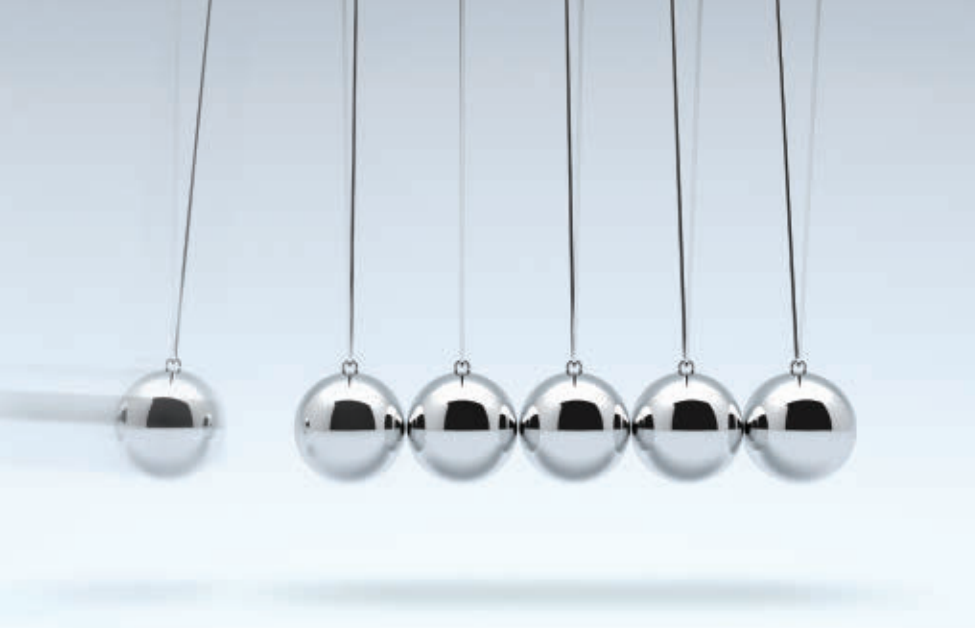
The rhythmic click-clacking of the metal balls in a Newton's cradle has long entertained physics students. Now, scientists have re-created the toy on an atomic scale, using it to probe how quantum systems reach a balanced state known as thermal equilibrium.

Leave a mug of hot coffee on the counter, and it will gradually cool until it reaches thermal equilibrium, matching the temperature of the room. That process, called thermalization, is well understood on the scale of coffee cups. But at the quantum level, thermalization becomes murky.

“This is an area of physics that we fundamentally don't understand,” says Benjamin Lev, a physicist at Stanford University. That lack of understanding of such a basic process means that “it behooves us scientists to investigate,” he says. So he and colleagues studied how introducing chaos into a quantum Newton's cradle paves the way for thermalization. Lev presented the work June 26, and his group published the research May 2 in *Physical Review X*.

A Newton's cradle consists of suspended metal spheres dangling in a row. Pull back one ball on the end and let it fall back to hit its neighbor, and a ball on the other end pops out before swinging back and repeating the process. This regularly repeating motion continues until friction slows the balls' swing.

The quantum version replaces those spheres with a row of chilled, laser-trapped atoms. Lev and colleagues created an array of about 700 such quantum Newton's cradles, each composed of around 50 atoms of the element dysprosium, and kicked them into



Metal spheres in a Newton's cradle swing back and forth rhythmically. The toy has inspired a quantum experiment where atoms replace the balls.

toward thermal equilibrium, then switched to a slower advance.

The result could be important for designing ultrasmall devices and quantum computers, which could perform efficient calculations using quantum mechanics (*SN*: 3/19/16, p. 18; *SN*: 7/8/17, p. 28). “If you want to have a quantum computer, it will be very far off equilibrium,” says Jörg Schmiedmayer, a physicist at Technische Universität Wien in Austria who was not involved with the research. That’s because, in equilibrium, information is lost thanks to the scrambling of particles’ properties.

So understanding how quantum systems reach equilibrium is a rapidly developing topic of study, says Schmiedmayer. “In 20 years... we will have this completely different understanding of the thermodynamics of quantum systems.” ■

motion with a laser.

For the quantum Newton’s cradle to thermalize, all the atoms must be moving randomly — akin to the jiggling molecules in a cup of coffee — instead of in a regular back-and-forth pattern. To achieve that randomness, Lev and colleagues took advantage of the fact that dysprosium atoms are magnetic. In addition to colliding with one another, the

atoms tugged on one another magnetically. That additional interaction introduced chaos that scrambled the atoms’ motions (*SN Online*: 9/16/13).

By changing the orientation of the atoms’ magnetic poles, Lev and colleagues tuned the strength of the magnetic interactions and studied how the system approached equilibrium. At first, the atoms rapidly progressed



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HUMANS & SOCIETY

Kids of Lucy's species walked upright

But hominid youngsters still had grasping toes, foot fossil shows

BY BRUCE BOWER

Walking was afoot long ago among young members of a hominid species best known for Lucy's partial skeleton.

A largely complete, 3.3-million-year-old child's foot from *Australopithecus afarensis* shows that the appendage would have aligned the ankle and knee under the body's center of mass, a crucial design feature for upright walking, scientists report July 4 in *Science Advances*.

"The overall anatomy of this child's foot is strikingly humanlike," says study director Jeremy DeSilva, a paleoanthropologist at Dartmouth College.

But the foot retains some hints of ape-like traits. Compared with children today, for example, the *A. afarensis* child, a roughly 3-year-old female, had toes more capable of holding onto objects or anyone carrying her, the team found. "Young children having some ability to grasp mom could have made a big energetic difference for *Australopithecus afarensis* adults as they traveled," DeSilva says.

Debate about whether *A. afarensis* primarily walked upright or hung out in trees has raged for nearly 40 years. Accumulating lower-body fossils and ancient footprints point to an adept two-legged stride among *A. afarensis* adults. But little was known about whether *A. afarensis* tykes walked early in life or slowly developed a strideworthy stance.

The foot fossil, about the size of an adult human thumb, comes from a skeleton previously excavated at Dikika, Ethiopia (*SN: 9/23/06, p. 195*). DeSilva and colleagues compared bones from the Dikika foot fossil with corresponding bones of humans and other apes. Samples included adults and juveniles.

The researchers discovered that the child's midfoot bones supported a low arch. A key, humanlike bone on the outer side of the child's foot contributed to arch support. Other evidence indicates that a moderately arched foot, typical of people but not other apes, reduces physical stress and lower-leg



A 3.3-million-year-old partial foot fossil indicates that members of the *Australopithecus afarensis* species walked upright early in life.

injuries while walking upright.

But the Dikika child had a surprisingly small, apelike heel bone, DeSilva says. Other fossil finds indicate that *A. afarensis* adults had sturdy heel bones like those of human adults and children. *A. afarensis* heel bones became more robust in response to regular walking throughout childhood, DeSilva suspects.

Walking-related features of the Dikika child's foot highlight the importance of a ground-based lifestyle for Lucy's species, says paleoanthropologist Carol Ward of the University of Missouri in Columbia. "These bones are not entirely human, but all the hallmarks of a humanlike foot seem evident in the arrangement of joints and proportions within the foot." ■

MATH & TECHNOLOGY

Flawed gem stores and sends qubits

Synthetic diamond could help build a quantum internet

BY MARIA TEMMING

A new kind of artificial diamond is a cut above the rest for quantum memory.

Unlike other synthetic diamonds, which can either store quantum information for a long time or transmit it clearly, the new diamond does both. This designer crystal, described in the July 6 *Science*, could be a key building block in a quantum internet. Such a network would allow people to send ultrasecure messages and connect quantum computers globally (*SN: 10/15/16, p. 13*).

A synthetic diamond can serve as

quantum storage thanks to a type of flaw in its carbon lattice: Two neighboring carbon atoms are replaced with a noncarbon atom and an empty space. This pairing has a quantum property known as spin, which can be in an "up" state, a "down" state or both at once. Each state reflects a bit of quantum data, or qubit, that may be 1, 0 or both at once. A diamond transmits qubits by encoding them in photons that travel through fiber-optic cables.

Qubit-storing diamond defects are usually made with nitrogen atoms, which can store data for milliseconds—a relatively long time in the quantum realm. But nitrogen defects can't communicate that data clearly. They emit photons at a broad range of frequencies, which muddles the information written into the photons.

Defects made with silicon atoms emit light more precisely, but until now haven't been able to store qubits for longer

than several nanoseconds due to their electrical interactions with nearby particles, explains electrical engineer Nathalie de Leon of Princeton University.

De Leon and colleagues got around the problem by forging silicon defects in a diamond infused with boron. This extra chemical ingredient shielded the delicate silicon defects from electrical interactions with nearby particles, extending the defects' quantum memory. The boron-infused crystal nearly rivaled the long-term quantum memory of nitrogen defects, storing qubits for about a millisecond. And it emitted about 90 percent of its photons at the exact same frequency—compared to just 3 percent of photons spat out by nitrogen defects.

Tweaking the silicon defects' environment was a creative way to help keep a better grip on qubits, says Evelyn Hu, an applied physicist at Harvard University. ■

GENES & CELLS

Edited cancer cells combat cancer

CRISPR/Cas9 technique shrunk tumors in mice

BY LAUREL HAMERS

Using gene editing, scientists have hoodwinked tumor cells into turning against their own kind.

Cancer cells circulating in the bloodstream have something of a homing instinct, able to return to the tumor where they originated. Researchers engineered these roving tumor cells to secrete a protein that triggers a death switch in resident tumor cells they encounter in mice. These cancer-fighting cancer cells have a built-in suicide switch—they self-destruct before they can start tumors of their own, the team reports in the July 11 *Science Translational Medicine*.

The new study isn't the first attempt to fight cancer with cancer. Previous research has used circulating tumor

cells to deliver cancer-killing viruses to noncirculating tumor cells, for example. But the new approach uses a gene-editing technology called CRISPR/Cas9 to manipulate the offensive-line cancer cells and give them more sophisticated properties, such as the ability to self-destruct.

"The new twist here is the use of CRISPR-based technology to add resistance or sensitivity features to the parental cells," says Renata Pasqualini, a cancer biologist at Rutgers Cancer Institute of New Jersey in Newark.

Getting the technique to work took several steps. First, researchers hunted for a protein that could trigger cell death in many types of cancer cells. The winning candidate, a protein called S-TRAIL, wasn't particularly toxic to healthy cells.

Then, the team tested two different approaches. The first used glioblastoma (a kind of brain cancer) cells that were resistant to the effects of S-TRAIL. Researchers edited genes in these cells to make them produce lots of S-TRAIL, and then set the cells loose on cancer cells that were sensitive to the protein.

In another approach, scientists took glioblastoma cells that were sensitive to S-TRAIL's effects and cut out the genes that impart that sensitivity before giving the cells the genes to produce the protein.

Both kinds of engineered cells made tumors in mice smaller. Mice given the treatments lived longer, too.

Each approach has pros and cons, says study coauthor Khalid Shah, a stem cell researcher at Brigham and Women's Hospital in Boston. In a clinical setting—still a long way off—using cells that aren't yet resistant to S-TRAIL could be "a little bit cumbersome," he says. Although doctors could collect patients' own cancer cells and turn them into a targeted weapon, the wait time for that cellular engineering might make the option a no-go for very sick patients.

The other approach, built with standard cells that are already resistant to S-TRAIL, could be stockpiled in hospitals for quick and easy access. But because those cells would be foreign to a patient, there would be a greater risk that the body would reject them. ■

LIFE & EVOLUTION

Some dinos went big in their own way

Early sauropod relatives offer new insights into gigantism

BY CAROLYN GRAMLING

For sauropods, the largest land animals ever, there may have been more than one way to get gigantic.

Most early relatives of the herbivorous dinosaurs had a suite of features thought to be the essential blueprint for gigantism: sturdy pillarlike legs, elongated necks and forelimbs, and bones that grew continuously rather than in seasonal spurts. But an analysis of fossilized sauropodomorphs—a group that includes sauropods, some ancestors and similarly shaped relatives—suggests that some of the dinos had a different strategy for becoming big, researchers report July 9 in *Nature Ecology and Evolution*.

Paleontologist Cecilia Apaldetti of the Universidad Nacional de San Juan in Argentina and colleagues exam-

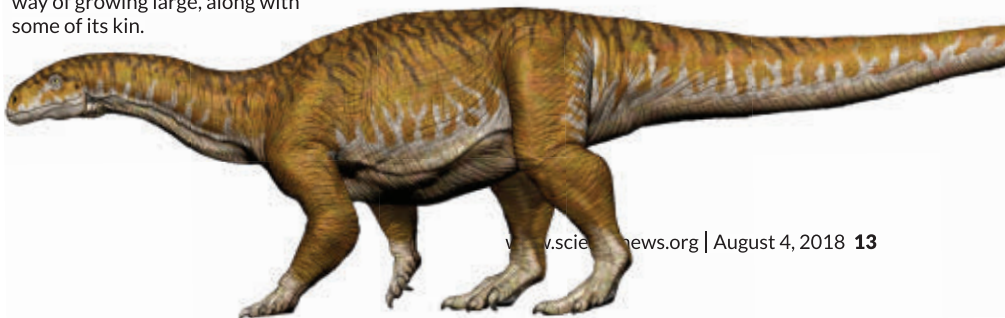
ined four sauropodomorphs, including a newly identified species dubbed *Ingentia prima* and three specimens of a sauropodomorph called *Lessemsaurus sauropoides*. Dating to the Late Triassic between 237 million and 201 million years ago, these Lessemsauridae dinos weighed an estimated seven to 10 metric tons, more than an African elephant.

All four specimens had a combination of features distinct from other

Ingentia prima, which weighed more than an African elephant, may have had a unique way of growing large, along with some of its kin.

sauropodomorphs. The dinos had crouched hind limbs and flexed front limbs, with elbows splayed slightly outward. Patterns of bone growth suggest that the animals "grew in a cyclical but extremely accelerated growth, at a speed even higher than that of the giants that grew continuously," Apaldetti says.

Vertebrate paleontologist Jeffrey Wilson of the University of Michigan in Ann Arbor says the growth may not have been seasonal; there may have been long time lags between growth spurts, part of a transition to sauropod-like growth. "One of the things I think future work will do is help resolve the ambiguity over whether the Lessemsauridae were taking their own adventure into gigantism." ■



HUMANS & SOCIETY

Kids are winning a battle of self-control

White, middle-class children wait longer than they used to

BY BRUCE BOWER

Hold that marshmallow and don't ask for s'more.

Some kids today wait much longer to get an extra treat in the famed marshmallow test than they did in the 1960s or even the '80s. So much for the view that internet-savvy, smartphone-toting tykes want what they want at warp speed.

This willingness to delay gratification has recently bloomed among U.S. preschoolers from predominantly white, middle-class families, say psychologist Stephanie Carlson and colleagues. Youngsters ages 3 to 5 in the 2000s waited an average of two minutes longer during the marshmallow test than children in the '60s did, and a minute longer than '80s kids did, the scientists report online June 25 in *Developmental Psychology*.

Reasons for kids' rising patience are unclear. Carlson's team offers several possible explanations, including increases in the abilities to think abstractly, pay attention, plan and prioritize. Those increases have been linked to preschool attendance and early use of digital technologies.

From the start, the marshmallow test has examined kids' willingness to resist an available goody while waiting 10 to 15 minutes to receive double the edible pleasure. Researchers have assumed the test taps into an enduring ability to control oneself, although responses can vary greatly across cultures (*SN*: 8/5/17, p. 13).

"The marshmallow test cannot determine a child's future, but it is a reliable indicator of how well kids can reflect on a challenging situation and come up with strategies to achieve their goal," says Carlson, of the University of Minnesota in Minneapolis. "That may portend well for school and social situations."

But the new findings don't address whether youngsters' willingness to delay gratification in the lab translates into an ability to resist everyday temptations, says study coauthor Walter Mischel of Columbia University, the psychologist who directed the first marshmallow tests in the '60s (*SN*: 11/15/14, p. 28).

In the new study, the team compared data from three groups of 3- to 5-year-olds: 165 kids who did the marshmallow test between 1965 and 1969, 135 who did so between 1985 and 1989, and 540 tested between 2002 and 2012.

The average amount of time kids waited for a treat increased in each generation — from about five minutes in the '60s to six minutes in the '80s and seven minutes in the 2000s. That trend was observed among both boys and girls, younger and older preschoolers, and kids in different parts of the United States.

It's not known if the trend applies to kids from poor and nonwhite families. Previous work suggests that kids on the lower end of the economic scale often choose an immediate but lesser treat

on the test, Carlson says. The behavior may make sense if kids live in unpredictable settings or don't trust adults (*SN*: 11/17/12, p. 10).

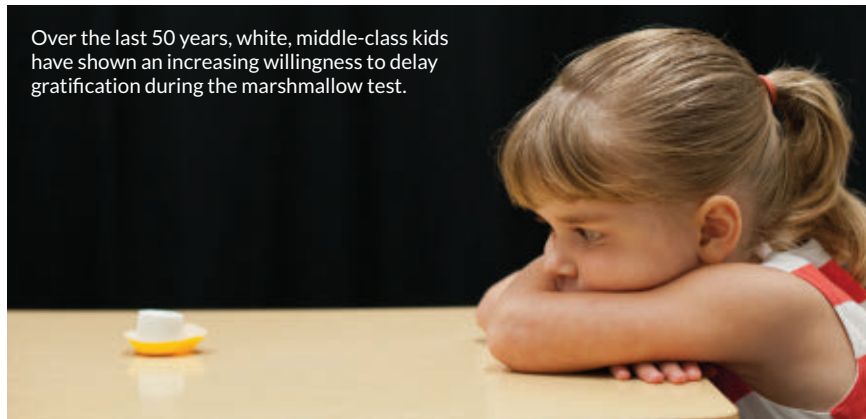
Carlson's findings follow a report, published online May 25 in *Psychological Science*, indicating that long wait times on the marshmallow test are only weakly linked to school success and healthy behavior as a teenager. Studies of kids who initially took the marshmallow test in the '60s had suggested a stronger link (*SN*: 5/27/89, p. 325).

Psychologist Tyler Watts of New York University and colleagues analyzed academic and behavioral data for 918 teens who had taken the marshmallow test in 1995 or 1996 at age 4½. Many of them came from lower-middle-class or poor homes. Kids whose moms had college degrees waited an average of almost 5.4 minutes on the test; children whose moms hadn't graduated from college waited almost four minutes. Little evidence for a link between delaying gratification in childhood and teen achievement appeared after accounting for early verbal and math skills and other mental abilities.

An increasing percentage of mothers have graduated from college in recent years, which could help explain why kids today wait longer on the marshmallow test, says psychologist Terrie Moffitt of Duke University. But it's difficult to compare findings from different marshmallow tests, she says. Kids' willingness to wait for extra treats can change due to unmeasured factors that vary across studies, such as instructions given to children, the test setting and even the size and color of marshmallows, Moffitt holds.

What's striking is that nearly 60 percent of preschoolers tested in the 2000s waited the entire 10-minute delay period, versus almost 40 percent in the '80s and about 30 percent in the '60s, says Duke psychologist Avshalom Caspi. Perhaps performance on the marshmallow test no longer predicts teen achievement because most kids are now waiting the same amount of time for extra treats, he says. If a test doesn't elicit a variety of scores from kids, that test's ability to forecast later behavioral differences suffers. ■

Over the last 50 years, white, middle-class kids have shown an increasing willingness to delay gratification during the marshmallow test.



BODY & BRAIN

Scared of heights? Try virtual therapy

People became less fearful after avatar-led sessions

BY MARIA TEMMING

Therapy patients in the future may spend a lot more time exploring virtual environments than sitting on sofas.

In a clinical trial of a new virtual reality treatment for people with a fear of heights, participants reported being much less afraid after using the program for just two weeks. Unlike other VR therapies, which require a real-life therapist to guide patients, the new system uses an animated avatar. This kind of fully automated counseling system, described online July 11 in the *Lancet Psychiatry*, may make psychological treatments for phobias and other disorders more accessible.

This is “a huge step forward” for therapeutic VR, says Jennifer Hames, a clinical psychologist at the University of Notre Dame in Indiana who wasn’t involved in the study. By bringing therapy out of the counselor’s office and into primary care

clinics — or even people’s homes — the system could help those who aren’t comfortable or don’t have the means to speak with a therapist face-to-face, she says.

Users immerse themselves in this VR program using a headset, handheld controllers and headphones. An animated counselor guides the user through a virtual 10-story office complex, where upper floors overlook a ground-level atrium. On every floor, users perform tasks designed to test fear responses and help them learn that they’re safer than they might think. Tasks start out relatively easy, like standing close to a drop-off where a safety barrier gradually lowers, and progress to more difficult challenges, like riding a moving platform out into the open space over the atrium.

“The person builds up memories that being around heights is safe, and this counteracts the old fear beliefs,” says Daniel Freeman, a clinical psychologist at the University of Oxford.

Freeman and colleagues recruited 100 adults who were moderately to severely afraid of heights. Forty-nine participants used the program for about six half-hour sessions over two weeks. The other participants received no treatment.

Participants filled out a questionnaire



In a virtual reality program, an avatar guides users through activities (like saving a cat from a tree) that help them overcome a fear of heights.

that rated their fear of heights from 16 to 80 (with 80 being most severe), before treatment, immediately afterward and two weeks later. People who underwent treatment dropped about 25 points on average on the questionnaire’s scale. People who got no treatment were stable.

The researchers still need to investigate how VR therapy stacks up against sessions with a therapist, Hames says. And since the team tracked treatment effects for no more than two weeks after the experiment, it’s not known how long the effects last, though previous research on therapist-led VR treatments has shown lasting impacts for at least a year.

It’s also not clear how well this type of system could address more complex mental health issues, says Mark Hayward, a clinical psychologist at the University of Sussex in England who wrote a commentary about the study, also in *Lancet Psychiatry*. ■

BODY & BRAIN

New ‘hunger’ neurons found in mice

Targeting similar cells in people could be a way to control appetite

BY LAURA SANDERS

Newly identified nerve cells deep in the brains of mice compel them to eat. Similar cells exist in people, too, and may ultimately represent a new way to target eating disorders and obesity.

These neurons, described in the July 6 *Science*, are not the first discovered to control appetite. But because of the mysterious brain region where they are found and the potential relevance to people, the results “are worth pursuing,” says neurobiologist and physiologist Sabrina Diano of Yale University School of Medicine, who was not involved in the study.

Some neurons in a brain region called

the nucleus tuberalis lateralis, or NTL, malfunction in Huntington’s, Alzheimer’s and other neurodegenerative diseases. Not much is known about the NTL, says study coauthor Yu Fu of the Singapore Bioimaging Consortium, Agency for Science, Technology and Research.

In people, the NTL is a small bump along the bottom edge of the hypothalamus, which regulates eating. Mice weren’t thought to have a similar structure, until Fu and colleagues discovered it by chance.

NTL neurons sprang into action when mice were hungry or when the hunger-signaling hormone ghrelin was present, the team found. When the team arti-

cially activated the cells, mice ate more and gained weight faster than normal mice. When the team killed the neurons, mice didn’t eat as much and gained less weight than mice that had the cells.

Alzheimer’s and Huntington’s have been tied to metabolic problems and appetite changes. The demise of appetite-controlling NTL cells may explain why.

If the cells do indeed control appetite in humans, the NTL wouldn’t be working alone. Nearby neurons in and around the hypothalamus play big roles in prodding the body to eat when food is available. High-calorie foods are now often easy to come by. “When suddenly we are faced with food abundance, our bodies simply can’t cope,” Fu says. Tweaking the behavior of these appetite-controlling cells, perhaps with drugs, may one day offer a way to treat obesity or eating disorders. ■

MONEY'S MURKY ORIGINS

From cacao beans to shell beads, currency developed in mysterious ways **By Bruce Bower**

Wherever you go, money talks. And it has for a long time.

Sadly, though, money has been mum about its origins. For such a central element of our lives, money's ancient roots and the reasons for its invention are unclear.

As cryptocurrencies such as Bitcoin multiply into a flock of digital apparitions, researchers are still battling over how and where money came to be. And some draw fascinating parallels between the latest, buzzworthy cryptocurrencies, which require only a virtual wallet, and a type of money developed by one Micronesian island community that wouldn't fit in anyone's wallet, pocket or purse (see Page 18).

When it comes to money's origins, though, conflict reigns. Economists have held one view of money's origins for hundreds of years. But a growing number of anthropologists and archaeologists, holding a revisionist view, say that economists' standard story is bankrupt.

Economists and revisionists alike agree that an object defined as money works in four ways: First, it serves as a means for exchanging goods and services. Currency enables payment of debts. It represents a general measure of value, making it

possible to calculate prices of all sorts of items. And, finally, money can be stored as a wealth reserve.

From there, the two groups split. Mainstream economists assume that bartering of goods and services inspired money's invention. Anthropologists and archaeologists contend that early states invented currency as a means of debt payment.

"Much academic work assumes that [monetary systems] arose in nation-states within the last 200 to 400 years," says sociocultural anthropologist Daniel Souleles of Copenhagen Business School in Frederiksberg. But financialized transactions and debt show up in lots of places much further back in time.

Recent research from the Americas adds new questions to the debate. These investigations suggest that money independently appeared for different reasons and assumed different tangible forms in many parts of the world, starting thousands of years ago.

Debt bet

Since the 1776 publication of Adam Smith's *The Wealth of Nations*, a consensus among economists has held that people's self-interested trading decisions automatically balance supply and demand with little or no need for government involvement. A natural human tendency to barter one product for another, say potatoes for pottery, led to the invention of money in ancient Eurasian states, economists hold.

That well-worn story gets money all wrong, anthropologists and archaeologists say. "Adam Smith based his 'creation myth' of financial systems on ignorance of what actually happened in the past," says archaeologist Robert Rosenswig of the University at Albany in New York.

Early governments created money to pay off public works debts and to collect taxes, Rosenswig contends. Bartering had nothing to do with it. Instead, money grew out of older systems of credit and debt, which anthropologists have documented for more than a century. In small-scale societies, debts concern obligations to others. Among hunter-gatherer and farming groups, for example, daughters given away in marriage create debts that are partially repaid with goods known as bride-wealth. Full repayment requires that the recipient of the first bride provide a bride in return. No cash needed.

Revisionists argue that a transition to a new form of money-friendly debt started at least 5,500 years ago in the agricultural states of Mesopotamia and Egypt. In Mesopotamia, the silver

Pay it forward

~5,500 years ago

First monetary units appear in Mesopotamia and Egypt, mainly to calculate debts.

~4,000 years ago


Eurasian traders seem to use silver chunks of roughly standardized weights as payment.

2,800 to 2,100 years ago

Possible use of cacao, cotton, seashells and salt as currencies by the Izapa city-state in southern Mexico.

~2,600 years ago

Coins appear in the kingdom of Lydia (today's Turkey). Greece, Persia, India and China follow suit.



Painted murals found in a small pyramid at the Classic Maya site of Calakmul depict scenes of people exchanging and consuming goods in what may have been a marketplace. Stylistic details indicate that the images date to nearly 1,400 years ago.

shekel — a lump of metal, not a coin — was a basic monetary measure. Rulers decreed that one shekel's weight in silver was equivalent to a bushel of barley. Shekels of silver, gold and other metals were used in other ancient societies. Precise weights of shekels appear to have varied and are difficult to pin down. Farmers were taxed to support royal lifestyles and public works. What the farmers and other commoners couldn't pay in goods was recorded as debt in shekels. Merchants and tradespeople acquired goods from temple and palace officials on credit.

Mesopotamia-era merchants traveling through Eurasia may have used chunks of silver, measured in roughly standardized shekels, to pay for some transactions. But whether those lumps of silver could settle debts is unknown.

Coins stamped with images of animals or rulers, guaranteeing the metal's value, first appeared in the kingdom of Lydia, in what's now Turkey, around 2,600 years ago. Soon after, cities and states in Greece, Persia, India and China began to strike their own coins. From the start, coins funded armies and wars of conquest. In the process, coins became legal tender for all sorts of transactions. Marketplaces were a result of this system, not its cause, revisionists argue.

David Graeber, an anthropologist at the London School of Economics and Political Science, laid out this alternative view in his 2011 book *Debt: The First 5,000 Years*.

Graeber relied mainly on evidence from African, Asian and European societies. But his book has inspired a growing line of research into money's murky origins in the Americas. Many

~1,400 years ago
Perishable forms of money appear during the Classic Maya heyday.

1,327 years ago
Earliest known depiction of textiles and cacao beans presented as tribute to a Maya king.

~800 years ago
Chumash people on the Channel Islands pay debts to chiefs with currency carved from shells.

~300 years ago
Yap islanders in Micronesia begin quarrying limestone and carving it into massive disks, called rai, used as money.

of those investigators met to discuss their findings in April in Washington, D.C., at the Society for American Archaeology's annual meeting.

Some see Graeber's focus on debt as vital to understanding when and how the ancient Maya and nearby societies transformed goods, such as cacao beans and woven cotton, into currencies. But bartering can't be ruled out as a precursor of perishable payments in those same societies. For now, there are more questions than answers.

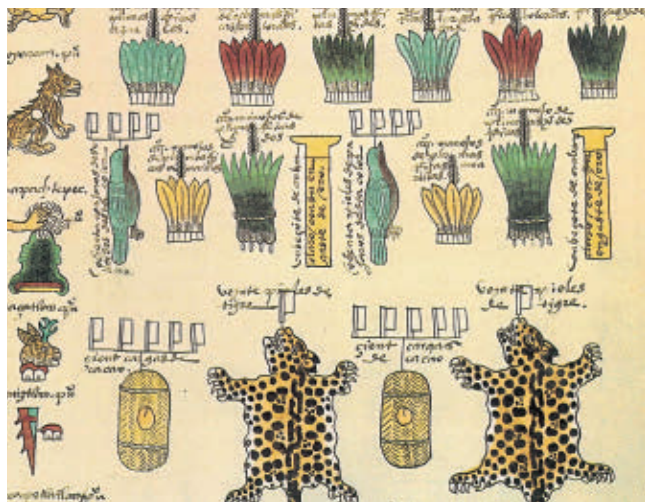
"Debt played a huge role in ancient Central America and Mexico, but it's not clear how currencies emerged there," says anthropological archaeologist Joanne Baron of Bard High School Early College in Newark, N.J.

Maya markets

In the 1500s, Spaniards wrote of observing a thriving system of marketplaces in societies stretching from Mexico to Central America, including the Aztecs and the Maya. Spanish chroniclers described currencies, most prominently cacao beans and woven cloth, that were widely used to buy goods, pay taxes and debts, calculate monetary values and store family wealth.

Researchers have long suspected that Maya marketplaces and merchants plus various goods used as currencies appeared as early as around 1100, after the fall of the Classic Maya civilization's kings and city-states. Evidence now suggests, however, that such perishable forms of money appeared even earlier, during the Classic Maya heyday, from 250 to 900.

Converting various items into legal tender "occurred in ancient America, not just in Europe," says Kathryn Sampeck, an anthropological archaeologist at Illinois State University in Normal. Consider a set of mid-seventh century murals discovered about a decade ago in a small pyramid at Calakmul in Mexico. These scenes illustrate marketplace exchanges at a powerful Classic Maya center that controlled a string of



An Aztec tribute, or tax-collection, list (shown in part) included jade beads, bird feathers, cacao and jaguar pelts. Around 600 years ago, Aztec rulers may have acquired large amounts of cacao and cotton cloth from this region to use as currencies.



Bitcoin: Been there, done that

Digital currencies, such as Bitcoin, and the blockchain technologies used to record digital transactions on a public ledger may not be so revolutionary.

At least several hundred years ago, islanders on Yap in western Micronesia used principles at the heart of cryptocurrencies to conduct business, says archaeologist Scott Fitzpatrick of the University of Oregon in Eugene.

"Stone money transactions on Yap were the precursor to Bitcoin and blockchain technologies," Fitzpatrick says. At April's annual meeting of the Society for American Archaeology in Washington, D.C., he explained the connection between the carved stone disks, some weighing more than a Honda Accord and standing taller than a man, and today's cyber-tokens floating in digital space.

Based on studies of rock sources and dating of sites on Yap and nearby islands, Fitzpatrick thinks that, before European contact in 1783, inhabitants of Yap sailed about 400 kilometers to other islands in Micronesia to quarry limestone from caves and rock-shelters. Sea voyagers negotiated with local leaders for access to limestone deposits.

Stone carvers went along for the ride and formed stone disks on site. A central hole was cut into each circular chunk of rock so men could run a wooden pole through the opening to hoist the rock. These weighty pieces of currency, called rai, were transported to Yap on rafts.

Arriving back home, travelers presented newly



Yap islanders in Micronesia sailed to nearby islands for limestone to carve into huge disks used as money called raï.

acquired raï to their fellow community members at a public gathering. Everyone heard which individuals or clan groups took ownership of particular disks. Each raï was assigned a value based on size, evenness of shape, stone quality and risks taken on the journey. After being inspected and verified by a local chief, raï were displayed at communal spots, such as ritual dancing grounds.

Ownership of a disk could be transferred, for instance, as a wedding gift, to secure political allies or in exchange for food from residents of nearby islands after a severe storm. These deals also occurred in front of the whole community. No matter who acquired a raï, it stayed in its original location.

Bitcoin and blockchain work in much the same way, Fitzpatrick says. Bitcoin “miners” solve complex mathematical puzzles to release units of currency. Those units are transported and securely stored across the public blockchain ledger. Full transaction histories for each bitcoin are available to all network participants. Bitcoins can be exchanged for goods or services or given away at any time by participants in the digital system.

A comparison of stone money on Yap to blockchain technology “is legitimate,” says anthropological archaeologist Kathryn Sampeck of Illinois State University in Normal. Yap islanders pioneered a public, oral system for securely tracking and exchanging raï. Blockchain does the same by maintaining digital histories and updates about units of cryptocurrency.

Others disagree. Researchers such as anthropologist David Graeber of the London School of Economics and Political Science, who view money as the product of government taxation and debt, don’t think Yap disks qualify as currency. For instance, raï can’t be divided into smaller parts to make purchases or easily carried from place to place.

Digital currencies don’t live up to their name either, the same group argues. Bitcoin and its cousins are unregulated exchange units with wildly fluctuating values. That makes these digital creations unlikely to catch on among consumers and tax collectors, critics predict.

The fate of cryptocurrencies is, for now, cryptic. “Not a whole lot of people buy stuff with Bitcoin and the concept of cryptocurrencies is very abstract,” says anthropological archaeologist Joanne Baron of Bard High School Early College in Newark, N.J. Stone money’s future on Yap is also up in the air, Fitzpatrick says. Although rarely exchanged for anything these days and often abandoned in the jungle, raï are now being rescued and renovated by islanders interested in their past. — *Bruce Bower*

Limestone vs. blockchain Archaeologist Scott Fitzpatrick and finance professor Stephen McKeon, both of the University of Oregon in Eugene, see parallels between the public, decentralized way in which limestone money on the island of Yap was valued and distributed and the modern-day blockchain technology used for Bitcoin and other digital currency transactions.

	Bitcoin digital currency	Raï stone money
Mining	A Bitcoin miner solves a complex mathematical puzzle to release units of the cryptocurrency. Blockchain technology verifies the transaction for all those in the network to see.	Yap residents traveled to nearby islands where limestone was mined and carved into circular raï. At home, the miners described each item’s manufacturing history to the community so that everyone knew a raï’s worth.
Storage (custody)	Sets of bitcoins are held in a digital ledger where network participants can check the accuracy of ownership and value claims.	By displaying raï in public places, villagers and others could verify the quality and features of each item.
Peer-to-peer negotiation	This process occurs when a Bitcoin miner receives a digital request for Bitcoins.	A Yapese group worked out a deal with nearby islanders to quarry certain limestone deposits.
Exchange	After verification and placement on the blockchain, Bitcoins can be exchanged between owners or given for various goods and services.	After verification and placement in a public place, raï could be exchanged for various goods and services.
Auditability	Full transaction histories for each Bitcoin are available to all those in a blockchain network.	Oral transaction histories for each raï were available to all community members on Yap.

satellite sites (*SN Online*: 4/17/18). Calakmul's painted pyramid sat in the middle of an open area that included a large marketplace, archaeologists suspect.

Murals on the pyramid's walls depict people of different social classes, as indicated by their clothes and jewelry, apparently exchanging tamales, tobacco and pottery. Several painted scenes show woven cloth of various sizes and colors displayed for exchange. One painting portrays a woman wearing the simple clothes of a villager offering what's probably a mug of hot chocolate to a man in exchange for tamale dough.

Over the next few decades, as Maya rulers demanded cacao and textiles as tribute payments, a kind of tax collection from subjects, the two products became currencies with standard values, Baron argued at the archaeology meeting. A painted vase dating to 691 depicts the earliest known instance of textiles and cacao beans presented as tribute to a king. A sack at a king's feet is labeled "3 pik," which researchers have translated as a term for 24,000 cacao beans.

After 691, painted pottery and carved monuments at other Classic Maya sites increasingly show sacks of cacao beans and cloth bundles in tribute scenes. Royal courts probably stored tribute and used it to pay court members and to buy marketplace goods, Baron says.

Among the Classic Maya, though, bartering may have been a direct forerunner of cacao and cloth currencies, Baron proposed in the March *Journal of Anthropological Archaeology*. In an analysis of archaeological evidence and accounts from

Spanish officials, she concludes that people of all social classes traded fine textiles at Calakmul marketplaces before kings began to collect cloth tributes. At Tikal, Calakmul's rival center, specialized weaving implements found in households from all social ranks indicate that high-quality threadmaking began decades or more before the state built marketplaces and collected cloth tributes, Baron says. Tribute collection from the late 600s into the 700s led to the setting of values for specific sizes and colors of textiles at Calakmul, Tikal and related Maya sites. At the same time, increasing demand among Maya elites for cacao as tribute influenced the emergence of monetary values calculated by cacao bean counts.

"What began as barter items may have become currency for the Classic Maya," Baron says.

State money

Monetary systems probably developed in some populations of southern Mexico and Central America centuries before the dawn of Classic Maya civilization, Albany's Rosenswig proposed at the April meeting. But identifying money's birthplaces in that part of the world is especially tricky, since currencies such as cacao and cloth typically don't preserve at ancient sites, Rosenswig says.

He looks to key evidence from pottery and murals, plus the remains of large palace buildings, public works and written accounts of warfare. Centralized governments and their need to tax subjects and convert valuable goods into currencies to pay for wars and costly construction set the stage for Maya monetary systems, he says. These types of government activities can be documented at archaeological sites.

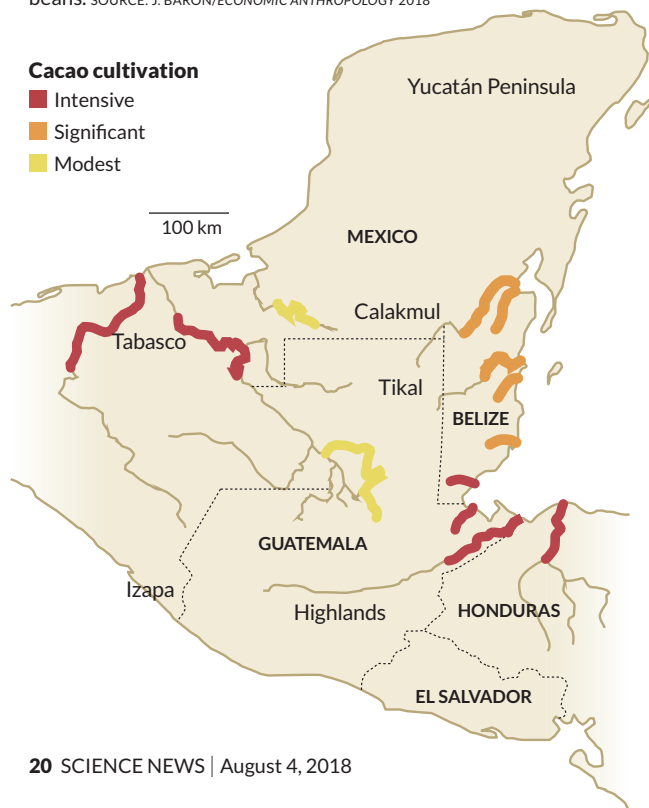
Consider Izapa, one of a network of city-states on the Pacific coast of southern Mexico, Guatemala and El Salvador that rose to prominence between roughly 2,800 and 2,100 years ago. Izapa was situated in a region containing cacao, cotton and other resources. Rulers there apparently commissioned the building of temples and other large structures. Carved monuments show kings committing ritual killings to justify their rule. Kings at Izapa and neighboring sites demanded as tribute large quantities of cacao, cotton and two other items that the Classic Maya may have used later as currencies: *Spondylus* seashells and salt.

"Currencies would have been useful for trade between these closely spaced kingdoms," Rosenswig says.

City-states in ancient Mesoamerica, the region from central Mexico through much of Central America, appear to have created their own monetary systems around the same time as Europeans and Asians started making coins, says anthropological archaeologist Stephen Kowalewski of the University of Georgia in Athens. Kowalewski has conducted a review of what's known about state sizes, political organization and marketplaces where goods were exchanged in ancient Greece and Mesoamerica.

As an increasing number of Maya researchers now believe, Old and New World societies independently created their

Cacao cash Classic-era Maya money grew on trees where conditions allowed. Cacao trees flourished in Tabasco and other places with humid river valleys, heavy rainfall and protection from sun and wind. Maya rulers at Calakmul and Tikal collected annual tributes in cacao beans. SOURCE: J. BARON/ECONOMIC ANTHROPOLOGY 2018



own monetary systems and currencies, he says.

Ancient American societies that circulated perishable currencies didn't enable some individuals and families to accumulate wealth on the scale of the ancient Greeks, perhaps the best known early coin minters, Kowalewski asserted at the archaeology meeting. In the Greek world, individuals could amass and sell land, goods and slaves as private property. That enabled some Greeks to go from humble beginnings to great wealth. In Mesoamerica, farming communities regulated land holdings, especially in places with the most fertile soil, Kowalewski said. That made it harder for individuals other than royalty to become wealthy.

With the flowering of monetary systems, and the amassing of wealth, came slavery. Not everyone agrees that humans forced into bondage were treated as flesh-and-blood units of currency. But archaeologist Scott Hutson of the University of Kentucky in Lexington argued at the April meeting that before Europeans arrived in Mesoamerica, commercial transactions included using enslaved people as human currency.

Classic-era Maya inscriptions, for instance, indicate that war captives could be given to kings as tribute. Some captives were ransomed for cacao and other items considered valuable to Maya royals, including spiky *Spondylus* shells. In central Mexico's Nahua society, part of the Aztec empire around 500 years ago, farming families sometimes sold their children as slaves to the wealthy during hard times. Even when their fortunes improved, Nahua farmers often couldn't acquire enough valuables to buy back their kids.

But slavery was a side operation for Mesoamerican rulers, Kowalewski says. In Greece and other ancient Mediterranean societies, slaves were sold and traded in massive numbers. Scholars estimate that slaves made up around half or more of the population of ancient Greece's Athens city-state. Greek slaves mined silver for coins, farmed the land and even became highly placed civil servants.

Slavery might have bankrolled the earliest forms of democracy and capitalism in the Mediterranean, Kowalewski says.

Shell game

Ancient states in the Mediterranean and Mesoamerica can't explain everything about money's roots, though. Consider the Chumash Indians, who lived more than 2,000 kilometers north of Mesoamerican societies in what's now southern California.

Starting roughly 800 years ago, Chumash groups started paying debts to their chiefs with currency carved from the thick centers of olive-shaped snail shells. A surging demand for mainland goods by increasing numbers of Chumash living on the Channel Islands, located off the California coast, may have stimulated the invention of shell money.

Archaeologist Lynn Gamble of the University of California, Santa Barbara presented a case for that scenario in April.

"Chumash shell money was made in large quantities on the Channel Islands, which lacked many resources available on the mainland," Gamble says. Channel Islanders probably



plunked down currency in exchange for marriage partners as well as various goods, such as bird feathers for ritual outfits, she proposes.

Chumash people used various beads for decoration and trade long before they turned cup-shaped beads into money, Gamble says. Excavations at Chumash sites have unearthed beads made of stone, bone and seashells that date to more than 8,000 years ago. Those beads weren't distributed in large quantities throughout settlements as was typical of later beads used as money, Gamble explains.

Shell money beads appeared much later, she says. At that time, heaps of these shell beads carved in cuplike shapes appear in many households. Shell money was also scattered in Chumash cemeteries and placed in graves. Beads treated as money didn't emerge until Chumash settlements of that time reached populations of 800 to 1,000 people. Groups of that size needed a standard currency to simplify a growing number of economic exchanges, Gamble suspects.

From the beginnings of shell money, Chumash commoners were probably always in debt to chiefs and their assistants, Gamble adds. Spanish accounts from the late 1700s describe feasts organized by Chumash chiefs, where workaday folk were expected to bring food, shell money and other valuables to pay for the event and give to leaders as tribute.

Chumash people primarily bought and sold goods with their marine currency, which coexisted with longstanding trade practices. Once shell money developed a following, it was probably included in debt payments to chiefs, Gamble suspects.

Whether or not Chumash money owes more to economic exchanges than to chiefly debts, an even bigger puzzle remains. Some ancient societies, such as the Inca and earlier empires based in the Andes, kept meticulous accounting records about all sorts of goods and tribute, but had no money. Gamble says researchers don't know why money developed in the Chumash people's relatively simple, hunter-gatherer society and not, say, in the early 16th century Inca state.

In the ancient world, money talked in some places and never uttered a word in others. ■

Explore more

■ David Graeber. *Debt: The First 5,000 Years*. Melville House Publishing, 2011.



Computer programs call out lies on the internet **By Maria Temming**

Scrolling through a news feed often feels like playing Two Truths and a Lie.

Some falsehoods are easy to spot. Like reports that First Lady Melania Trump wanted an exorcist to cleanse the White House of Obama-era demons, or that an Ohio school principal was arrested for defecating in front of a student assembly. In other cases, fiction blends a little too well with fact. Was CNN really raided by the Federal Communications Commission? Did cops actually uncover a meth lab inside an Alabama Walmart? No and no. But anyone scrolling through a slew of stories could easily be fooled.

We live in a golden age of misinformation. On Twitter, falsehoods spread further and faster than the truth (*SN*: 3/31/18, p. 14). In the run-up to the 2016 U.S. presidential election, the most popular bogus articles got more Facebook shares, reactions and comments than the top real news, according to a BuzzFeed News analysis.

Before the internet, “you could not have a person sitting in an attic and generating conspiracy theories at a mass scale,” says Luca de Alfaro, a

computer scientist at the University of California, Santa Cruz. But with today’s social media, peddling lies is all too easy — whether those lies come from outfits like DisinfoMedia, a company that has owned several false news websites, or a scrum of teenagers in Macedonia who raked in the cash by writing popular fake news during the 2016 election.

Most internet users probably aren’t intentionally broadcasting bunk. Information overload and the average Web surfer’s limited attention span aren’t exactly conducive to fact-checking vigilance. Confirmation bias feeds in as well. “When you’re dealing with unfiltered information, it’s likely that people will choose something that conforms to their own thinking, even if that information is false,” says Fabiana Zollo, a computer scientist at Ca’ Foscari University of Venice in Italy who studies how information circulates on social networks.

Intentional or not, sharing misinformation can have serious consequences. Fake news doesn’t just threaten the integrity of elections and erode public trust in real news. It threatens lives. False rumors that spread on WhatsApp, a smartphone messaging



system, for instance, incited lynchings in India this year that left more than a dozen people dead.

To help sort fake news from truth, programmers are building automated systems that judge the veracity of online stories. A computer program might consider certain characteristics of an article or the reception an article gets on social media. Computers that recognize certain warning signs could alert human fact-checkers, who would do the final verification.

Automatic lie-finding tools are “still in their infancy,” says computer scientist Giovanni Luca Ciampaglia of Indiana University Bloomington.

Researchers are exploring which factors most reliably peg fake news. Unfortunately, they have no agreed-upon set of true and false stories to use for testing their tactics. Some programmers rely on established media outlets or state press agencies to determine which stories are true or not, while others draw from lists of reported fake news on social media. So research in this area is something of a free-for-all.

But teams around the world are forging ahead because the internet is a fire hose of information, and asking human fact-checkers to keep up is like aiming that hose at a Brita filter. “It’s sort of mind-numbing,” says Alex Kasprak, a science writer at Snopes, the oldest and largest online fact-checking site, “just the volume of really shoddy stuff that’s out there.”

Substance and style

When it comes to inspecting news content directly, there are two major ways to tell if a story fits the bill for fraudulence: what the author is saying and how the author is saying it.

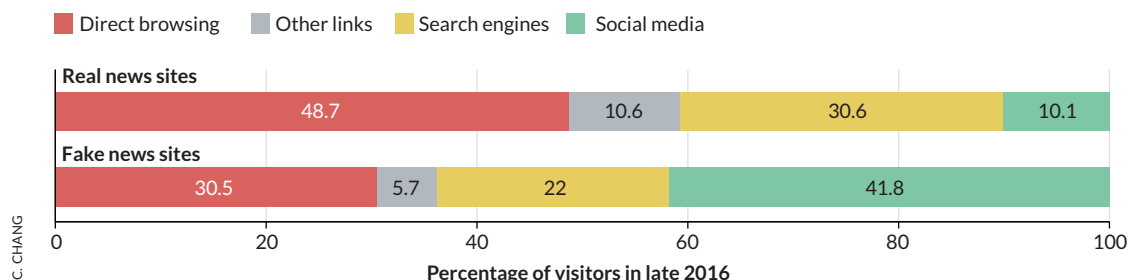
Ciampaglia and colleagues automated this tedious task with a program that checks how closely related a statement’s subject and object are. To do this, the program uses a vast network of nouns built from facts found in the infobox on the right side of every Wikipedia page — although similar networks have been built from other reservoirs of knowledge, like research databases.

In the Ciampaglia group’s noun network, two nouns are connected if one noun appeared in the infobox of another. The fewer degrees of separation between a statement’s subject and object in this network, and the more specific the intermediate words connecting subject and object, the more likely the computer program is to label a statement as true.

Take the false assertion “Barack Obama is a Muslim.” There are seven degrees of separation between “Obama” and “Islam” in the noun

Reader referrals Visitors to real news websites mainly reach those sites directly or from search engine results. Fake news sites attract a much higher share of their incoming web traffic through links on social media.

SOURCE: H. ALLCOTT AND M. GENTZKOW/J. ECON. PERSPECT. 2017



network, including very general nouns, such as “Canada,” that connect to many other words. Given this long, meandering route, the automated fact-checker, described in 2015 in *PLOS ONE*, deemed Obama unlikely to be Muslim.

But estimating the veracity of statements based on this kind of subject-object separation has limits. For instance, the system deemed it likely that former President George W. Bush is married to Laura Bush. Great. It also decided George W. Bush is probably married to Barbara Bush, his mother. Less great. Ciampaglia and colleagues have been working to give their program a more nuanced view of the relationships between nouns in the network.

Verifying every statement in an article isn’t the only way to see if a story passes the smell test. Writing style may be another giveaway. Benjamin Horne and Sibel Adali, computer scientists at Rensselaer Polytechnic Institute in Troy, N.Y., analyzed 75 true articles from media outlets deemed most trustworthy by *Business Insider*, as well as 75 false stories from sites on a blacklist of misleading websites. Compared with real news, false articles tended to be shorter and more repetitive with more adverbs. Fake stories also had fewer quotes, technical words and nouns.

Based on these results, the researchers created a computer program that used the four strongest distinguishing factors of fake news — number of nouns and number of quotes, redundancy and word counts — to judge article veracity. The program, presented at last year’s International Conference on Web and Social Media in Montreal, correctly sorted fake news from true 71 percent of the time (a program that sorted fake news from true at random would show about 50 percent

accuracy). Horne and Adali are looking for additional features to boost accuracy.

Verónica Pérez-Rosas, a computer scientist at the University of Michigan in Ann Arbor, and colleagues compared 240 genuine and 240 made-up articles. Like Horne and Adali, Pérez-Rosas’ team found more adverbs in fake news articles than in real ones. The fake news in this analysis, reported at arXiv.org on August 23, 2017, also tended to use more positive language and express more certainty.

Computers don’t necessarily need humans to tell them which aspects of fake articles give these stories away. Computer scientist and engineer Vagelis Papalexakis of the University of California, Riverside and colleagues built a fake news detector that started by sorting a cache of articles into groups based on how similar the stories were. The researchers didn’t provide explicit instructions on how to assess similarity. Once the program bunched articles according to likeness, the researchers labeled 5 percent of all the articles as factual or false. From this information, the algorithm, described April 24 at arXiv.org, predicted labels for the rest of the unmarked articles. Papalexakis’ team tested this system on almost 32,000 real and 32,000 fake articles shared on Twitter. Fed that little kernel of truth, the program correctly predicted labels for about 69 percent of the other stories.

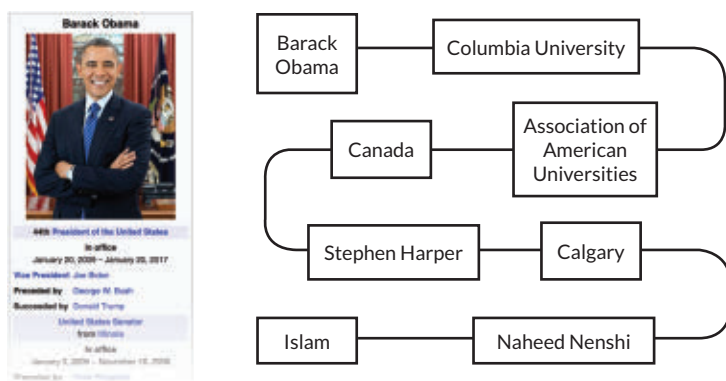
Adult supervision

Getting it right about 70 percent of the time isn’t nearly accurate enough to trust news-vetting programs on their own. But fake news detectors could offer a proceed-with-caution alert when a user opens a suspicious story in a Web browser, similar to the alert that appears when you’re about to visit a site with no security certificate.

In a similar kind of first step, social media platforms could use misinformation watchdogs to then send to human fact-checkers. Today, Facebook considers feedback from users — like those who post disbelieving comments or report that an article is false — when choosing which stories to fact-check. The company then sends these stories to the professional skeptics at FactCheck.org, PolitiFact or Snopes for verification. But Facebook is open to using other signals to find hoaxes more efficiently, says Facebook spokesperson Lauren Svensson.

No matter how good computers get at finding fake news, these systems shouldn’t totally replace human fact-checkers, Horne says. The final call on

Roundabout route An automated fact-checker judges the assertion “Barack Obama is a Muslim” by studying degrees of separation between the words “Obama” and “Islam” in a noun network built from Wikipedia info. The very loose connection between these two nouns suggests the statement is false. SOURCE: G.L. CIAMPAGLIA ET AL./PLOS ONE 2015



Frequently used words in legitimate news

"think"	"know"	"consider"	Words that express insight
"work"	"class"	"boss"	Work-related words
"not"	"without"	"don't"	Negations
"but"	"instead"	"against"	Words that express differentiation
"percent"	"majority"	"part"	Words that quantify

Frequently used words in fake news

Words that express certainty	"always"	"never"	"proven"
Social words	"talk"	"us"	"friend"
Words that express positive emotions	"happy"	"pretty"	"good"
Words related to cognitive processes	"cause"	"know"	"ought"
Words that focus on the future	"will"	"gonna"	"soon"

Truth and lies A study of hundreds of articles revealed stylistic differences between genuine and made-up news. Real stories contained more language conveying differentiation, whereas faux stories expressed more certainty. SOURCE: V. PÉREZ-ROSAS ET AL/ARXIV.ORG 2017

whether a story is false may require a more nuanced understanding than a computer can provide.

"There's a huge gray scale" of misinformation, says Julio Amador Diaz Lopez, a computer scientist and economist at Imperial College London. That spectrum — which includes truth taken out of context, propaganda and statements that are virtually impossible to verify, such as religious convictions — may be tough for computers to navigate.

Snopes science writer Kasprak imagines that the future of fact-checking will be like computer-assisted audio transcription. First, the automated system hammers out a rough draft of the transcription. But a human still has to review that text for overlooked details like spelling and punctuation errors, or words that the program just got wrong. Similarly, computers could compile lists of suspect articles for people to check, Kasprak says, emphasizing that humans should still get the final say on what's labeled as true.

Eyes on the audience

Even as algorithms get more astute at flagging bogus articles, there's no guarantee that fake news creators won't step up their game to elude detection. If computer programs are designed to be skeptical of stories that are overly positive or express lots of certainty, then con authors could refine their writing styles accordingly.

"Fake news, like a virus, can evolve and update itself," says Daqing Li, a network scientist at Beihang University in Beijing who has studied fake news on Twitter. Fortunately, online news stories can be judged on more than the content of their narratives. And other telltale signs of false news might be much harder to manipulate —

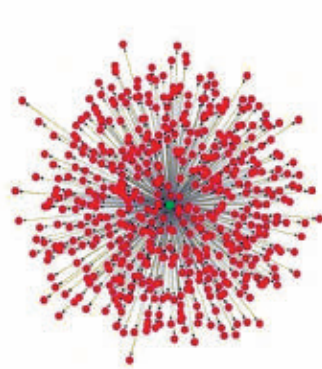
namely, the kinds of audience engagement these stories attract on social media.

Juan Cao, a computer scientist at the Institute of Computing Technology at the Chinese Academy of Sciences in Beijing, found that on China's version of Twitter, Sina Weibo, the specific tweets about a certain piece of news are good indicators for whether a particular story is true. Cao's team built a system that could round up the tweets discussing a particular news event, then sort those posts into two groups: those that expressed support for the story and those that opposed it. The system considered several factors to gauge the credibility of those posts. If, for example, the story centered on a local event that a user was geographically close to, the user's input was seen as more credible than the input of a user farther away. If a user had been dormant for a long time and started posting about a single story, that abnormal behavior counted against the user's credibility. By weighing the ethos of the supporting and the skeptical tweets, the

Branching out

On Twitter, most people reposting (red dots) real news get it from a single, central source (green dot). Fake news spreads more through people reposting from other reposters.

Spread of real news on Twitter



Spread of fake news on Twitter



program decided whether a particular story was likely to be fake.

Cao's group tested this technique on 73 real and 73 fake stories, labeled as such by organizations like China's state-run Xinhua News Agency. The algorithm examined about 50,000 tweets about these stories on Sina Weibo, and recognized fake news correctly about 84 percent of the time. Cao's team described the findings in 2016 in Phoenix at an Association for the Advancement of Artificial Intelligence conference. UC Santa Cruz's de Alfaro and colleagues similarly reported in Macedonia at last year's European Conference on Machine Learning and Principles and Practices of Knowledge Discovery in Databases that hoaxes can be distinguished from real news circulating on Facebook based on which users like these stories.

Rather than looking at who's reacting to an article, a computer could look at how the story is getting passed around on social media. Li and colleagues studied the shapes of repost networks that branched out from news stories on social media. The researchers analyzed repost networks of about 1,700 fake and 500 true news stories on Weibo, as well as about 30 fake and 30 true news networks on Twitter. On both social media sites, Li's team found, most people tended to repost real news straight from a single source, whereas fake news tended to spread more through people reposting from other reposters.

A typical network of real news reposts "looks much more like a star, but the fake news spreads

more like a tree," Li says. This held true even when Li's team ignored news originally posted by well-known, official sources, like news outlets themselves. Reported March 9 at arXiv.org, these findings suggest that computers could use social media engagement as a litmus test for truthfulness, even without putting individual posts under the microscope.

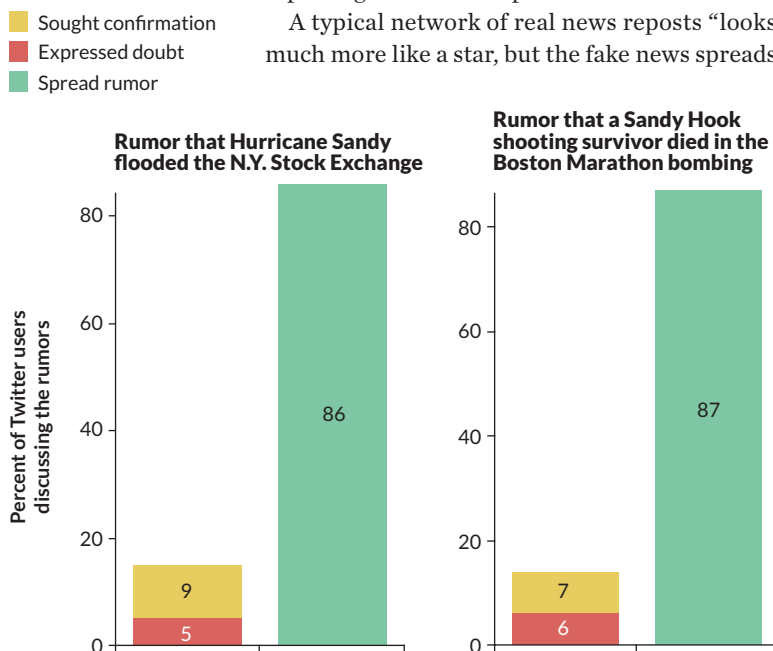
Truth to the people

When misinformation is caught circulating on social networks, how best to deal with it is still an open question. Simply scrubbing bogus articles from news feeds is probably not the way to go. Social media platforms exerting that level of control over what visitors can see "would be like a totalitarian state," says Murphy Choy, a data analyst at SSON Analytics in Singapore. "It's going to become very uncomfortable for all parties involved."

Platforms could put warning signs on misinformation. But labeling stories that have been verified as false may have an unfortunate "implied truth effect." People might put more trust in any stories that aren't explicitly flagged as false, whether they've been checked or not, according to research posted last September on the Social Science Research Network by human behavior researchers Gordon Pennycook, of the University of Regina in Canada, and David Rand at Yale University.

Rather than remove stories, Facebook shows debunked stories lower in users' news feeds, which can cut a false article's future views by 80 percent, company spokesperson Svensson says. Facebook also displays articles that debunk false stories whenever users encounter the related stories — though that technique may backfire. In a study of Facebook users who like and share conspiracy news, Zollo and colleague Walter Quattrociocchi found that after conspiracists interacted with debunking articles, these users actually increased their activity on Facebook conspiracy pages. The researchers reported this finding in June in *Complex Spreading Phenomena in Social Systems*.

There's still a lot of work to be done in teaching computers — and people — to recognize fake news. As the old saying goes: A lie can get halfway around the world before the truth has put on its shoes. But keen-eyed computer algorithms may at least slow down fake stories with some new ankle weights. ■



Sheeples The majority of Twitter users who discussed false rumors about two disasters posted tweets that simply spread these rumors. Only a small fraction posted seeking verification or expressing doubt about the stories. SOURCE: B. WANG AND J. ZHUANG/

NATURAL HAZARDS 2018

Explore more

- K. Shu et al. "Fake news detection on social media: A data mining perspective." arXiv.org. August 7, 2017.



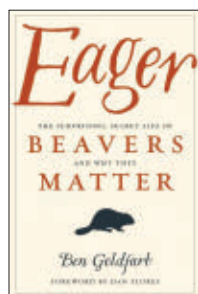
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BOOKSHELF

Beavers to the rescue

Most people probably don't think of beavers until one has chewed through the trunk of a favorite tree or dammed up a nearby creek and flooded a yard or nearby road. Beavers are pests, in this view, on par with other members of the order Rodentia. But a growing number of scientists and citizens are recognizing the merits of these animals, science writer Ben Goldfarb explains in his new

book *Eager*. Beavers are industrious architects, key engineers of healthy ecosystems and a potential solution to a host of environmental problems.

Neither the American beaver, *Castor canadensis*, nor its Eurasian cousin, *C. fiber*, are endangered. But by the 20th century, both species had been wiped out from many parts of their ranges, Goldfarb writes. The animal's luscious, thick fur — with up to 126,000 hairs per stamp-sized patch of skin — was prized by hatmakers. Hunters and trappers killed beavers by the hundreds and thousands for their valuable pelts. To picture the scope of the damage, consider the haul of the Hudson's Bay Company in 1875, its biggest pelt-trading year: The company took in more than 270,000 beaver furs, largely from Canada.

With this level of hunting, whole swaths of continents were left bereft of beavers and their buildings. Beaver dams are more than just stoppages for waterways. "The structures come in an almost limitless range of shapes and sizes, from speed bumps the length of a human stride to a half-mile-long dike, visible from space," Goldfarb writes. The lodges, dams, burrows and other structures offer the animals shelter from predators and weather, as well as storage for food. And the



Returning beavers to areas where the dam builders have disappeared could help with drought, flooding and other environmental problems.

structures turn fast, narrow streams into swamps, wetlands and marshes that host a wide range of wildlife, from fish to insects to birds. These aren't classically pretty ecosystems, but they are incredibly diverse and provide benefits such as water storage and pollution control.

Restoring beavers to landscapes where they've been missing could help with many environmental problems, Goldfarb says. He describes how beavers can help landowners survive drought and flooding, and provide shelter for young salmon and other economically valuable fish. Beaver structures also trap pollutants and excess nutrients before they cause problems downstream, and perhaps even trap extra carbon in sediment and plants and thus help mitigate climate change.

Goldfarb backs up these benefits with a pile of scientific studies. Still, he notes, ranchers, farmers, politicians and others can be hard to convince: When beaver and landowner interests collide, some people are still more likely to grab their guns than call in a beaver control specialist (yes, they exist). In some localities, there are even conflicting policies, some promoting beaver restoration and others encourag-

ing beaver eradication. But despite those challenges, conservation efforts have been successful, and beaver populations are on the rise in many places where the animals had nearly disappeared.

Goldfarb's writing shines with beautiful language and colorful stories — like that time dozens of beavers were air-dropped into Idaho in one of the most successful beaver restoration projects in history. That tale and others make *Eager* an especially pleasant read. The mountains of evidence of beavers' ecological benefits provided within the book's pages just might make a "Beaver Believer" out of you. — Sarah Zielinski

TODO

Bug Fest

AUGUST 11-12

Go on a scientist-led walk, nibble on edible insects and meet an array of creepy-crawlies at this celebration of all things entomological.

ACADEMY OF NATURAL SCIENCES
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Space: An Out-of-Gravity Experience

THROUGH JANUARY 1, 2019

This interactive exhibit invites visitors to experience what life is like on board the International Space Station.

MUSEUM OF SCIENCE, BOSTON

King Tut: Treasures of the Golden Pharaoh

THROUGH JANUARY 6, 2019

At the largest King Tut exhibit ever presented outside of Egypt, see over 150 objects recovered from the pharaoh's tomb (including the nearly 3-meter-tall statue at right).

CALIFORNIA SCIENCE CENTER, LOS ANGELES



Student Innovations

High school student generates electricity using biodegradable resources

Macdonald Chirara

Society for Science & the
Public Community Innovation
Award winner

In Macdonald Chirara's community in Zimbabwe, people often face electricity shortages and they use firewood as a source of energy. This practice can add to increased rates of deforestation and contribute to global climate change. Chirara wants to offer an alternative way to produce electricity for his community.

To solve this problem, he created a biogas digester setup, which converts organic waste into electricity. The technology uses readily available resources such as animal waste and a local invasive plant to produce biogas.

"Biogas has the potential to provide clean renewable energy and to facilitate sustainable development of [an] energy supply for Zimbabwe and Africa at large," Chirara says.

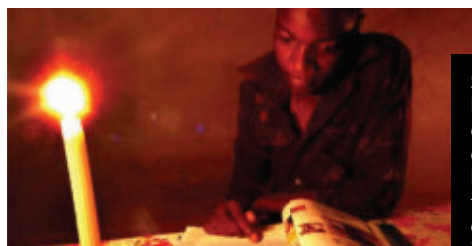
His device measured a maximum of 1.5 volts. "This electricity can be used especially in rural areas, where most households are not yet connected to the national grid, or in urban areas as a backup power source," he says.

His work was selected by his local science fair for recognition with a Society for Science & the Public Community Innovation Award. This award honors students participating in science fairs around the world who are making a difference in their communities. In 2018, the Society rewarded 20 young scientists with \$500 prizes — and Chirara was one of them.

Previous recipients include Madeleine Yang, from Bloomfield, Mich., who produced a more effective influenza vaccine; Shubh Dholakiya, from Rajkot, India, who built an accessible bike for disabled people; and Claire Wayner, from Baltimore, who studied ways to decrease bacteria in stormwater filtration systems.

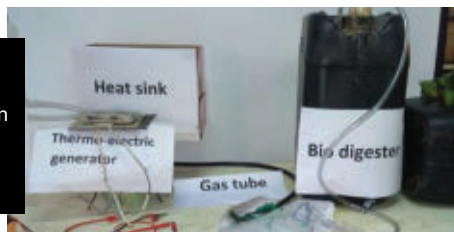


In some rural areas in Africa, people often use firewood as a source of energy. This is contributing to deforestation and climate change.



Students often have to read by candlelight to complete their homework due to a shortage of electricity in Zimbabwe.

Macdonald Chirara's biogas digester setup can convert biogas to cooking oil and electricity.





JUNE 23, 2018

Genetic testing blues

Several companies pledge to tell you your cellular age from a drop of blood, but some scientists have likened such testing to “molecular palm reading,” **Cori Vanchieri** reported in “Telomere testing is not a good age indicator” (SN: 6/23/18, p. 4). These at-home tests measure the length of telomeres, which protect the ends of chromosomes. Online reader **Doug** lamented on the tests’ popularity,

riffing off famous blues guitarist Albert King: “Everybody wants to go to heaven, but nobody wants to die.”



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Hacking it

Fleets of autonomous taxis coordinated by an algorithm could curb traffic congestion and vehicle pollution, **Maria Temming** reported in “Precision choreography among self-driving taxis would ease traffic” (SN: 6/23/18, p. 5).

“And what happens when the system gets hacked?” asked online reader **RME76048**. “Sounds like a primo target for an ambitious hacker.”

A control center for dispatching autonomous taxis would not necessarily be responsible for driving each car in the fleet, says MIT physicist **Moe Vazifteh**. That is, the command center could direct cars to take certain routes, but the car itself would manage its own speed, watch for pedestrians, follow road signs and otherwise navigate safely to its destinations. If the taxi fleet’s dispatch system were compromised, individual cars could reject trip recommendations that they judged to be safety risks, **Vazifteh** says.

Walk this way

Alaskan glaciers retreated in time for the first colonizers of the Americas to possibly use canoes or other sea vessels to travel down the coast, **Bruce Bower** reported in “A coastal route could have led humans into the Americas” (SN: 6/23/18, p. 13). “I have been fascinated by the peopling of the Americas for years and found this one of the best, and ... one of the most logical explanations I have yet read,” reader **Charles P. Van Royen** wrote.

Van Royen agreed that the first people in the Americas may have made their way by boat, but he suggested that they could have simply walked along the shore. “Would love to see an analysis of the extent of those Pacific coast beaches 17,000 years ago, whether they could have been walked all the way down to South America or whether boats would have been helpful in some areas to avoid climbing mountainous terrain,” he wrote. “But, come to think about it, humans have been climbing mountains for thousands of years, so no boat required except maybe to go fishing.”

Noether takes center stage

A century after she published a groundbreaking mathematical theorem, Emmy Noether is finally getting her due, **Emily Conover** reported in “Emmy Noether’s vision” (SN: 6/23/18, p. 20).

Reader **Ravi Gupta** was delighted to learn about Noether. “As a grad student in physics, I recall my mind being blown when we learned in quantum mechanics class that every symmetry comes with a conserved quantity. Unfortunately, our professor never mentioned that this brilliant insight came courtesy of Emmy Noether,” **Gupta** wrote. “Thanks for shining a spotlight on her and educating lay-people and physicists alike!”

Relative geniuses

In “A maze of genealogy results” (SN: 6/23/18, p. 26), **Tina Hesman Saey** reviewed ancestry tests from five different consumer genetic testing companies and reported that her results were all over the map.

Reader **Dixie Luoma** shared her own experience with one of the ancestry tests that **Saey** reviewed, National Geographic Geno 2.0. That test analyzes mitochondrial DNA to tell users which famous people from history, or “geniuses,” they may be related to.

“Like you, I supposedly have a mitochondrial DNA connection to Petrarch, Copernicus and Abraham Lincoln,” **Luoma** wrote. “It would be even more amusing if you were to have also been told that you have genius matches (as I supposedly have) to Queen Victoria, Benjamin Franklin, Marie Antoinette, Napoleon and Maria Theresa.”

Saey says Geno 2.0 also matched her with those historical figures.

“It will be very disappointing if I ultimately discover that the ... results end up with similar ‘Genius’ matches for most of the participants,” **Luoma** wrote. “When I decided to join in the testing, I was hoping for reliable results. Perhaps that point in this type of DNA testing is still well in the future.”

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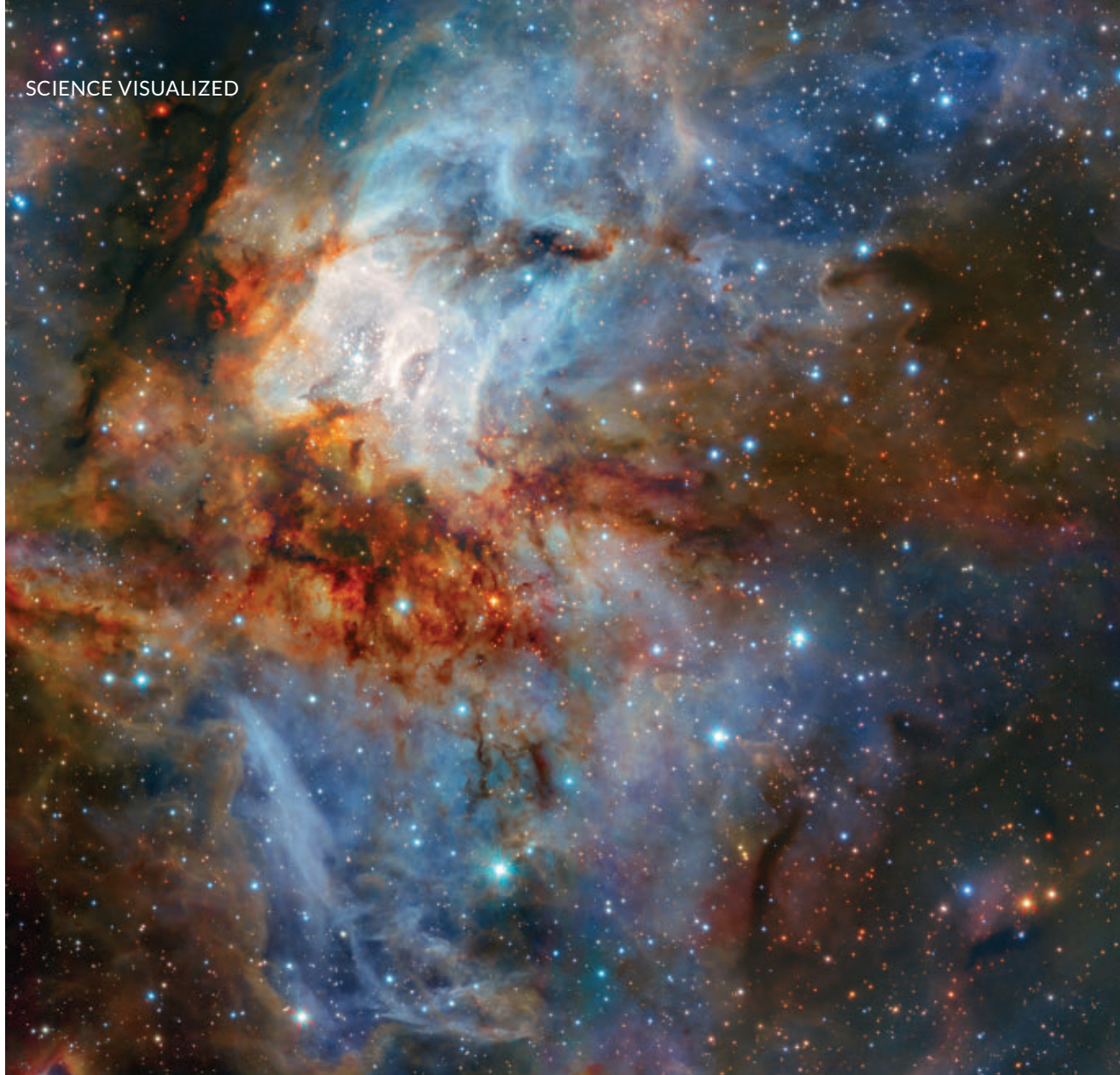
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Starlight, starbright

A new image from the Very Large Telescope in Chile reveals how hundreds of young stars sculpt and illuminate gas and dust in their stellar nursery.

Released July 11 by the European Southern Observatory, the picture (above) shows star cluster RCW 38, which is about 5,500 light-years from Earth toward the constellation Vela, in infrared light. Bright young stars shine in blue; streams of cooler dust glow in red and orange. The stars are so bright and hot that their radiation pushes the dust and gas around them into intricate lacelike webs.

This image was taken while astronomers were testing a new observation system on the Chilean telescope, including an infrared imager called HAWK-I.

Previous pictures of this cluster taken in visible light (one shown at right) are far less detailed, as the dust and gas block starlight. But longer-wavelength infrared light can shine through the fog. — *Lisa Grossman*



FROM TOP: K. MUZIC/ESO; ESO

» GEOLOGIC ROAD TRIP OF THE MONTH

PIPESTONE NATIONAL MONUMENT

Pipestone National Monument, 1.5 miles north of the town of Pipestone, is known as the source of pipestone, valued for at least four hundred years by numerous Native American tribes. They carved pipes from the soft, red, clay-rich rock found here. The pipestone was originally deposited as mud about 1,700 million years ago. The primary layer used for pipestone is a layer of mud several inches thick between beds of quartz sand. The sand has since been cemented into the very hard pink Sioux Quartzite, which was deposited by streams long before there was any vegetation on the land. The heat and pressure of burial has altered the mud to pipestone. The pipestone has been named catlinite in honor of artist and historian George Catlin, who in 1836 described the pipestone quarries and the Native Americans who dug the stone.

Walk the 0.75-mile-long Circle Tour that starts at the visitor center. You will see the quarries, both rock types, a waterfall, and native prairie plants. Many of the rock surfaces are faceted and polished by northwest winds. Pipestone's downtown Historic District includes twenty buildings that are on the National Register of Historic Places, each built of the local quartzite between 1880 and 1900. See a more detailed description of the Sioux Quartzite in the road guide for US 75:Ortonville—Interstate 90.

Along the road into the monument are large granite boulders called the Three Maidens. Seven pieces, including three large ones, were once part of a single large boulder since fractured by frost action. The Native Americans realized that the rock was not local in origin and gave it special spiritual significance. The granite boulder, very unlike the surrounding quartzite, was transported here by glaciers from granite near Millbank, South Dakota, or the Ortonville area, about 90 miles to the north.



*Quarry in Sioux Quartzite at Pipestone National Monument.
The dark red layer at water level is the pipestone.*



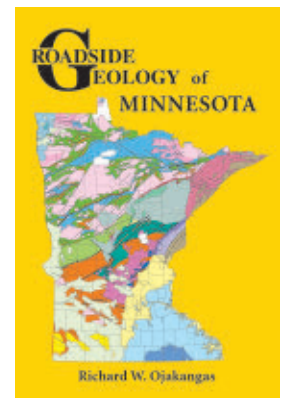
Cross-bedded Sioux Quartzite on a trail at Pipestone National Monument.

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RICHARD W. OJAKANGAS

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