SN
SCIENCE NEWS MAGAZI
SOCIETY FOR SCIENCE & THE
NOVEMBER 25, 2017

Penciling in Gene Edits

Ancient Mosses Reveal Warming

Bronze Age Movers and Shakers

Great Pyramid Hides Great Void

Uneven Terrain

Simulating the universe's lumps may explain its accelerating expansion

"I've gotten many compliments on this watch. The craftsmanship is phenomenal and the watch is simply pleasing to the eye."
—M., Irvine, CA

"GET THIS WATCH."
—M., Wheeling, IL

Back in Black: The New Face of Luxury Watches
"...go black. Dark and handsome remains a classic for a reason"
— Men's Journal

I'll Take Mine Black...No Sugar

In the early 1930s watch manufacturers took a clue from Henry Ford's favorite quote concerning his automobiles, "You can have any color as long as it is black." Black dialed watches became the rage especially with pilots and race drivers. Of course, since the black dial went well with a black tuxedo, the adventurer's black dial watch easily moved from the airplane hangar to dancing at the nightclub. Now, Stauer brings back the "Noire", a design based on an elegant timepiece built in 1936. Black dialed, complex automatics from the 1930s have recently hit new heights at auction. One was sold for in excess of $600,000. We thought that you might like to have an affordable version that will be much more accurate than the original.

27 jewels and hand-assembled parts drive this classic masterpiece.

Basic black with a twist. Not only are the dial, hands and face vintage, but we used a 27-jeweled automatic movement. This is the kind of engineering desired by fine watch collectors world-wide. But since we design this classic movement on state of the art computer-controlled Swiss built machines, the accuracy is excellent. Three interior dials display day, month and date. We have priced the luxurious Stauer ***Noire*** at a price to keep you in the black… only 3 payments of $33. So slip into the back of your black limousine, savor some rich tasting black coffee and look at your wrist knowing that you have some great times on your hands.

An offer that will make you dig out your old tux. The movement of the Stauer ***Noire*** wrist watch carries an extended two year warranty. But first enjoy this handsome timepiece risk-free for 30 days for the extraordinary price of only 3 payments of $33. If you are not thrilled with the quality and rare design, simply send it back for a full refund of the item price. But once you strap on the ***Noire*** you'll want to stay in the black.

Exclusive Offer—Not Available in Stores

Stauer Noire Watch ~~$399†~~
Your Cost With Offer Code **$99** + S&P **Save $300**
OR 3 credit card payments of $33 + S&P

1-800-333-2045

Offer Code: NWT344-06
You must use this offer code to get our special price.

† Special price only for customers using the offer code versus the price on Stauer.com without your offer code.

Stauer®
14101 Southcross Drive W.,
Dept. NWT344-06
Burnsville, Minnesota 55337
www.stauer.com

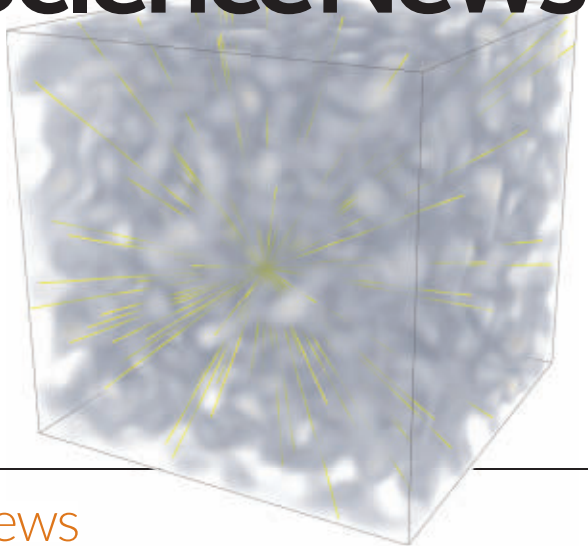
BBB ACCREDITED BUSINESS **Rating of A+**
CONSUMER AFFAIRS ACCREDITED

27-jewel automatic movement • Month, day, date and 24-hour, sun/ moon dials • Luminous markers • Date window at 3' o'clock • Water resistant to 5 ATM • Crocodile embossed leather strap in black fits wrists to 6½"–9"

Stauer...Afford the Extraordinary.™

VOL. 192 | NO. 9

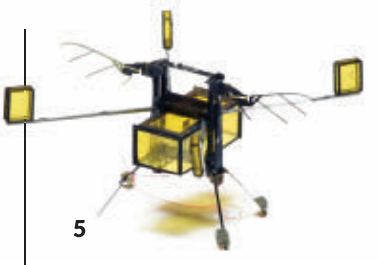
ScienceNews



22

Features

News



5

Departments

SOCIETY UPDATE
Broadcom MASTERS finalists announced

12

COVER Simulations of lumpy universes that consider general relativity (one shown) may shift knowledge of the cosmos. *James Mertens*

CLOCKWISE FROM TOP: JAMES MERTENS; YUFENG CHEN, E. FARRELL HELBLING, HONGQIANG WANG; TIM LAMAN

In science, some big risks are worth the rewards

At the end of my previous Editor's Note (*SN: 11/11/17, p. 2*), I wrote about one of the great discoveries of the 1920s. By studying distant nebulae, Edwin Hubble found that our galaxy is not alone in the universe. Instead, it is one of an amazing multitude of "island universes." When I wrote those words, I had no idea that just a couple of weeks later, I would get to visit the impressive instrument that made Hubble's discovery possible.

On the evening of November 1, I joined many dozens of other astronomy enthusiasts to celebrate the 100th anniversary of the 100-inch Hooker telescope at Mount Wilson Observatory, about an hour drive from Pasadena, Calif. The telescope, named for the Los Angeles businessman who provided initial funding, was the masterwork of solar astronomer George Ellery Hale. At the time, and for more than three decades, it was the largest telescope in the world.

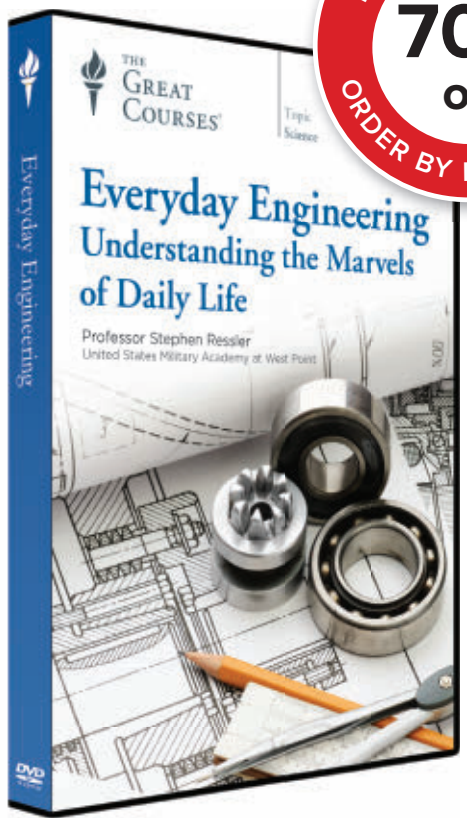
Undertaking such a grand endeavor was risky. No one knew whether a glass disk 100 inches in diameter could be cast with the optical quality required for a telescope mirror. (The mirror ended up with bubbles and swirls. Hale, not knowing whether they'd cause problems, crossed his fingers and proceeded with years of grinding and shaping.) Even as the disk was being prepped, Hale hadn't secured the final funding. Plus, there was the trouble of hauling the mirror, which weighed more than 4 tons, up the mountain, along with the rest of the materials for the telescope and its dome. My own drive proved perilous enough, with some 4,500 feet of elevation gain via nail-biting turns and guardrails too low to offer any comfort.

The poet Alfred Noyes, who was at Mount Wilson on November 1, 1917, when the completed telescope first turned to the sky, later wrote of the scientists: "Where was the gambler that would stake so much,— / Time, patience, treasure, on a single throw? / ... All their youth / Was fuel to the flame of this one work."

In this case, the risk was worth the reward. Not only did Hubble use the telescope to reveal the vast cosmos beyond our galaxy and redefine our universe, but observations with the same telescope also showed that our universe is expanding. Speaking at the anniversary event, John Mulchaey, director of the Carnegie Observatories, called the 100-inch "the most important telescope built in the modern era." Its discoveries launched much of modern astronomy. Now we can ask questions earlier astronomers never thought to ask: Why is the universe expanding? Why is that expansion accelerating? (See Page 10 and Page 22 for more on that topic.) We can probe deeper into the universe's beginning and end.

Success wasn't guaranteed. Big efforts in science don't always pay off. Hypotheses can lead in the wrong direction, and experiments can come up empty. Often researchers are left yearning for more data. We don't, for example, yet know how important a newly discovered void in the Great Pyramid of Giza will be (Page 6) or exactly how gut fungi affect human health (Page 10). Though genetic findings are rewriting the story of nomadic herders, their role in the Bronze Age is still somewhat murky (Page 16). But Hale had the right attitude. He wanted larger telescopes not because of what he knew he would find, but for what he didn't know was out there. — *Elizabeth Quill, Acting Editor in Chief*

THE GREAT COURSES®



Understand the Genius of Everyday Technologies

Great masterpieces of engineering are everywhere. The achievements of everyday engineering are worth admiring for their own sake. They represent some of the most inspired thinking of our civilization, and by looking under the hood to see how these technologies work, you learn about basic scientific principles that have remarkable applications.

Everyday Engineering: Understanding the Marvels of Daily Life is an indispensable guide to the way things work in the world. Conducting this eye-opening tour is Professor Stephen Ressler, an award-winning civil engineer and a nationally honored leader in engineering education. No background in science or engineering is needed to follow this riveting presentation, which gives you deep insight into the complex systems that enhance your life—providing a broad understanding of everyday engineering that you can apply to any technological issue that crosses your path.

Offer expires 12/10/17

THEGREATCOURSES.COM/8SN

1-800-832-2412

Everyday Engineering: Understanding the Marvels of Daily Life

Taught by Professor Stephen Ressler
UNITED STATES MILITARY ACADEMY AT WEST POINT

LECTURE TITLES

1. Engineering and Technology in Your World
2. Your House as an Engineered System
3. Three Structural Systems for Load Bearing
4. Platform-Framed Housing Construction
5. The Building Envelope
6. Site Design and Storm Runoff
7. Dam, Reservoir, and Aqueduct Design
8. Water Treatment and Distribution
9. Wastewater Disposal and Treatment
10. Fossil Fuels: Coal, Oil, and Natural Gas
11. Power Generation from Coal
12. Oil, Gas, and Nuclear Power
13. Renewable Sources of Electricity
14. Electrical Power Transmission: The Grid
15. Electrical Power Distribution
16. Everyday Thermodynamics: Refrigeration
17. Heating, Ventilating, and Air-Conditioning
18. Home Energy Efficiency
19. Passive Solar and Net-Zero-Energy Homes
20. The Plain Old Telephone Service
21. The Global Telecommunications Network
22. Cellular Phone Technology
23. Satellites and Satellite Communications
24. Simple Machines around the House
25. User-Centered Design
26. The Internal Combustion Engine
27. Torque, Power, and Transmission
28. The Drivetrain
29. Suspension, Steering, and Braking
30. Highway Engineering
31. Traffic Engineering
32. Everyday Bridges
33. Tunnel Engineering
34. The Railroad
35. Solid Waste Disposal and Recycling
36. The Future: Engineering for Sustainability

Everyday Engineering:
Understanding the Marvels of Daily Life
Course no. 1116 | 36 lectures (30 minutes/lecture)

SAVE UP TO $270

DVD	~~$384.95~~	NOW $114.95
Video Download	~~$324.95~~	NOW $84.95

+$15 Shipping & Processing (DVD only)
and Lifetime Satisfaction Guarantee

Priority Code: 152281

For over 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free apps for iPad, iPhone, Android, Kindle Fire, or Roku. Over 600 courses available at www.TheGreatCourses.com.

Excerpt from the November 18, 1967 issue of *Science News*

50 YEARS AGO

Electric limbs

Very subtle control of artificial limbs by means of a tiny electronic device may become possible.... [The] electronic device ... [is] designed to be injected into a muscle through a thick hypodermic needle. A tiny package strapped to the outside of the limb will beam radio waves at the device, which will return them, modified by the electric current produced in the muscle.

UPDATE: Artificial limbs have become more sophisticated than in the past, and users' control of today's prostheses is more precise. In 2012, researchers announced that a paralyzed woman could control a robotic arm with her thoughts with the help of a brain implant (*SN: 6/6/12, p. 5*). And in 2014, a man regained the sense of touch through a prosthetic hand via electrodes implanted in his arm's still-functioning nerves (*SN: 3/8/14, p. 16*). Several companies are developing other high-tech prostheses.

Although darker than those found on Lord Howe Island, these stick insects, from nearby Ball's Pyramid, are the same species.

INTRODUCING

Lord Howe stick insects get a second chance

It's a rare triumph when a species comes back from the dead. A new genetic analysis has officially established what many entomologists and conservation biologists hoped was true: The Lord Howe stick insect (*Dryococelus australis*) lives.

Nicknamed "tree lobsters," the dark-brown crawlers are nocturnal, flightless creatures that can grow up to 15 centimeters long. They feed on tea trees, which are dense shrubs found on Lord Howe Island in New South Wales, Australia. Black rats, introduced to the island in the 1920s, wiped out the walking sticks. Or so researchers thought.

In 2001, scientists climbing Ball's Pyramid,

HOW BIZARRE

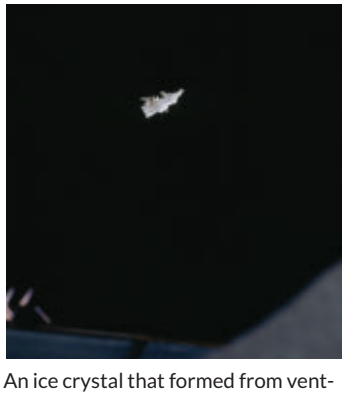
Space toilets could be a research tool

The search for life may get an assist from the call of nature.

Astronomers could learn a lot from the plumes of subsurface ocean water spewing from icy moons like Saturn's Enceladus. And space toilets might help researchers figure out how to engage with those odd bursts of liquid.

Replicating the plumes in Earth-based labs is not easy. So planetary scientist Ralph Lorenz of Johns Hopkins University suggests going with natural experiments venting water into space. He raised the idea on October 17 at an American Astronomical Society meeting in Provo, Utah.

Candid discussions of space waste are scarce in the scientific literature, says Lorenz, who is designing future missions to Saturn's moons. "I don't know if the human spaceflight community is squeamish about it."



An ice crystal that formed from venting fuel cells during the first flight of the space shuttle *Discovery* in 1984 grew so long that it had to be knocked off with a robotic arm.

During the 1984 flight of the space shuttle *Discovery*, a 60-centimeter-long icicle grew from a fuel cell vent, which ejects wastewater in a similar way to a space toilet. That process could hint at how big ice particles in plumes can grow.

And dents on the Japanese Space Flyer Unit, retrieved from orbit in 1996 by the space shuttle *Endeavour*, revealed traces of phosphorus and sulfur. Those relics may have been from urine ice particles flushed from *Endeavour* that rained on the spacecraft, an analysis published in 2000 in *Advances in Space Research* suggested. That might be good news for finding biosignatures at Enceladus — molecules associated with life that could be preserved in ice from the plumes.

— Lisa Grossman

FROM TOP: ROHAN CLEAVE, MELBOURNE ZOO; NASA

a treacherous rocky outcrop southeast of Lord Howe Island, discovered three stick insects feeding on a lone bush. The following year, researchers spotted 24 more. The insects looked eerily similar to the Lord Howe insects, but some physical differences between the new finds and museum specimens called for genetic testing to see if the two were the same.

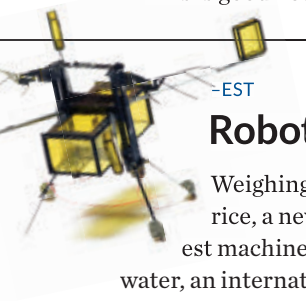
Now, a comparison of the DNA of the Ball's Pyramid stick insects with that of the museum specimens from Lord Howe suggests that the two are the same species. Though the museum specimens have a flatter body, larger spines on their legs and a lighter brown coloring, DNA found within the mitochondria of the two populations is more than 99 percent identical, the researchers report October 23 in *Current Biology*.

This is good news for conservation biologists intent on reintroducing the long-lost insect to Lord Howe Island. "Now that we know that it is the original stick insect, there is a much stronger case" for releasing it into the original habitat, says evolutionary biologist and study coauthor Sasha Mikheyev of the Okinawa Institute of Science and Technology Graduate University in Japan.

Lord Howe stick insects avoided extinction on Australia's desolate Ball's Pyramid.

The Melbourne Zoo has been breeding stick insects taken from Ball's Pyramid since 2003, with the goal of reintroducing them to Lord Howe. As of November 2, about 14,500 insects — spanning 14 generations — have been bred at the zoo.

Before sending the critters to their original homeland, however, the Lord Howe Island Board plans to eradicate the black rats and a second nonnative rodent in 2018. Without these predators, the tree lobsters have a better chance of reestablishing, Mikheyev says. "The story of this insect really highlights the fragility of island ecosystems," he adds. "With this species, we have a second chance." — *Mariah Quintanilla*



TECH

Robot doesn't stop at flying

Weighing the same as about three grains of rice, a new insect-inspired robot is the lightest machine to fly, swim and launch itself from water, an international team of researchers reports October 25 in *Science Robotics*. The bot is about one-thousandth the weight of existing aerial-aquatic robots and could be a prototype for search-and-rescue operations and water-quality samplers.

To hover, the bot flaps its translucent wings 220 to 300 times per second, somewhat faster than a housefly. Once submerged, the robot slows its flapping to about nine beats per second to maintain stability. For the tricky water-to-air transition, the bot does some chemistry. It uses a device to split water collected in a central chamber into hydrogen and oxygen gas. As the chamber fills with gas, the buoyancy lifts the vehicle high enough to hoist its wings out of the water. An onboard "sparker" then creates a tiny explosion that rockets the bot about 37 centimeters into the air. Microscopic holes at the top of the chamber release excess pressure, preventing a loss of robot limbs.

The machine doesn't land well, and it can only pierce the water's surface with the help of soap, which lowers the surface tension. But the experiment points to the possibilities of using different forms of locomotion in a single robot, says study coauthor Robert Wood, a bioengineer at Harvard University. — *Mariah Quintanilla*

SCIENCE STATS

Pollution takes massive toll

About 1 in every 6 premature deaths worldwide is linked to dirty air, water and soil.

Most of those deaths are concentrated among the world's poorest populations, according to a study published online October 19 in the *Lancet* that documents the health and economic toll of pollution in 2015. More than half of the air pollution–related deaths occurred in India and China. The report, by the *Lancet* Commission on pollution and health, is the first to bring together the health costs of air, water and soil pollutants "all under one umbrella," says study coauthor Richard Fuller, president of the nonprofit Pure Earth in New York City.

An estimated 9 million people died from pollution exposure in 2015, the commission reports. That's "three times as many deaths as AIDS, tuberculosis and malaria combined," the report notes. About 90 percent of the world's urban population lives in cities in which air quality does not meet World Health Organization standards. "The take-home of this is to show how high the health burden is, and how decisions made today can save lives today, not just sometime in the future," says Joel Kaufman of the University of Washington School of Public Health in Seattle. — *Laura Beil*

9 million
Estimated number of people worldwide killed by pollution exposure in 2015

~90 percent
Proportion of city dwellers who live in places with poor air quality

3x
Pollution's death toll versus AIDS, tuberculosis and malaria combined

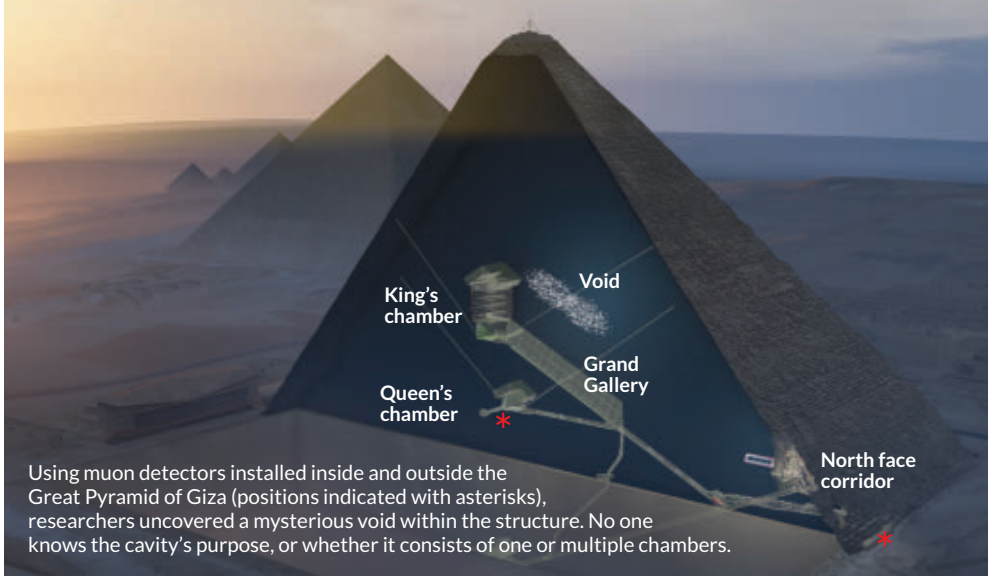
FROM TOP: FANNY SCHERTZER/WIKIMEDIA COMMONS (CC BY 4.0); YUFENG CHEN, E. FARRELL HELBLING, HONGQIANG WANG

Watch a flying, swimming bot in action at **bit.ly/SN_InsectBot**

HUMANS & SOCIETY

Hidden void found in Great Pyramid

Particle physics lets scientists peek inside iconic monument



Using muon detectors installed inside and outside the Great Pyramid of Giza (positions indicated with asterisks), researchers uncovered a mysterious void within the structure. No one knows the cavity's purpose, or whether it consists of one or multiple chambers.

BY MARIA TEMMING

High-energy particles from outer space have helped uncover an enigmatic void deep inside the Great Pyramid of Giza.

Using high-tech devices typically reserved for particle physics experiments, researchers peered through the thick stone of the largest pyramid in Egypt for traces of cosmic rays and spotted a previously unknown empty space. The mysterious cavity is the first major structure discovered inside the roughly 4,500-year-old Great Pyramid since the 19th century, an international research team reports online November 2 in *Nature*.

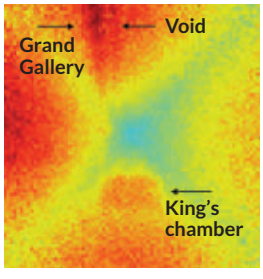
"It's a significant discovery," says Peter Der Manuelian, an Egyptologist at Harvard University who was not involved in the work, "although precisely what it means is unclear."

The open space may comprise one or more rooms or corridors; the particle-detector images reveal only the rough size of the void, not the details of its design. Eventually, though, this detail of the pyramid's architecture could offer new insights into one of the world's largest, oldest and most famous monuments. The only one of the ancient Seven Wonders of the World that's still standing, the Great Pyramid was built as a burial tomb for Pharaoh Khufu.

"Imagine you're an archaeologist and you walk into this room no one has walked in for [over] 4,000 years," says Nural Akchurin, a physicist at Texas Tech University in Lubbock who wasn't involved in the study. "That's huge. It's incredible."

Researchers probed the Great Pyramid's interior with devices that sense muons — by-products of spacefaring subatomic particles called cosmic rays striking atoms in the atmosphere. Muons continuously rain on Earth at nearly the speed of light. But while the subatomic particles easily streak through open air, rock can absorb or deflect them. By placing detectors near the base and areas deep inside the pyramid and measuring the number of muons that reached the detectors from different directions, scientists could detect empty spaces inside the ancient edifice.

For instance, if a detector inside the pyramid picked up slightly more muons from the north than the south, that would indicate there was slightly less rock on the north side to intercept incoming muons. That relative abundance of muons could indicate the presence of a chamber in that direction.



A detector pointed upward inside the Queen's chamber of the Great Pyramid of Giza captured an excess of muons coming down from the direction of the King's chamber, the Grand Gallery and a previously unknown void.

Muon imaging an enormous, dense construction like the Great Pyramid "is not an easy game," Akchurin says. The monument obstructs 99 percent of incoming muons before the particles can reach detectors, so collecting enough data to spot hollow spaces in such a structure takes several months.

The newly identified void was first seen with a type of muon detector called nuclear emulsion film, which the researchers laid out in an interior space called the Queen's chamber and the adjacent corridor. When muons zip through these films, the particles' chemical interactions with the material leave silver trails that reveal which direction the particles came from, explains Elena Guardincerri, a physicist at Los Alamos National Laboratory in New Mexico who was not involved in the work.

Upon developing these films, the researchers saw a surprising excess of muons coming through a region above the Grand Gallery, a sloping corridor that runs north-south through the middle of the pyramid. The cavity appears to be at least 30 meters across — about the size of the Grand Gallery itself. "Our first reaction was a lot of excitement," says study coauthor Mehdi Tayoubi, cofounder of the Heritage Innovation Preservation Institute in Paris. "We said, 'Wow, we got something big!' "

Tayoubi and colleagues confirmed their discovery with observations from two other types of muon detectors that generate electrical signals when muons pass through, placed inside the Queen's chamber and outside at the base of the pyramid.

Akchurin hopes this finding will pave the way for muon imaging of other ancient monuments — particularly at archaeological sites where traditional excavation may be difficult, like deep in the jungle or on mountainsides. ■

FROM TOP: SCANPYRAMIDS MISSION; K. MORISHIMA *ET AL*/*NATURE* 2017

GENES & CELLS

New gene editors fix common typos

Tools can repair single RNA or DNA bases that cause disease

BY TINA HESMAN SAEY

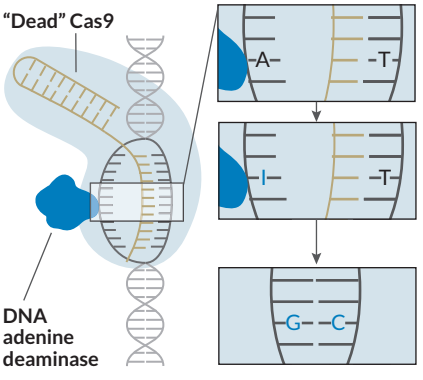
New gene-editing tools can correct typos that account for about half of disease-causing genetic spelling errors.

Scientists have revamped the CRISPR/Cas9 gene editor so it converts the DNA base adenine to guanine, biological chemist David Liu and colleagues report online October 25 in *Nature*. In a separate study, published online October 25 in *Science*, a research team led by CRISPR pioneer Feng Zhang reengineered a gene editor called CRISPR/Cas13 to correct the same typos in RNA instead of DNA.

The new editors offer scientists an expanded set of precision tools for correcting genetic diseases.

CRISPR/Cas9 is a molecular scissors that snips DNA. Scientists can guide the scissors to a specific place in an organism's genetic instruction book with a guide RNA that matches DNA at the target site. The tool has been used to make mutations or correct them in animal, including human, cells (*SN: 10/14/17, p. 8*).

Genetic rewrite In a base editor, an enzyme that alters the chemical structure of DNA bases is fused to a "dead" version of Cas9 that can't cut DNA. A new base editor uses the enzyme DNA adenine deaminase to turn adenine-thymine (A-T) base pairs into guanine-cytosine (G-C) pairs. Initially, adenine is converted to inosine (I), which cells interpret as guanine. Later, I-T pairs get switched to G-C.



E. OTWELL

A variety of innovations allow CRISPR/Cas9 to change genetic instructions without cutting DNA (*SN: 9/3/16, p. 22*). Earlier versions of these "base editors," which target typos related to the other half of disease-causing genetic spelling errors, have been used to alter genes in plants, fish, mice and even human embryos.

Such noncutting gene editors may be safer than traditional cutting versions, says Gene Yeo, an RNA biologist at the University of California, San Diego. "We know there are drawbacks to cutting DNA." Mistakes often arise when cellular machinery attempts to repair DNA breaks. And CRISPR sometimes cuts DNA at places similar to the target, raising the possibility of introducing mutations. "Permanent irreversible edits at the wrong place in the DNA could be bad," Yeo says. "These two papers have different ways to solve that problem."

The new editors let scientists rewrite all four bases that store information in DNA and RNA. Those bases are adenine (A), which pairs with thymine (T) (or uracil,U, in RNA), and guanine (G), which pairs with cytosine (C). About half of the 32,000 mutations associated with genetic diseases change G-C pairs to A-T pairs, says Liu, a Howard Hughes Medical Institute investigator at Harvard University. Until now, he says, there was little anyone could do about those.

In RNA, DNA's chemical cousin, some naturally occurring enzymes can reverse this common mutation. Such enzymes chemically convert adenine to inosine (I), which cells interpret as guanine.

Zhang, of the Broad Institute of MIT and Harvard, and colleagues made an RNA-editing enzyme called ADAR2 into a programmable gene-editing tool. The team started with CRISPR/Cas13, molecular scissors that cut RNA. Dulling the blades, so to speak, let the tool grasp instead of slice. The team then bolted the A-to-I converting portion of ADAR2 onto CRISPR/Cas13. Dubbed REPAIR, the tool edited from 13 to about 27 percent of RNAs of two genes in human cells grown in dishes. No undesired changes were detected.

Editing RNA is good for temporary fixes, such as shutting down proteins that promote inflammation. But to fix many mutations, permanent DNA repairs are required, Liu says.

In 2016, Liu's team made a base editor that converts C to T. Chinese researchers reported online September 23 in *Protein & Cell* that they used that base editor in human embryos to repair a mutation that causes beta-thalassemia, a blood disorder. But the editor couldn't make the other change, switching A to G.

Unlike with RNA, no enzymes naturally make the A-to-I conversion in DNA. So Nicole Gaudelli, in Liu's lab, forced *E. coli* bacteria to evolve such an enzyme. Then the researchers bolted the *E. coli* DNA converter, TadA, to a disabled version of Cas9 that couldn't cut both DNA strands. The result was a base editor, called ABE, that could switch A-T base pairs into G-C pairs in about 50 percent of human cells tested.

This base editor works more like a pencil than scissors, Liu says. In lab dishes, Liu's team corrected a mutation in human cells from a patient with an iron-storage blood disorder called hereditary hemochromatosis. The team also re-created beneficial mutations that allow blood cells to keep making fetal hemoglobin. Those mutations are known to protect against sickle cell anemia.

Another group reported in the October *Protein & Cell* that base editing appears to be safer than traditional cut-and-paste CRISPR/Cas9 editing. Liu's results seem to support that. His team found that about 14 percent of the time cut-and-paste CRISPR/Cas9 made changes at nine of 12 possible "off-target" sites. The new A-to-G base editor altered just four of the 12 off-target sites and only 1.3 percent of the time.

That's not to say cut-and-paste editing isn't useful, Liu says. "Sometimes, if your task is to cut something, you're not going to do that with a pencil. You need scissors." ■

Editor's note: Feng Zhang is on the board of trustees of the Society for Science & the Public, which publishes Science News.

EARTH & ENVIRONMENT

Wind threatens East Antarctic glacier

Airflow pushes warm seawater to melt ice shelf from below

BY CAROLYN GRAMLING

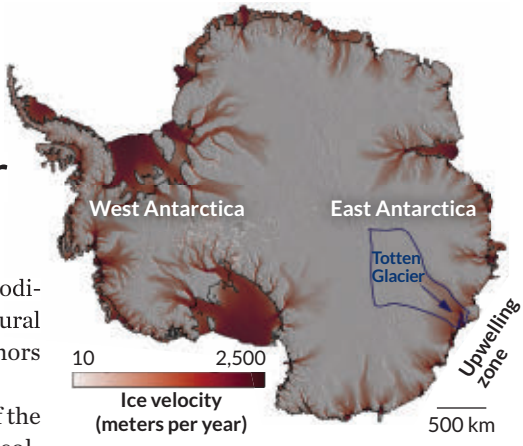
Wind is helping to awaken one of Antarctica's sleeping giants. Warm ocean waters, driven inland by winds, are undercutting an ice shelf that holds back a vast glacier from sliding into the ocean, researchers report November 1 in *Science Advances*.

Totten Glacier is East Antarctica's largest glacier, with a drainage basin covering an area about the size of France. The floating front edge, the Totten ice shelf, sticks out like a tongue over the water. Anchored to the seafloor by a raised sill, the shelf is like a buttress, slowing the glacier's movement toward the ocean. If the entire glacier slips into the sea, it could raise global sea level by at least 3.5 meters.

Previous work has shown that the ice shelf is being melted from below. The ice shelf floats within a pool of its own cold meltwater that sits atop a deeper, saltier and warmer layer; the layers generally don't mix. But the warmer layer periodically rises enough to slip through natural troughs carved into the sill that anchors the ice shelf, melting it from below.

Now, geophysicist Chad Greene of the University of Texas at Austin and colleagues say wind probably controls the water's inflow. The team examined nearly 14 years of satellite data, comparing 629 pairs of images to track how the ice shelf's position and size changed. Then, the team used wind and sea ice measurements over the same period to create an almanac of changes in wind direction and intensity.

When wind pushes a mass of water in one direction, more water wells up from below to fill the void, the researchers found. The data also revealed another pattern. About 19 months after wind churned the waters and brought the warmer water upward, the ice shelf was noticeably thinner and had sped up.



Totten Glacier isn't moving as fast as West Antarctic glaciers, but wind-driven upwelling of warm seawater may speed up its seaward flow.

East Antarctic winds are expected to intensify within the next century due to warming. The ice shelf will probably thin, and the glacier will flow faster, perhaps one day sliding into the sea, the team says.

"We have little data on the ocean and ice shelf conditions in this region," says geophysicist Fernando Paolo of NASA's Jet Propulsion Laboratory in Pasadena, Calif. But the study's nearly 14-year record is still somewhat short to infer a definitive link between wind-driven upwelling and ice shelf melt, he says. ■

BODY & BRAIN

Faux cells could treat diabetes

Synthetic structures regulated mice's blood sugar for days

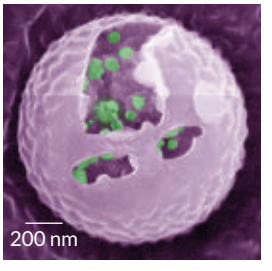
BY MARIA TEMMING

Artificial cells made from scratch in the lab could one day offer a more effective, patient-friendly diabetes treatment.

Type 1 diabetes, which affects over 1 million Americans, is characterized by the immune system destroying insulin-making beta cells in the pancreas. For the first time, researchers have made synthetic cells that mimic how natural beta cells sense blood sugar concentration and secrete just the right amount of insulin. In mice, these cells regulated blood sugar for up to five days, researchers report October 30 in *Nature Chemical Biology*.

If the mouse results translate to humans, people with diabetes could inject these artificial beta cells to automatically regulate blood sugar levels for days at a time.

That would be "a huge leap forward" for people who now have to check blood sugar and inject insulin several times a day, says bioengineer Omid Veiseh of Rice University in Houston, who wasn't involved in the research.



An artificial beta cell (shown in a fluorescent image) has sacs (green) that release insulin into the bloodstream when blood sugar is high.

Fashioned from human-made materials and biological ingredients such as proteins, the faux cells carry insulin-filled pouches much like the insulin-carrying compartments in real beta cells. When an artificial beta cell is surrounded by excess blood sugar, its insulin sacs fuse with its outer membrane and eject insulin into the bloodstream. As blood sugar levels drop, insulin packets stop fusing with the membrane, stemming the cell's insulin secretion.

Biomedical engineer Zhen Gu of the University of North Carolina at Chapel Hill and colleagues injected the synthetic cells into diabetic mice. The animals' blood sugar levels normalized within an hour and stayed that way up to five days, when the faux cells ran out of insulin.

Even for patients who manage their insulin with automated mechanical pumps, synthetic cells offer more precise, real-time blood sugar regulation, says Michael Strano, a chemical engineer at MIT.

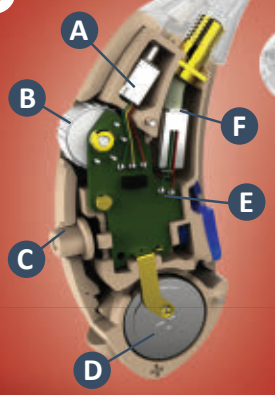
And, Gu adds, unlike transplanted beta cells or genetically engineered ones (*SN: 1/15/11, p. 9*), artificial cells could be mass-produced and have a longer shelf life. Gu and colleagues plan to perform further tests on lab animals to assess the cells' long-term health effects before running clinical trials. ■

FROM TOP: C.A. GREENE/UNIV. OF TEXAS INSTITUTE FOR GEOPHYSICS 2017; GU LAB/UNC–NC STATE

Affordable Hearing Aid Technology Only $299!*

(*Each when you buy a pair)

Learn about our great digital technology at an affordable price.



FREE 1 YEAR SUPPLY OF BATTERIES with coupon code!

A) Microphone
B) Volume Control Wheel
C) Program Button
D) Long Lasting Battery
E) Digital Signal Processor
F) Receiver (Speaker)
G) Sound Tube

The Revolutionary HCX!

- Digital sound processing chip provides **crystal clear sound and makes speech easier to understand** with less feedback than old analog technology
- Multiple memory programs **adapt to most listening situations**
- Nearly invisible thin tube design
- Long lasting size 13 batteries and a **low battery warning**
- 10 bands of layered noise reduction helps to **emphasize voices while balancing out background noise**
- **100% Money Back Guarantee**

5 Star Reviews ★★★★★

They Are Fantastic! "I just received my HCX hearing aids and they are fantastic. Advanced Affordable is far superior and far more affordable!" *- Chuck D.*

Wonderful Company! "I will definitely recommend your company to my patients." *- Dr. Arun P.*

2 Hearing Aids Benefit

Your brain is designed to use both ears working together to fully understand what you hear. In fact, studies show that you may be able to **hear up to 3 times better** in noisy situations when using two hearing aids.

Digital Hearing Aid Technology... For Only $299!*

All digital hearing aids work the same way. The **microphone** picks up the sound and sends an electrical signal to the digital signal processor. The **digital signal processor** is the "brains" of the hearing aid. It takes the sound it receives and adjusts the sound to amplify important speech sounds as well as filtering out unwanted noise. (To ensure the best in quality, our digital processor is designed and manufactured right here in the **United States.**) Once the processor has amplified the sound, it is passed to the **receiver** (also known as the speaker) which emits a corrected and amplified sound through the **sound tube** into your ear.

Most importantly, your new HCX™ hearing aids work at a **fraction of the cost** of name-brand hearing aids. In addition to the technical components of the hearing aid, you also have a **volume control** that can be modified with a light touch of the finger. Your new hearing aids come with **3 different audio programs** that help you listen in different sound environments. You will love the Open-fit design, that is so light you probably won't even feel that you are wearing your hearing aids – you'll just be hearing clearly!

Even better in **Pairs!**

You can spend thousands for a high-end hearing aid or you can spend **just $329** for a hearing aid that is great for most hearing losses **(only $299 each when you buy a pair)**. We are so sure you will love our product, that we offer a **100% Money Back Guarantee - Risk Free** if you are not satisfied for any reason.

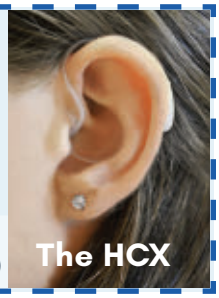
MONEY SAVING OFFER!

Call: 1-877-721-7415

Use Coupon Code: **S7A** at checkout to get a **FREE 1 year supply of batteries!**

Only $299 Each When You Buy A Pair!

(Coupon Code & Price Valid For A Limited Time Only with hearing aid purchase)



Advanced Affordable Hearing™
Affordable Quality Since 1996!

A+ BBB ACCREDITED BUSINESS | 100% MONEY BACK GUARANTEE | RISK FREE Trial | US Company Owned And Operated | FDA REGISTERED

Visit and Save: **www.AdvancedHearing.com/S7A**

GENES & CELLS

Gut fungi linked to health problems

Mycobiome may play role in obesity and Crohn's disease

BY TINA HESMAN SAEY

Fungi affect gut health in unexpected ways, new studies suggest.

High-fat diets may alter relationships between bacteria and fungi in mice's intestines, possibly contributing to obesity, researchers report in the September/October *mSphere*. In the November *Digestive and Liver Disease*, other researchers propose that a fungus teams with bacteria to fuel gut inflammation in Crohn's disease.

These studies are part of a growing body of research indicating that relationships between bacteria and fungi affect health, says fungal biologist David Andes of the University of Wisconsin School of Medicine and Public Health in Madison.

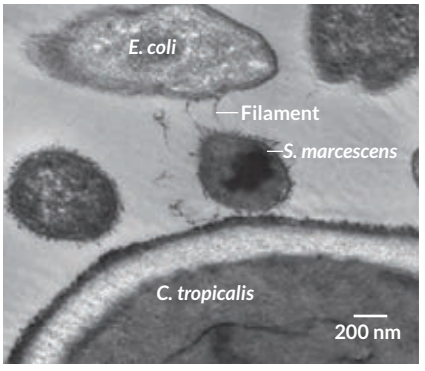
Scientists have already linked gut bacteria, part of the microbiome, to health issues. Far less is known about the role of the gut's fungi, or mycobiome."To get the whole picture," Andes says, "we're going to need to start looking at the mycobiome in addition to the microbiome."

To help draw that picture, pediatrician Cheryl Gale of the University of Minnesota in Minneapolis wanted to know whether high-fat diets change fungal communities as they do bacterial mixes.

Gale's team fed mice either standard or high-fat chow. As expected, mice on the high-fat diet gained weight. Also, *Firmicutes* bacteria associated with obesity increased, while *Bacteroidetes* bacteria decreased in abundance.

Fungi also changed. Mice on high-fat diets tended to have less *Saccharomyces cerevisiae* yeast and more *Candida albicans* in their guts than mice fed normal chow. *S. cerevisiae*, used in making beer and bread, has been linked to good health. *C. albicans* causes yeast infections.

Gale's team also discovered that relationships between bacteria and fungi changed when mice's diets changed. Her team can't yet show a direct connection between the composition of gut fungi and obesity, but suspects that shifting interactions between bacteria and fungi might lead the host to gain weight.



Biofilms of *Candida tropicalis* fungus along with *E. coli* and *Serratia marcescens* bacteria may play a role in Crohn's disease. *S. marcescens*' protein filaments help stabilize the biofilm.

Other researchers investigated how a microbial triad might contribute to an inflammatory bowel disease. People with Crohn's disease have an overabundance of *Candida tropicalis* fungus along with *E. coli* and *Serratia marcescens* bacteria, say Christopher Hager and Mahmoud Ghannoum of Case Western Reserve University School of Medicine in Cleveland.

When grown separately in dishes, the organisms "grew fine," Hager says. "But when you mixed all three of them together, they just grew out of control." The trio formed biofilms, structured microbial communities that can shield bacteria from antibiotics.

In the presence of bacteria, *C. tropicalis* stretches out into long filaments. Microscopy showed that *E. coli* fuses to the fungal growths. *S. marcescens* makes protein strings that somehow stabilize the biofilm. This partnership may allow the microbes to outcompete loner microbes.

Together the three organisms, but especially the fungus, may promote intestinal inflammation, Hager says.

It's too early for doctors to change their patients' treatments based on these studies, Andes says. But, he adds, a full understanding of health should include all the kingdoms of life. ■

ATOM & COSMOS

Some dark energy alternatives nixed

LIGO detection rules out class of acceleration theories

BY LISA GROSSMAN

Ripples in spacetime travel at the speed of light. That fact, confirmed by the recent detection of merging stellar corpses, kills a category of theories that mess with the laws of gravity to explain why the universe is expanding at an increasing rate.

On October 16, physicists announced that the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, had detected gravitational waves from a neutron star collision (*SN: 11/11/17, p. 6*). The neutron stars also emitted high-energy light shortly after merging. That observation showed for the first time that gravitational waves, the shivers in spacetime set off when massive bodies move, travel at the speed of light to within a tenth of a trillionth of a percent.

Within a day, five papers were posted at arXiv.org upending hundreds of acceleration theories that predicted gravitational waves should travel faster than light — an impossibility without changes to Einstein's laws of gravity. These theories "are very, very dead," says Miguel Zumalacárregui, a cosmologist at the University of California, Berkeley who coauthored one of the papers. "We need to go back to our blackboards and start thinking of other alternatives."

In the 1990s, observations of exploding stars showed that more-distant explosions were dimmer than theories predicted. That finding suggested the universe is expanding at an ever-increasing rate. Researchers struggle to explain why.

The most popular explanation is that spacetime is filled with a peculiar entity dubbed dark energy (see Page 22). It's "like a mysterious fluid that pushes everything apart and counteracts gravity," says cosmologist Jeremy Sakstein of the University of Pennsylvania, coauthor of another of the new papers.

In the simplest version of this theory,

C.L. HAGER AND M.A. GHANNOUM/*DIGESTIVE AND LIVER DISEASE* 2017

dark energy's density has not changed over time, so physicists call it a cosmological constant. The cosmological constant idea, which doesn't require any changes to gravity, matches observations of the wider universe, but has some theoretical difficulties. For instance, dark energy is about 120 orders of magnitude weaker than theorists calculate it should be.

Also, different methods for measuring today's expansion rate reach slightly different numbers. One measurement suggests that distant galaxies are speeding away from each other at 73 kilometers per second for each megaparsec (about 3.3 million light-years) of space between them. Another measurement finds the expansion rate is 67 km/s per megaparsec. One of them must be wrong, or the theory behind dark energy needs a tweak.

Instead of invoking a substance to counteract gravity, some theorists tried to explain the universe's expansion by weakening gravity itself. These theories take hundreds of forms. Some suggest that gravity leaks out into extra dimensions of space and time. Many others account for the universe's speedy spreading by adding a different mysterious entity — some unknown particle perhaps — that drains gravity's strength as the universe evolves.

But the new entity would have another crucial effect: It could slow the speed of light waves, similar to the way light travels more slowly through water than through air. The best alternatives to dark energy required gravitational waves to travel faster than light, which they don't.

Theoretical physicist Justin Khoury of the University of Pennsylvania was surprised to see one gravitational wave observation rule out so many theories. "The fact that we're learning something about dark energy because of this measurement is incredibly exciting," he says.

Observing gravitational waves and light waves at the same time offers another way to measure how fast the universe is expanding. Once LIGO and other observatories have seen 10 or 20 more neutron star collisions, researchers should be able to tell which expansion estimate is correct and figure out whether dark energy needs an update, Zumalacárregui says. ■

LIFE & EVOLUTION

'Sloppy' blue hue benefits flowers

Nanoscale imperfection makes a color that bees learn fast

BY SUSAN MILIUS

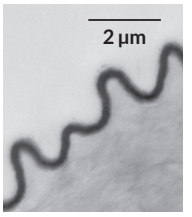
A bit of imperfection could be perfect for flowers creating a "blue halo" effect that bees can see.

At least a dozen families of flowering plants, from hibiscuses to daisy relatives, have species that can create a bluish-ultraviolet tinge using arrays of nanoscale ridges on petals, researchers report in the Oct. 26 *Nature*. These flowers could be the first shown to benefit from the sloppiness of natural fabrication, says coauthor Silvia Vignolini, a physicist who specializes in nanoscale optics at the University of Cambridge.

Flowers, of course, can't reach industrial standards for uniform nanoscale fabrication. Yet the halo may be a case where natural imperfections are important to a flower's display. Tests with artificial flowers showed that the nanoglitches made it easier for bees to learn that a showy petal meant a sugary reward, Vignolini and colleagues found.

Blue pigments are rare in living things. Partly ordered nanostructures in blue spiders, for instance, create colorful illusions by muting some wavelengths of light while intensely reflecting others (*SN: 1/9/16, p. 5*).

Flower petals make their blue halo illusion with somewhat irregular versions of what are called diffraction gratings, rows of ridges like the recording surface on a CD. A perfectly regular array of ridges would create true iridescence, changing color depending on the angle a viewer takes. The flowers' imperfections, variations in ridge height and spacing, weaken or destroy the iridescence. A viewer swooping by would see less color shifting and more of a bluish-ultraviolet tinge reflected at a wider range of angles.



Bees can easily learn to recognize a bluish tinge found on some flowers (dark center circle, below). This "blue halo" is created by irregular nanoscale structures (shown in cross section at right) in petals.

E. MOYROUD ET AL/NATURE 2017

To see whether bees respond more to iridescence or a blue halo, the researchers created artificial flowers, pieces of epoxy resin with nanoscale-ridged arrays.

In tests, Vignolini's group offered bumblebees a pair of "flowers," one that held sugar water and one with a nasty-tasting solution, to see how quickly bees learned to distinguish sweet from foul. When a flower's nanoridges had imperfections creating a blue halo, bees learned the task faster than when the flower had perfect iridescence. Imperfect arrays were an advantage for the flowers in creating displays that pollinating bees find memorable, the researchers conclude.

Before the tests, researchers weren't sure whether flowers would benefit from perfect iridescence and were just falling short in growing perfect arrays. The blue halo might have been a side effect of challenging botanical fabrication. The bee experiments, however, showed the opposite. These are the first tests to show that some disorder is not just a downside of natural fabrication but "has a function," Vignolini says.

That result makes sense to visual ecologist Nathan Morehouse of the University of Cincinnati. Iridescence itself might have a downside because it changes color as an insect or bird changes its angle of approach. So iridescence may not be an easy-to-learn signal. ■

LIFE & EVOLUTION

New species of orangutan identified

Fewer than 800 apes remain in this endangered population

Researchers have named described a third species of orangutan, *Pongo tapanuliensis*.

BY BRUCE BOWER

Orangutans living in forested foothills on the Indonesian island of Sumatra represent a previously unknown species.

Skeletal and genetic evidence puts the apes on a separate evolutionary trajectory from other Sumatran orangutans (*Pongo abelii*) and Bornean orangutans (*Pongo pygmaeus*), say evolutionary anthropologist Michael Krützen of the University of Zurich and colleagues. The new species, *Pongo tapanuliensis*, or the Tapanuli orangutan, is described online November 2 in *Current Biology*.

The name *P. tapanuliensis* refers to the Sumatran districts — North, Central and South Tapanuli — where no more than 800 of the apes inhabit several areas. The orangutans face extinction due to road construction, illegal forest clearing and killings by villagers and hunters, the scientists say. Estimates of the total number of living orangutans vary, but the World Wildlife Fund puts it at about 120,000.

Researchers observed Tapanuli orangutans in their hilly habitat as early as the 1930s. Yet the apes have been overlooked in favor of Sumatran orangutans that live in swampy forests farther north. A chance to explore Tapanuli orangutan biology came in 2013. Krützen's team gained access to the skeleton of an adult male killed by villagers. Comparisons with 33 Sumatran and Bornean male skeletons revealed differences in the skull and teeth of the Tapanuli ape, including a narrow palate and a relatively short jaw joint.

Analysis of DNA from 37 orangutans, including two Tapanuli animals, indicated Tapanuli and Sumatran apes diverged from a common ancestor about 3.4 million years ago. Shared gene variants point to interbreeding after the split. Cross-species hookups declined sharply about 100,000 years ago, then stopped by 10,000 years ago. Sumatran and Bornean apes separated about 674,000 years ago.

Scenarios in which closely related ape species interbred after evolving into distinct biological populations probably occurred frequently, Krützen says. DNA studies suggest ancient chimpanzees and bonobos interbred, as did *Homo sapiens* and Neandertals (*SN: 10/15/16, p. 22*).

Krützen's team makes a good case for a third orangutan species that interbred for a long time with a closely related species, says biological anthropologist Rebecca Ackermann of the University of Cape Town in South Africa. "I'd go out on a limb and say not only that [interbreeding] played an important role in the evolution of all living apes, but that it shaped the evolution of extinct ones as well." ■

MATTER & ENERGY

Photons caught swapping energy

Light particles mimic behavior of superconducting electrons

BY EMILY CONOVER

Light is a fan of the buddy system. Photons, or particles of light, have been spotted swapping energy with partners. This behavior resembles how electrons pair up in materials that conduct current without resistance, known as superconductors, researchers report in a paper accepted in *Physical Review Letters*.

Although the photons exchange energy like electrons do, it's unknown whether the particles are actually bound together as electrons are, and whether photons could produce an effect analogous to superconductivity. "How far can we push this similarity?" asks study coauthor Ado Jorio, a physicist at the Universidade Federal de Minas Gerais in Brazil. "Can we find with photons incredible results like we find for electrons?"

In certain solid materials cooled to extremely low temperatures, electrons form partnerships called Cooper pairs, which allow superconductivity to occur. Though the negatively charged particles typically repel one another, two electrons can bind together by exchanging phonons, or quantum packets of vibration, via the lattice of ions within these chilled materials. This alliance coordinates the electrons' movements and thereby eases their passage through the material, allowing them to flow without resistance. Superconductivity's potential applications — including energy-efficient power transmission and levitating trains — have attracted heaps of scientific interest.

Now, Jorio and colleagues have shown photons behaving similarly to superconducting electrons. When the team shined a laser on water, pairs of photons emerging from the liquid at the same time tended to have complementary energies. While one photon had lost a little energy, another had gained the same amount, indicating they were exchanging quantum vibrations. The effect appeared in a variety of transparent materials, says Jorio, and, unlike with electrons, occurred at room temperature.

The team also showed that the exchanged quantum vibrations were "virtual" — appearing only for fleeting moments — just like the vibrations exchanged by electrons. The theory that explains the interaction "is exactly the same as for the electrons," Jorio says.

It's too early to know how far the analogy with superconducting electrons extends, says Ben Sussman, a physicist at the National Research Council of Canada in Ottawa. But the connection is worth investigating: "This is an interesting rabbit hole indeed." ■

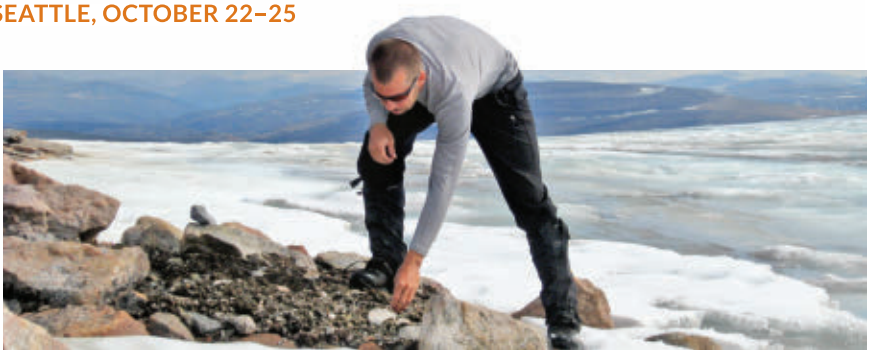
TIM LAMAN

EARTH & ENVIRONMENT

Mosses tell story of retreating ice

Arctic summer is hottest it has been in at least 40,000 years

BY CAROLYN GRAMLING



Geologist Kurt Refsnider collects mosses revealed by retreating ice on Canada's Baffin Island. Radiocarbon dates for the mosses suggest the region has less ice cover now than 40,000 years ago.

Some mosses in the Canadian Arctic, long entombed in ice, are now emerging into the sunlight. And the radiocarbon ages of those plants suggest that summer temperatures in the region are the warmest they've been in tens of thousands of years.

As the planet warms and the ice retreats on northeastern Canada's Baffin Island, the change is revealing long-buried plants. In some areas, the plants last saw the sun at least 40,000 years ago — and possibly as much as 115,000 years ago. Paleoclimatologist Gifford Miller of the University of Colorado Boulder reported the finding October 22. "We were stunned," he said.

The research is very compelling, said geomorphologist Lee Corbett of the University of Vermont in Burlington. "It truly is an indication that humans are pushing the climate into a new regime, one that modern, agriculture-based civilizations have never witnessed."

To track the growth and retreat of ice cover, Miller and colleagues have been hunting for mosses along the edges of the island's retreating ice sheets. Radiocarbon dates of the emerging plants correspond to when the mosses were last exposed to the atmosphere.

So far, Miller's team has determined 370 distinct ages for plant samples. The ages tend to cluster into groups, each representing a time when the ice expanded across the island and entombed the plants. One large group dates to around 3,700 years ago, another to around 900 years ago and a third to around A.D. 1450, corresponding to a cold period known as the Little Ice Age.

But in a few regions, the plants were so old that they had no detectable radiocarbon left. Radioactive carbon has a half-life of about 5,730 years, after which about half of the radiocarbon in the original sample will have decayed away. So after about 40,000 to 50,000 years, almost all of an object's radiocarbon is gone.

Mosses with the "dead" radiocarbon were found at high elevations, where persistent ice caps are now slowly melting away. Because the radiocarbon clock stops at about 50,000 years, it's not possible to determine exactly when those spots were last ice-free. But an ice core from Greenland suggests that the planet experienced continuous cold from 40,000 to about 115,000 years ago, Miller said.

Originally, the researchers expected to find plants dating to medieval times, which would have suggested that the region is the warmest it's been since the Middle Ages. "We never anticipated we'd find plants 40,000 years old," Miller said. "It's a bit spooky because it provides quantitative evidence that the magnitude of summer warmth is already sufficient to melt all ice in the eastern Canadian Arctic. It's just a matter of time now." ■

LIFE & EVOLUTION

T. rex arms may have been for slashing

Animal's tiny limbs were far from useless, paleontologist argues

BY CAROLYN GRAMLING

Tyrannosaurus rex may have had small arms, but it was no pushover.

The roughly 1-meter-long limbs weren't just vestigial reminders of a longer-armed past, paleontologist Steven Stanley of the University of Hawaii at Manoa said October 23. Instead, the limbs were well-adapted for vicious slashing at close quarters, he argued.

T. rex ancestors had longer arms that the dinos used for grasping. But at some point, tyrannosaurs began to use their giant jaws for grasping instead, and the limbs eventually atrophied. Many people have hypothesized that the shrunken arms were, at best, used for mating or perhaps pushing the animal up off the ground; at worst, they were functionless.

But Stanley noted that the arms were quite strong, with robust bones that could sustain the impact of slashing. Each arm ended in two sharp claws about 10 centimeters long. Two claws give more slashing power than three, because each one can apply heavier pressure. The claws' edges were also beveled and sharp like those of a bear, not flat like the grasping claws of an eagle. Those traits support the slasher hypothesis, Stanley concluded.

Many scientists aren't convinced. It's unlikely that an adult *T. rex* would have used its arms as a primary weapon, said vertebrate paleontologist Thomas Holtz of the University of Maryland in College Park. The arms of a fully grown *T. rex* would barely reach past its chest, greatly reducing the potential strike zone. But a *T. rex*'s arms grew more slowly than its body, so younger dinos would have had proportionally longer arms. It's possible that juveniles might have found them useful for slashing prey, Holtz said. ■

G. MILLER

LIFE & EVOLUTION

Climate change may threaten bamboo-eating lemurs

The only lemurs so dependent on bamboo that they gnaw on hard, nutrient-poor stems during the dry season might dwindle away as dry seasons grow longer.

Reconstructing the history of the greater bamboo lemur (*Prolemur simus*) in Madagascar suggests that, over thousands of years, these lemurs have already vanished from drier areas. As parts of the island dry further with changing climate, remaining populations might go hungry and fade away, an international research team warns in the Nov. 6 *Current Biology*.

Other animals will eat bamboo shoots and leaves. But the greater bamboo lemur is the only mammal besides the giant panda that sticks with the uninviting bamboo during the dry season. That's when the plants stop sprouting and offer only culm — the tough, old, yellowing stems poor in nutrients.

This lemur species had already been feared extinct once, around the middle of the last century, but relic populations turned up. Survivors remain more toward the eastern part of Madagascar, where dry seasons are apparently survivable, at least for now. — *Susan Milius*

Greater bamboo lemurs, which depend on nutrient-poor, yellowing bamboo stems during dry seasons (left), could suffer more as the climate changes. More nutritious, tender bamboo (right) can feed even a baby lemur.

BOTH: JUKKA JERNVALL

ATOM & COSMOS

Solar system welcomes new visitor

Astronomers may have just spotted the first asteroid caught visiting the solar system from another star.

Hawaii's Pan-STARRS 1 telescope found the object, now dubbed 'Oumuamua, on October 18. Observations from other telescopes suggest the object's trajectory is at an unusually steep angle to the plane on which the planets lie, and it doesn't orbit the sun. 'Oumuamua's slingshot route suggests it's a recent visitor to the solar system and is on its way out. The discovery was announced in a bulletin published October 25 by the International Astronomical Union's Minor Planet Center.

All other known asteroids come from within the solar system and circle the sun. Astronomers first pegged the object as a comet due to its elongated path. But additional telescope observations on October 25 indicated 'Oumuamua looks like a single, sharp point of light; a comet would have an extended icy halo. The asteroid is probably no more than 400 meters across, zoomed in at 25.5 kilometers per second and is fleeing the solar system at 44 km/s.

Astronomers are now analyzing the colors in the asteroid's reflected light to figure out what the asteroid is made of — a clue to its origins. — *Lisa Grossman*

MATTER & ENERGY

Light's weird dual nature weathers trip to space and back again

Light is two-faced: Sometimes it behaves like a wave, sometimes like a particle. Now, scientists have shown that light's shifty disposition persists even after trekking thousands of kilometers into space and back again, researchers report October 25 in *Science Advances*.

Depending on how light is measured, it can either be particle-like, lighting up a camera pixel, for example, or wavelike, interfering with other waves like ripples on the surface of water. It's one of the many oddities of quantum mechanics. Before light is measured, quantum theory suggests, it is in a particle-wave limbo, neither purely one nor the other.

Physicists have tested this idea by performing "delayed-choice" experiments, in which researchers send light into a device and randomly choose whether to flip a switch that seems to retroactively change the light's behavior. In one configuration, light travels down two paths at once and acts like a wave, interfering with itself. In the other, light acts like a particle, taking a single path. That choice of configuration can be made even after the light has traveled through the device but before being measured, revealing that light remains in quantum limbo until it is finally detected.

Now, Paolo Villoresi of the University of Padua in Italy and colleagues have taken the method into space. The team sent light through a ground-based apparatus and up to a satellite, which bounced the light back to the device. While the light was in transit, the team used a random number generator to determine whether to configure the apparatus so that the light would behave like a particle or wave. The light behaved as expected, verifying that quantum mechanics holds, even over a trip to space and back. — *Emily Conover*

EARTH & ENVIRONMENT

Dino-dooming asteroid impact created chilling sulfur cloud

The asteroid collision that may have doomed the dinosaurs really stank. Analysis of gases released from vaporized rocks at the impact site in modern-day Mexico suggests that the smashup released up to three times as much smelly, climate-cooling sulfur as once thought.

The Chicxulub impact spewed roughly 325 billion tons of sulfur and 425 billion tons of carbon dioxide, scientists report October 31 in *Geophysical Research Letters*.

The CO_2 release might have contributed to long-term planetary warming. But the massive sulfur cloud would have more immediately blocked out the sun, the scientists suggest, plunging Earth into a dark Narnia-style winter that was colder and longer than previously thought. An extended winter could help explain why so many organisms went extinct, even those far from the impact (*SN: 2/4/17, p. 16*).

The study suggests the impact released much more sulfur and much less CO_2 compared with some estimates from 20 years ago. The new calculations incorporate a better understanding of the asteroid's angle of impact, the composition of the rocks and how much gas would reach high enough into the air to influence climate. — *Laurel Hamers*

The best selling auto-loading scooter in Europe is now available in the US!

Finally... A scooter that loads itself in and out of your car.

Shipping Included

Introducing the Quingo® Flyte - the powerful, portable mobility scooter that you never have to lift. Now featuring patented 5-Wheel Anti-Tip Technology.

It's a sad fact. Many people who have mobility issues and could benefit from a scooter aren't able to use them away from home. Struggling to get it into a car or loading it onto a bumper-mounted lift just isn't worth the effort. Now, there's a better scooter, the Quingo® Flyte. It's easy to use, even for one person, and requires no more effort than closing a car's tailgate. Clever design enables it to fit into SUV's, mini-vans, crossovers and hatchbacks.

Quingo® Flyte can load and unload itself in less than 60 seconds using an innovative ramp and a simple remote. The built-in guide rails can be installed in minutes and safely direct your scooter to ground level.

Only one scooter is this powerful and portable

- Patented 5-Wheel Stability™ by Quingo takes you almost anywhere.
- No dismantling or lifting of heavy scooter parts.
- Fits most SUV's, mini-vans, crossovers and hatchbacks.
- Large motor + up to 350 pound capacity.
- Extra long range with BIG scooter performance.
- Won't bounce around in your car– locks in place.

Available in portable, auto-loading and luxury models

"For the first time in years I've been able to go with my granddaughters to the mall. A crowd gathers every time I unload my scooter from my car!"

– Judi K, Exeter, CA

This scooter provides 5-Wheel Anti-Tip Technology for stability, agility and comfort with its unique wheel configuration. The patented 5-wheel Bumpmaster™ design by Quingo enables it to ride safely over a wide variety of surfaces. It uses 4 ultra slim powerful batteries providing a range of up to 23 miles on a single charge.

The best selling auto-loading scooter in Europe is now available in the US! Don't wait to take advantage of this exciting new technology, call today to find out more.

Quingo® flyte

featuring 5-Wheel Anti-Tip Technology

Call now toll free for our lowest price Shipping Included.

1-888-624-7182

See it in action at www.QuingoUSA.com

Please mention code 107529 when ordering.

83715

Big Moves

How Asian nomadic herders built new Bronze Age cultures

By Bruce Bower

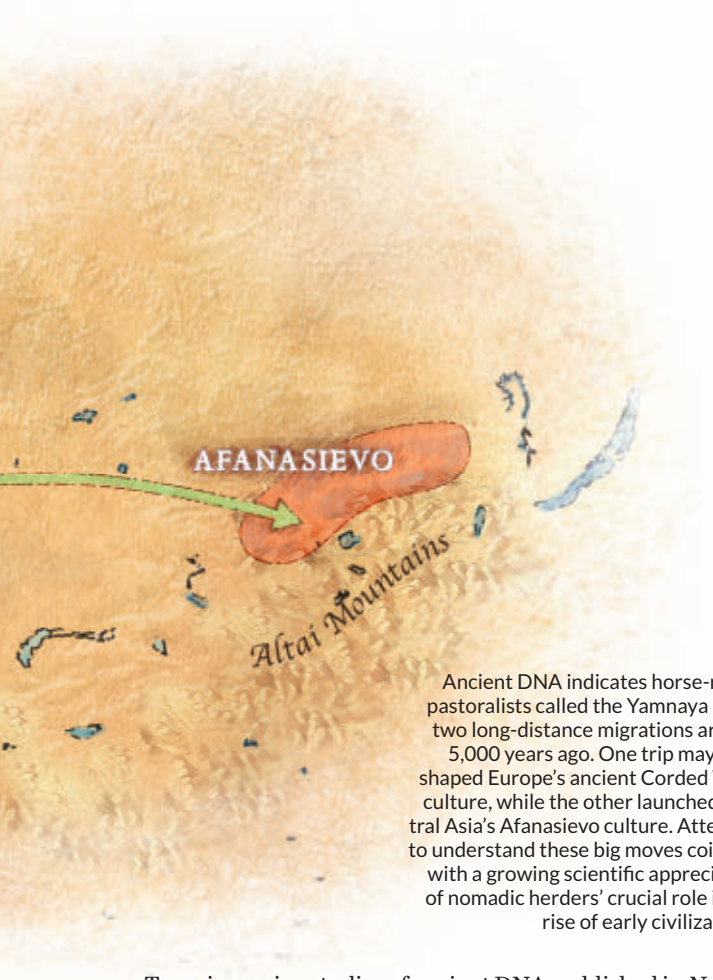
Nomadic herders living on western Asia's hilly grasslands made a couple of big moves east and west around 5,000 years ago. These were not typical, back-and-forth treks from one seasonal grazing spot to another. These people blazed new trails.

A technological revolution had transformed travel for ancient herders around that time. Of course they couldn't make online hotel reservations. Trip planners would have searched in vain for a Steppe Depot stocked with essential tools and supplies. The closest thing to a traveler's pit stop was a mountain stream and a decent grazing spot for cattle. Yet, unlike anyone before, these hardy people had the means to move — wheels, wagons and horses.

Here's how the journeys may have played out: At a time when rainfall dwindled and grasslands in western Asia turned brown, oxen-pulled wagons loaded with personal belongings rolled west, following greener pastures into central and northern Europe. Other carts rumbled east as far as Siberia's Altai Mountains, where Russia, China, Mongolia and Kazakhstan meet today. Families of men, women and children may have piled on board. Or travelers may have been mostly men, who married women from farming villages along the way. Cattle, sheep and goats undoubtedly trailed along with whoever made these trips, under the watchful guidance of horse riders. Wagons served as mobile homes while on the move and during periodic stops to let animals graze.

These journeys, by people now known as the Yamnaya, transformed human genes and cultures across a huge swath of Europe and Asia. Yamnaya people left their mark from Ireland to China's western border, across roughly 4,000 kilometers.

MESA SCHUMACHER



Ancient DNA indicates horse-riding pastoralists called the Yamnaya made two long-distance migrations around 5,000 years ago. One trip may have shaped Europe's ancient Corded Ware culture, while the other launched central Asia's Afanasievo culture. Attempts to understand these big moves coincide with a growing scientific appreciation of nomadic herders' crucial role in the rise of early civilizations.

Two pioneering studies of ancient DNA, published in *Nature* in 2015, unveiled the Yamnaya people's big moves. Getting those results was a pivotal moment for researchers who study the Eurasian Bronze Age, which stretched from around 5,000 to 3,000 years ago. Those two millennia witnessed the rise of metalworking, writing systems and other signature features of urban civilizations.

Now new papers try to explain how Yamnaya DNA made major inroads into Bronze Age Europe during the first 200 to 300 years of that key period. The two studies differ on whether the Yamnaya influenced European cultures and languages in one big sweep or over an extended period.

A mobile web

Researchers have often overlooked these Yamnaya nomads and other herding cultures as early forces of globalization. But archaeological evidence increasingly portrays Bronze Age pastoralists — who moved their cattle and campsites from one seasonal grazing spot to another — as a web of mobile societies that formed an intercontinental communication system. Research at sites across Asia's grasslands, foothills and mountain ranges indicates that these herders forged extensive trade networks crucial to the rise of agricultural states. Herders still thrive in several parts of the world today, providing a variety of services to towns across remote, mountainous parts of Asia.

Granting special status to ancient pastoralists as civilization builders is not a new idea. In the 1950s and 1960s, prominent archaeologists argued that horse-riding pastoralists launched a series of migrations out of their homeland, the Pontic-Caspian steppe region north of the Black Sea, from roughly 6,000 to 3,000 years ago. Those archaeologists saw these pastoralists as fierce nomadic warriors who spread the lifestyle, beliefs and language of what is known as Kurgan culture to farmers and foragers in Europe and parts of Asia. Kurgan groups, which included the Yamnaya, were known for burying their people in graves covered by dirt mounds. These groups had no writing system but spoke an early version of modern Indo-European languages, some archaeologists have argued. Indo-European tongues today include English, Spanish, Russian and Bengali, among more than 400 others.

By the 1980s, a different perspective took hold. Researchers proposed that Bronze Age European cultures and languages changed as ideas passed from one group to another. Europeans didn't form families with wayfaring, or marauding, pastoralists. Instead, locals adopted outsiders' practices as needed, but the natives kept their genes to themselves.

Proponents of that "migrating ideas" perspective take a cautious view of Yamnaya DNA in Europe. Genetic signatures of past migrations raise more questions than they answer, these researchers argue. DNA can't comment on why, say, Yamnaya people moved in the first place. The size of westward and eastward migrations and ways in which each passage unfolded over several centuries also remain mysterious. Perhaps most crucially, sets of genes shared by distant populations can't explain how ancient cultures and languages changed over time.

Despite the uncertainties, the Yamnaya's wandering DNA makes one thing clear, says Eske Willerslev, an evolutionary geneticist at the University of Copenhagen. "Bronze Age pastoralists moved long distances for a long time and had an important impact on European and central Asian civilizations." Willerslev directed one of the 2015 Yamnaya investigations. A team led by Harvard Medical School geneticist David Reich conducted the other study. Efforts to flesh out how ancient herders became movers and shakers in the rise of civilization are now in full swing, as evidenced by a range of new papers.

Traveling genes

Willerslev's and Reich's ancient DNA investigations, conducted independently in collaboration with different sets of archaeologists, reached the same conclusion: Yamnaya people reshaped central and northern Europeans' DNA within a couple of hundred years after starting the journey west as early as 5,100 years ago. That came as a surprise to both research groups.

The smoking gun: DNA extracted from a total of 195 skeletons of Bronze Age northern and central Europeans in the two studies showed that those who lived between 4,900 and 4,400 years ago possessed a remarkably large amount of Yamnaya DNA. Yamnaya people contributed about 75 percent

of the ancestry of those farmers, the scientists concluded.

Ancient Europeans with Yamnaya heritage belonged to what archaeologists call the Corded Ware culture, known for decorating pottery by pressing ropes into still-soft clay and making stone battle-axes. Yamnaya newcomers took the lead in creating the Corded Ware culture after reaching central and northern Europe, proposes archaeologist David Anthony of Hartwick College in Oneonta, N.Y.

"We never would have known that Yamnaya people produced two distinct cultures by looking at archaeological finds alone," says Anthony, who coauthored the 2015 paper by Reich's group. Absent a genetic link, it would look like the Yamnaya, who previously had made nothing resembling Corded Ware pottery or battle-axes, had no hand in Corded Ware culture.

Population declines among European farmers and foragers around 5,000 years ago (*SN: 11/2/13, p. 12*), possibly due to epidemics (*SN: 11/28/15, p. 7*), may have enabled incoming Yamnaya to exert such influence. First, migrating herders sent war bands of teenage boys as advance forces to settle European territories (*SN Online: 8/7/17*), a team led by Kristian Kristiansen of the University of Gothenburg in Sweden proposed in the April *Antiquity*. The rest of the migrants arrived soon after, the researchers suspect. Yamnaya men then married women from local groups, possibly by abducting them. Kristiansen coauthored the 2015 paper by Willerslev's group.

Corded Ware culture emerged as a hybrid way of life that included crop cultivation, breeding of farm animals and some hunting and gathering, Kristiansen argues. Communal living structures and group graves of earlier European farmers were replaced by smaller structures suitable for families and single graves covered by earthen mounds. Yamnaya families had lived out of their wagons even before trekking to Europe. A shared emphasis on family life and burying the dead individually indicates that members of the Yamnaya and Corded Ware cultures kept possessions among close relatives, in Kristiansen's view.

"The Yamnaya and the Corded Ware culture were unified by a new idea of transmitting property between related individuals and families," Kristiansen says.

Excavations at seasonal settlements of ancient herders in Kazakhstan indicate consistent cultural practices throughout much of the Bronze Age. Examples include pottery unearthed at a site dating to about 3,900 to 3,600 years ago.

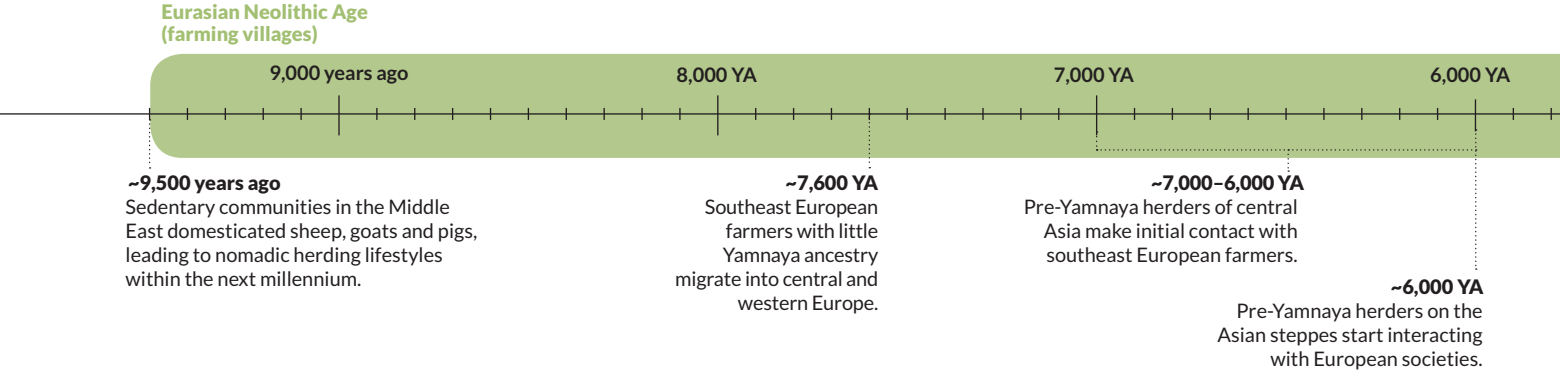
Yamnaya migrants must have spoken a fledgling version of Indo-European languages that later spread across Europe and parts of Asia, Kristiansen's group contends. Anthony, a longtime Kristiansen collaborator, agrees. Reconstructed vocabularies for people of the Corded Ware culture include words related to wagons, wheels and horse breeding that could have come only from the Yamnaya, Anthony says.

As Indo-European languages spread, the Yamnaya's genetic impact in Europe remained substantial, even after the disappearance of Corded Ware culture around 4,400 years ago, Reich's team reported online May 9 at bioRxiv.org. About 50 percent of the ancestry of individuals from a later Bronze Age culture, dubbed the Bell Beaker culture for its pottery vessels shaped like an inverted bell, derived from Yamnaya stock. Such pottery spread across much of Europe starting nearly 4,770 years ago and disappeared by 3,800 years ago. Migrations of either people or ideas may have accounted for that dispersal.

Even today, DNA from modern western, central and northern Europeans carries close to a 50 percent genetic contribution from the Yamnaya, Reich's team reported in 2015.

PAULA N.D. DUPUY, DMAP, KAZAKHSTAN

Follow the herd The road from early farming villages to the first large-scale civilizations in Europe and Asia intersected with the continent-spanning travels of Asian nomadic herders. Genetic studies have highlighted the role of pastoralists known as the Yamnaya, who influenced European and Asian cultures at least 5,000 years ago.



Many contacts, not one

Like many of his colleagues, archaeologist Volker Heyd of the University of Bristol in England was jolted by the 2015 reports of a close genetic link between Asian herders and a Bronze Age culture considered native to Europe. But, Heyd says, the story of ancient Yamnaya migrations is more complex than the rapid-change scenario sketched out by Kristiansen and Anthony.

No evidence exists that Yamnaya people rapidly developed practices typical of the Corded Ware culture in one part of Europe, Heyd argues in the April *Antiquity*. Cultural shifts in Europe around 5,000 years ago must have emerged from an extended series of small-scale dealings with Yamnaya and other pastoralists, which was then capped off by a large influx of steppe wagon travelers, he says.

For instance, individual graves and other signs of contact with the Yamnaya people and even earlier Asian pastoralists appear in Europe 1,000 to 2,000 years before DNA-transforming migrations occurred. Consider that the Yamnaya account for 5 percent of the ancestry of Ötzi the Iceman, who lived in southeastern Europe roughly 300 years before the Yamnaya's big move (*SN: 5/27/17, p. 13*). Little is known about those earlier encounters.

Efforts to decipher ties between Yamnaya and Corded Ware culture are complicated by the fact that DNA is available from just a few people from each group, says Heyd, who is currently excavating Yamnaya graves in Hungary. Ancient DNA samples analyzed in the 2015 papers come from only a handful of Yamnaya and Corded Ware culture sites in a few parts of Europe and Russia.

Heyd suspects that Yamnaya travelers had even earlier contacts, perhaps by 5,400 years ago, with central and eastern Europeans known for making globe-shaped pots with small handles. Individuals from that culture, excavated at two sites in Poland and Ukraine, possess no Yamnaya genes, a team affiliated with Reich's lab reported online May 9 at bioRxiv.org. But Heyd thinks mating between members of that European culture and Yamnaya migrants may have occurred a bit farther east, where cross-cultural contacts probably occurred at the boundary of European forests and Asian grasslands.

Other genetic clues point to a long history of Asian pastoralists crossing into parts of Europe. Small amounts of DNA from steppe herders, possibly the Yamnaya, appeared in three hunter-gatherer skeletons from southeastern Europe dating to as early as around 6,500 years ago.

DNA from many more Bronze Age people is needed to untangle relationships between migrating pastoralists and European groups they encountered, Heyd says. Further muddling matters, only about 5 percent of Yamnaya burials still exist, he estimates. Soviet-era construction projects in the 20th century destroyed a huge chunk of the rest.

Heyd's skepticism of the Yamnaya's singular contribution to Corded Ware culture makes sense, says archaeologist Ursula Brosseder of the University of Bonn in Germany. "Cultural phenomena, such as the Corded Ware culture, cannot be linked one-to-one to ethnic groups, genetic population groups or languages," she says. Brosseder, who studies ancient European cultures, also doubts that the rise of Indo-European languages, which are so dominant in much of the world today, can be attributed to one population of migrating herders.

Southern exposure

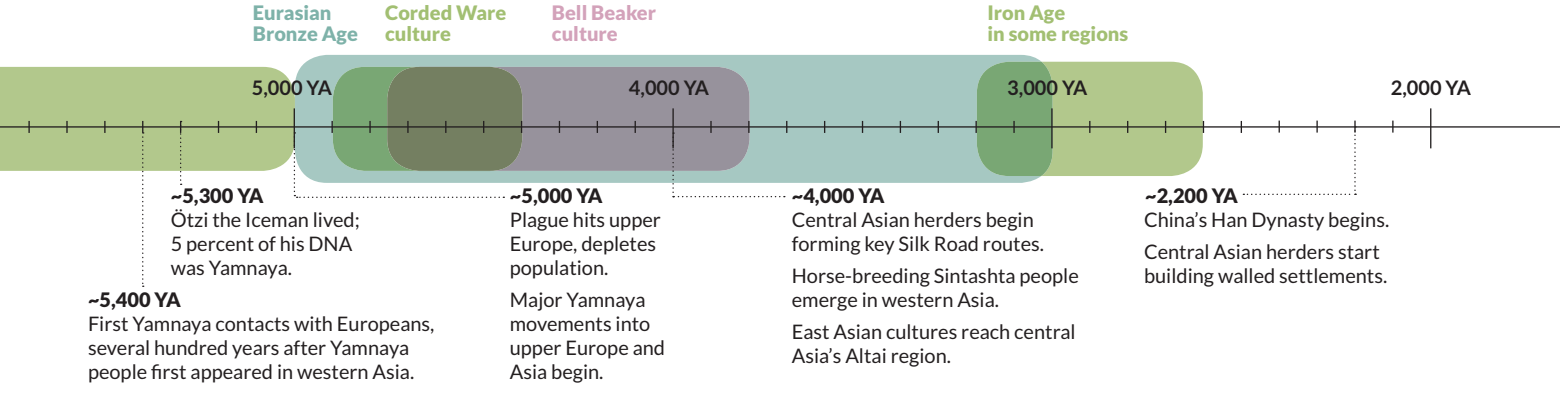
Brosseder and other critics of major Yamnaya migrations as game changers paint a different, two-pronged picture of what might have happened in Bronze Age Europe.

The story begins in the Middle East when farmers who spoke Indo-European languages domesticated goats and other animals 6,000 years ago or earlier. Animal breeding quickly gave rise to pastoralists, including the Yamnaya.

Around 5,000 years ago, a plague wiped out many farmers and foragers in upper parts of Europe. Herders migrated west to find better grazing pastures as a hotter, drier climate parched the central Asian steppes. In central and northern Europe, travelers encountered sparse populations struggling to survive. Natives adopted the newcomers' early Indo-European language and married them.

But a second wave of influence came from the south, at the same time or perhaps a bit earlier. Related Indo-European languages spread via farmers moving out of Mediterranean areas and Anatolia (now Turkey) to lower parts of Europe and to southern Asia. Those cultivators had nothing to do with the Yamnaya's big move and rarely mated with the herders.

Support for this scenario comes from 19 Bronze Age



TIMELINE: C. CHANG

farmers found in Crete, Greece and Turkey. These people's DNA was largely inherited from earlier farmers in western Anatolia and the Aegean, a team led by Harvard Medical School geneticist Iosif Lazaridis reported in the Aug. 10 *Nature*. Low amounts of Yamnaya ancestry, from 9 to 32 percent, appeared among these individuals.

That and other genetic studies of southeastern Europeans "suggest that some, but not all, branches of Indo-European [languages] came from steppe peoples," says linguist Paul Heggarty of the Max Planck Institute for the Science of Human History in Jena, Germany. Indo-European speakers past and present display a variety of genetic patterns over a huge geographic area, raising doubts about any simple explanation for the spread of this language family, Heggarty holds.

The scenario above, although not confirmed, conveys the complexity of Eurasian population movements and cultures that spread Indo-European languages, says archaeologist Colin Renfrew of the University of Cambridge. Renfrew proposed 30 years ago that Anatolian farmers carried an early Indo-European tongue into Europe starting perhaps 9,000 years ago. His influential argument rejected the idea that waves of migrating herders had reshaped language and culture.

In line with his ideas, genetic data in the 2015 reports indicated that farming groups from southeastern Europe and Anatolia had moved into the heart of Europe more than 6,000 years ago, where hunter-gatherers already lived. When Yamnaya DNA arrived, sets of gene variants typical of those farmers and hunter-gatherers plummeted.

But the 2015 Yamnaya papers also shifted Renfrew's thinking. He now accepts that Asian pastoralists reached central and northern parts of Europe around 5,000 years ago. What happened next, especially in southern Europe where the Yamnaya didn't leave a big mark, is unclear. "The genetic origins of Bronze Age people in Anatolia, which was a royal road into Europe, are almost a complete blank," he says. The same goes for the origins of members of the Bronze Age Indus Valley Civilization in southern Asia, where an early form of Indo-European languages may have been spoken.

Eastern moves

Even with all the questions surrounding the Yamnaya's western migration, perhaps the biggest mystery of all concerns what happened when these people moved east to central Asia's Altai Mountains.

Willerslev's team reported in 2015 that ancient DNA from early Bronze Age individuals who belonged to a poorly understood culture in the Altai region was virtually 100 percent identical to 5,000-year-old Yamnaya DNA. Yamnaya migrants may have developed that southern Siberian culture, known as Afanasievo culture, entirely on their own, making an even bigger impact than Yamnaya peers did on Europe's Corded Ware culture, the team concluded.

From southern Siberia, ancient people with Yamnaya roots may have brought one of the oldest and most poorly understood Indo-European languages, Tocharian, to inhabitants of what's now western China, the researchers speculated.

Whatever happened, central Asia was a hotbed of Bronze Age population movements, Willerslev and colleagues emphasized. After emerging around 4,000 years ago, western Asia's horse-breeding Sintashta people gave rise to a distinct culture in the Altai region a few hundred years later, the team reported based on DNA from 40 Bronze Age Asians. Ancient DNA similarities indicated that mating had occurred between Sintashta migrants and Altai people they encountered. Around 3,500 years ago, several eastern Asian cultures reached the Altai region and became dominant, genetic findings further suggested.

Archaeologist Michael Frachetti of Washington University in St. Louis doesn't doubt that different populations of Bronze Age herders continually moved through the heart of Asia. Research directed by Frachetti indicates that herders' seasonal migrations through mountainous regions starting 4,000 years ago created key Silk Road routes over the next two millennia (*SN: 4/15/17, p. 9*).

But researchers still know little about the genetic structure and daily lives of ancient Asian people such as the Yamnaya and various Altai communities, Frachetti cautions. It's not even clear whether excavated remains of Yamnaya people represent one culture or several cultures, he contends.

"From the Caspian Sea to China, many questions remain about Bronze Age pastoralists," Frachetti says. He is now collaborating with Reich's team on an

Graves from Europe's Corded Ware culture (left) and western Asia's Yamnaya culture (right) display similarities such as solo burials. Some researchers regard such similarities as signs of Yamnaya herders' momentous influence on European farmers around 5,000 years ago.

FROM LEFT: STATE OFFICE FOR HERITAGE MANAGEMENT AND ARCHAEOLOGY SAXONY-ANHALT, JURAJ LIPTÁK; PIOTR WŁODARCZAK

analysis of DNA from individuals previously excavated at Bronze Age sites in central and eastern Asia dating to around the time of Europe's Bronze Age.

Herders without borders

One thing is for sure: Ancient nomadic pastoralists are shedding their reputation as "barbarians" obsessed with raiding and warfare. That generalization got its start in early agricultural societies exposed to herders' raids and conflicts in border regions. Armed with writing systems, farming civilizations recorded one-sided accounts of nomadic groups as mounted savages.

Archaeological discoveries now suggest Bronze Age pastoralists specialized in intercontinental communication. Around 5,000 years ago, nomadic communities began to exchange knowledge, food and metalworking technology across increasingly vast stretches of Asia. Nomadic groups were the first engines of globalization, connecting agricultural civilizations in southwestern and eastern Asia via mountain valleys running across the continent, Frachetti says.

Ancient pastoralists relied on crops to some degree. A Bronze Age herder campsite in Kazakhstan yielded (from top) grains of broomcorn millet, peas, barley and wheat.

Herders moving through those valleys brought southwestern Asian crops into China and eastern Asian crops back the other way, says archaeologist Robert Spengler of the Max Planck Institute for the Science of Human History. While working their way across Asia through mountain valleys, pastoralists incorporated crops into their own way of life.

Seeds found at two herder campsites in Kazakhstan show that people there used bread wheat from southwest Asia and broomcorn millet from eastern Asia between 4,800 and 4,300 years ago (*SN: 5/3/14, p. 15*). These grains, found in small amounts, may have been eaten or employed in rituals of some kind.

Herders at 17 Kazakhstan sites dating to around 3,800 to 2,800 years ago ate fish as well as meat, and cultivated increasing amounts of millet over time. Archaeologist Emma Lightfoot of the University of Cambridge and colleagues analyzed chemical signatures of different types of food consumption in the bones of people from those Bronze and early Iron Age campsites. The results appeared in 2015 in *Archaeometry*.

Pastoralists also spread key ideas about life and death, as represented in burial practices across Bronze Age Asia, Frachetti contends. Graves of Bronze Age agricultural societies and pastoralist communities — stretching from south-central Asian deltas to central Asian steppes and western China's Xinjiang desert region — display common ways of interring the dead that can't be coincidental, he says. Those graves date to between around 4,200 and 3,500 years ago. Shared burial practices included placing dead bodies in a curled, sleeping position and providing the dead with special items for the afterlife, such as pottery vessels or baskets that contained food and various bronze objects, particularly jewelry, weapons and mirrors.

Ancient pastoralists moved complex settlements from one location to another while traveling with their herds between around 2,200 and 700 years ago, says archaeologist J. Daniel Rogers of the Smithsonian National Museum of Natural History in Washington, D.C. These steppe societies, which clustered in what's now Mongolia and northwestern China, frequently built walled settlements in river valleys along seasonal herding corridors.

Groups moving among seasonal grazing sites assembled temporary tent communities inside these spacious walled areas, Rogers concluded in the September *Archaeological Research in Asia*. Mobile communities included rulers, craft workers and even administrative personnel, he proposes.

Pastoralist and agricultural civilizations traded goods and ideas, even if conflicts sometimes broke out along the borders of the routes herders traveled. Frachetti adds, "Pastoralists formed their own brand of civilization based on mobility to keep their economies growing and people fed."

Outlasting civilizations

Few ancient or living pastoralists can be called classic nomads, moving constantly across the landscape. The number and length of annual migrations varies greatly from one group to another, says archaeologist Nikolay Kradin of the Far Eastern Branch of the Russian Academy of Sciences in Vladivostok. But herders today move at least once or twice a year to seasonal grazing spots.

Despite Soviet-era attempts to force Asian pastoralists to become farmers, about 40 million people currently engage in mobile herding in Asia, Africa and the Middle East, Kradin estimates. Dry grasslands and desert areas conducive to pastoralism cover about 25 percent of Earth's land surface, he says.

Mountain pastoralists in central Asia maintain valuable herds, some worth hundreds of thousands of dollars, Frachetti says. In their treks along mountain valleys that still serve as an unofficial highway connecting remote towns, herders provide lambs to slaughter for weddings, act as couriers between settled regions and create widespread social and family networks through marriage, business deals and trade.

Asian herders continue to specialize in mobility and networking across vast areas. These groups represent "nerve centers" for town dwellers dotting Asian valleys and mountain ranges.

"Mountain pastoralists of inner Asia don't need Artificial Intelligence to survive," Frachetti says. "They'll still be around when the major civilizations today melt into the ocean." The Yamnaya, whose genes have outlasted a bevy of Bronze Age cultures, would undoubtedly agree. ■

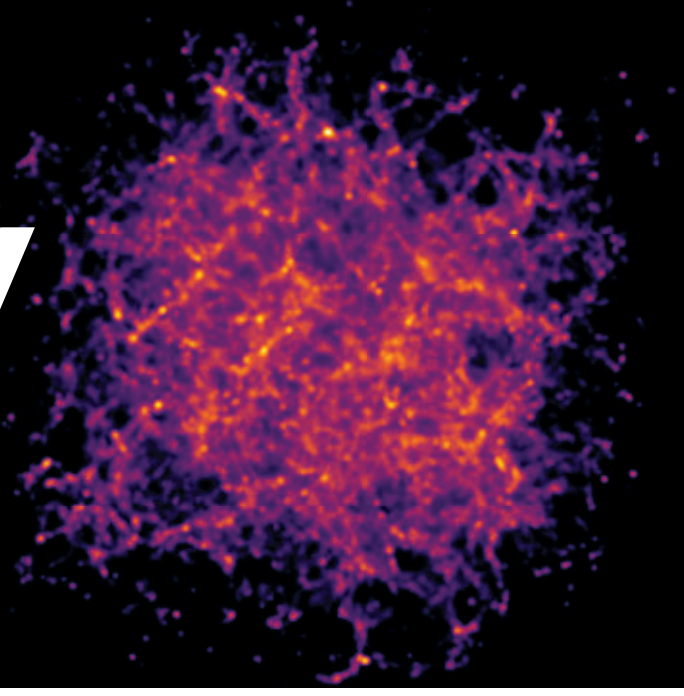
Explore more

- Kristian Kristiansen *et al.* "Re-theorising mobility and the formation of culture and language among the Corded Ware culture in Europe." *Antiquity*. April 2017.

P. DOUMANI ET AL/ARCHAEOLOGICAL RESEARCH IN ASIA 2015

FEATURE

Adventures in Lumpy Space



A lumpy universe, recently simulated using general relativity, shows clumps of matter (pink and yellow) that beget stars and galaxies.

H. MACPHERSON, PAUL LASKY, DANIEL PRICE

Simulating the universe using Einstein's theory of gravity may solve cosmic puzzles

By Emily Conover

If the universe were a soup, it would be more of a chunky minestrone than a silky-smooth tomato bisque.

Sprinkled with matter that clumps together due to the insatiable pull of gravity, the universe is a network of dense galaxy clusters and filaments — the hearty beans and vegetables of the cosmic stew. Meanwhile, relatively desolate pockets of the cosmos, known as voids, make up a thin, watery broth in between.

Until recently, simulations of the cosmos's history haven't given the lumps their due. The physics of those lumps is described by general relativity, Albert Einstein's theory of gravity. But that theory's equations are devilishly complicated to solve. To simulate how the universe's clumps grow and change, scientists have fallen back on approximations, such as the simpler but less accurate theory of gravity devised by Isaac Newton.

Relying on such approximations, some physicists suggest, could be mucking with measurements, resulting in a not-quite-right inventory of the cosmos's contents. A rogue band of physicists suggests that a proper accounting of the universe's clumps could explain one of the deepest mysteries in physics: Why is the universe expanding at an increasingly rapid rate?

The accepted explanation for that accelerating expansion is an invisible pressure called dark energy. In the standard theory of the universe, dark energy makes up about 70 percent of the universe's "stuff" — its matter and energy. Yet scientists still aren't sure what dark energy is, and finding its source is one of the most vexing problems of cosmology.

Perhaps, the dark energy doubters suggest, the speeding up of the expansion has nothing to do with dark energy. Instead, the universe's clumpiness may be mimicking the presence of such an ethereal phenomenon.

Most physicists, however, feel that proper accounting for the clumps won't have such a drastic impact. Robert Wald of the University of Chicago, an expert in general relativity, says that lumpiness is "never going to contribute anything that looks like dark energy." So far, observations of the universe have been remarkably consistent with predictions based on simulations that rely on approximations.

As observations become more detailed, though, even slight inaccuracies in simulations could become troublesome. Already, astronomers are charting wide swaths of the sky in great detail, and planning more extensive surveys. To translate telescope images of starry skies into estimates of properties such as the amount of matter in the universe, scientists need accurate simulations of the cosmos's history. If the detailed physics of clumps is important, then simulations could go slightly astray, sending estimates off-kilter. Some scientists already suggest that the lumpiness is behind a puzzling mismatch of two estimates of how fast the universe is expanding.

Researchers are attempting to clear up the debate by conquering the complexities of general relativity and simulating the cosmos in its full, lumpy glory. "That is really the new frontier," says cosmologist Sabino Matarrese of the University of Padua in Italy, "something that until a few years ago was considered to be science fiction." In the past, he says, scientists didn't have the tools to complete such simulations. Now researchers are sorting out the implications of the first published results of the new simulations. So far, dark energy hasn't been explained away, but some simulations suggest that certain especially sensitive measurements of how light is bent by

matter in the universe might be off by as much as 10 percent.

Soon, simulations may finally answer the question: How much do lumps matter? The idea that cosmologists might have been missing a simple answer to a central problem of cosmology incessantly nags some skeptics. For them, results of the improved simulations can't come soon enough. "It haunts me. I can't let it go," says cosmologist Rocky Kolb of the University of Chicago.

Smooth universe

By observing light from different eras in the history of the cosmos, cosmologists can compute the properties of the universe, such as its age and expansion rate. But to do this, researchers need a model, or framework, that describes the universe's contents and how those ingredients evolve over time. Using this framework, cosmologists can perform computer simulations of the universe to make predictions that can be compared with actual observations.

After Einstein introduced his theory in 1915, physicists set about figuring out how to use it to explain the universe. It wasn't easy, thanks to general relativity's unwieldy, difficult-to-solve suite of equations. Meanwhile, observations made in the 1920s indicated that the universe wasn't static as previously expected; it was expanding. Eventually, researchers converged on a solution to Einstein's equations known as the Friedmann-Lemaître-Robertson-Walker metric. Named after its discoverers, the FLRW metric describes a simplified universe that is homogeneous and isotropic, meaning that it appears identical at every point in the universe and in every direction. In this idealized cosmos, matter would be evenly distributed, no clumps. Such a smooth universe would expand or contract over time.

A smooth-universe approximation is sensible, because when we look at the big picture, averaging over the structures of galaxy clusters and voids, the universe is remarkably uniform. It's similar to the way that a single spoonful of minestrone soup might be mostly broth or mostly beans, but from bowl to bowl, the overall bean-to-broth ratios match.

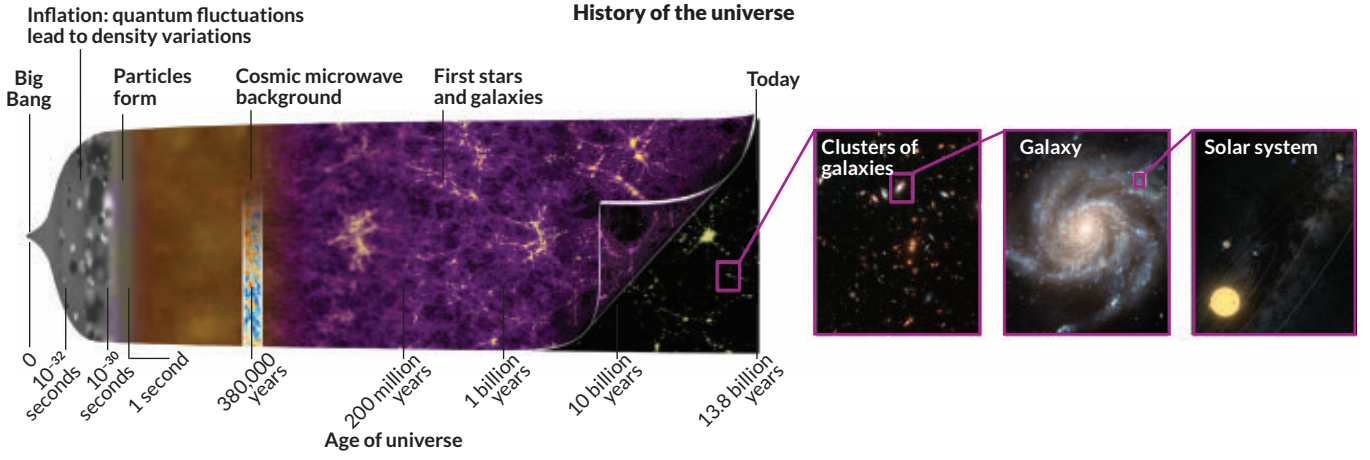
In 1998, cosmologists revealed that not only was the universe expanding, but its expansion was also accelerating (*SN: 2/2/08, p. 74*). Observations of distant exploding stars, or supernovas, indicated that the space between us and them was expanding at an increasing clip. But gravity should slow the expansion of a universe evenly filled with matter. To account for the observed acceleration, scientists needed another ingredient, one that would speed up the expansion. So they added dark energy to their smooth-universe framework.

Now, many cosmologists follow a basic recipe to simulate the universe — treating the cosmos as if it has been run through an imaginary blender to smooth out its lumps, adding dark energy and calculating the expansion via general relativity. On top of the expanding slurry, scientists add clumps and track their growth using approximations, such as Newtonian gravity, which simplifies the calculations.

In most situations, Newtonian gravity and general relativity are near-twins. Throw a ball while standing on the surface of the Earth, and it doesn't matter whether you use general relativity or Newtonian mechanics to calculate where the ball will land — you'll get the same answer. But there are subtle differences. In Newtonian gravity, matter directly attracts other matter. In general relativity, gravity is the result of matter and energy warping spacetime, creating curves that alter the motion of objects (*SN: 10/17/15, p. 16*). The two theories diverge in extreme gravitational environments. In general relativity, for example, hulking black holes produce inescapable pits that reel in light and matter (*SN: 5/31/14, p. 16*). The question, then, is whether the difference between the two theories has any impact in lumpy-universe simulations.

Most cosmologists are comfortable with the status quo simulations because observations of the heavens seem to fit

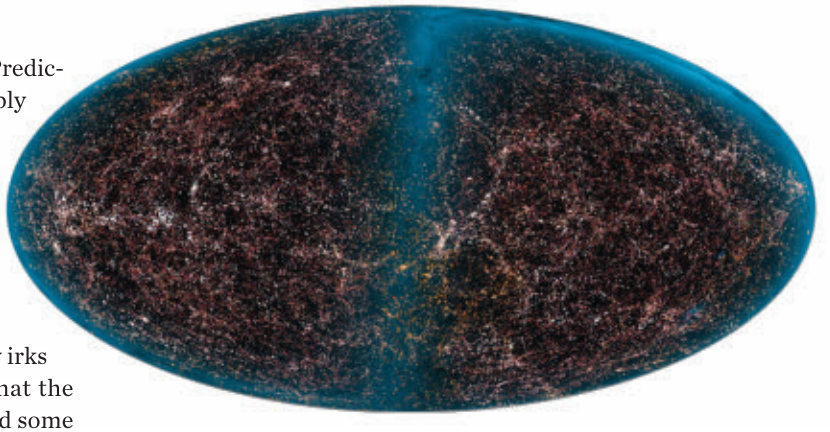
Growing a lumpy universe The universe has gradually grown lumpier throughout its history. During inflation, rapid expansion magnified tiny quantum fluctuations into minute density variations. Over time, additional matter glommed on to dense spots due to the stronger gravitational pull from the extra mass. After 380,000 years, those blips were imprinted as hot and cold spots in the cosmic microwave background, the oldest light in the universe. Lumps continued growing for billions of years, forming stars, planets, galaxies and galaxy clusters.



C. CARREAU/ESA

neatly together like interlocking jigsaw puzzle pieces. Predictions based on the standard framework agree remarkably well with observations of the cosmic microwave background — ancient light released when the universe was just 380,000 years old (*SN: 3/21/15, p. 7*). And measurements of cosmological parameters — the fraction of dark energy and matter, for example — are generally consistent, whether they are made using the light from galaxies or the cosmic microwave background.

However, the reliance on Newton's outdated theory irks some cosmologists, creating a lingering suspicion that the approximation is causing unrecognized problems. And some cosmological question marks remain. Physicists still puzzle over what makes up dark energy, along with another unexplained cosmic constituent, dark matter, an additional kind of mass that must exist to explain observations of how galaxies and galaxy clusters rotate. "Both dark energy and dark matter are a bit of an embarrassment to cosmologists, because they have no idea what they are," says cosmologist Nick Kaiser of École Normale Supérieure in Paris.



An image from the Two-Micron All Sky Survey of 1.6 million galaxies in infrared light reveals how matter clumps into galaxy clusters and filaments. Future large-scale surveys may require improved simulations that use general relativity to track the evolution of lumps over time.

Dethroning dark energy

Some cosmologists hope to explain the universe's accelerating expansion by fully accounting for the universe's lumpiness, with no need for the mysterious dark energy.

These researchers argue that clumps of matter can alter how the universe expands, when the clumps' influence is tallied up over wide swaths of the cosmos. That's because, in general relativity, the expansion of each local region of space depends on how much matter is within. Voids expand faster than average; dense regions expand more slowly. Because the universe is mostly made up of voids, this effect could produce an overall expansion and potentially an acceleration. Known as backreaction, this idea has lingered in obscure corners of physics departments for decades, despite many claims that backreaction's effect is small or nonexistent.

Backreaction continues to appeal to some researchers because they don't have to invent new laws of physics to explain the acceleration of the universe. "If there is an alternative which is based only upon traditional physics, why throw that away completely?" Matarrese asks.

Most cosmologists, however, think explaining away dark energy just based on the universe's lumps is unlikely. Previous calculations have indicated any effect would be too small to account for dark energy, and would produce an acceleration that changes in time in a way that disagrees with observations.

"My personal view is that it's a much smaller effect," says astrophysicist Hayley Macpherson of Monash University in Melbourne, Australia. "That's just basically a gut feeling." Theories that include dark energy explain the universe extremely well, she points out. How could that be if the whole approach is flawed?

New simulations by Macpherson and others that model how lumps evolve in general relativity may be able to gauge the importance of backreaction once and for all. "Up until now, it's just been too hard," says cosmologist Tom Giblin of Kenyon College in Gambier, Ohio.

To perform the simulations, researchers needed to get their hands on supercomputers capable of grinding through the equations of general relativity as the simulated universe evolves over time. Because general relativity is so complex, such simulations are much more challenging than those that use approximations, such as Newtonian gravity. But, a seemingly distinct topic helped lay some of the groundwork: gravitational waves, or ripples in the fabric of spacetime.

The Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, searches for the tremors of cosmic dustups such as colliding black holes (*SN: 10/28/17, p. 8*). In preparation for this search, physicists honed their general relativity skills on simulations of the spacetime storm kicked up by black holes, predicting what LIGO might see and building up the computational machinery to solve the equations of general relativity. Now, cosmologists have adapted those techniques and unleashed them on entire, lumpy universes.

The first lumpy universe simulations to use full general relativity were unveiled in the June 2016 *Physical Review Letters*. Giblin and colleagues reported their results simultaneously with Eloisa Bentivegna of the University of Catania in Italy and Marco Bruni of the University of Portsmouth in England.

So far, the simulations have not been able to account for the universe's acceleration. "Nearly everybody is convinced [the effect] is too small to explain away the need for dark energy," says cosmologist Martin Kunz of the University of Geneva. Kunz and colleagues reached the same conclusion in their lumpy-universe simulations, which have one foot in general relativity and one in Newtonian gravity. They reported their first results in *Nature Physics* in March 2016.

Backreaction aficionados still aren't dissuaded. "Before saying the effect is too small to be relevant, I would, frankly, wait a little bit more," Matarrese says. And the new simulations have potential caveats. For example, some simulated universes behave like an old arcade game — if you walk to one edge of the

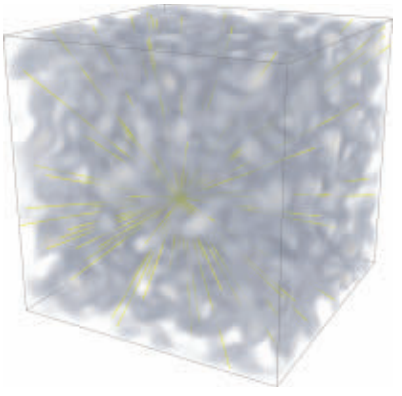
T.H. JARRETT, J. CARPENTER & R. HURT, OBTAINED AS PART OF 2MASS, A JOINT PROJECT OF UNIV. OF MASSACHUSETTS AND THE INFRARED PROCESSING AND ANALYSIS CENTER/CALTECH, FUNDED BY NASA AND NSF

universe, you cross back over to the other side, like Pac-Man exiting the right side of the screen and reappearing on the left. That geometry would suppress the effects of backreaction in the simulation, says Thomas Buchert of the University of Lyon in France. "This is a good beginning," he says, but there is more work to do on the simulations. "We are in infancy."

Different assumptions in a simulation can lead to disparate results, Bentivegna says. As a result, she doesn't think that her lumpy, general-relativistic simulations have fully closed the door on efforts to dethrone dark energy. For example, tricks of light might be making it seem like the universe's expansion is accelerating, when in fact it isn't.

When astronomers observe far-away sources like supernovas, the light has to travel past all of the lumps of matter between the source and Earth. That journey could make it look like there's an acceleration when none exists. "It's an optical illusion," Bentivegna says. She and colleagues see such an effect in a simulation reported in March in the *Journal of Cosmology and Astroparticle Physics*. But, she notes, this work simulated an unusual universe, in which matter sits on a grid — not a particularly realistic scenario.

For most other simulations, the effect of optical illusions remains small. That leaves many cosmologists, including Giblin, even more skeptical of the possibility of explaining away dark energy: "I feel a little like a downer," he admits.



Lumps (gray) within this simulated universe change the path light takes (yellow lines), potentially affecting observations. Matter bends space, slightly altering the light's trajectory from that in a smooth universe.

JAMES MERTENS

Surveying the skies

Subtle effects of lumps could still be important. In Hans Christian Andersen's "The Princess and the Pea," the princess felt a tiny pea beneath an impossibly tall stack of mattresses. Likewise, cosmologists' surveys are now so sensitive that even if the universe's lumps have a small impact, estimates could be thrown out of whack.

The Dark Energy Survey, for example, has charted 26 million galaxies using the Victor M. Blanco Telescope in Chile, measuring how the light from those galaxies is distorted by the intervening matter on the journey to Earth. In a set of papers posted online August 4 at arXiv.org, scientists with the Dark Energy Survey reported new measurements of the universe's properties, including the amount of matter (both dark and normal) and how clumpy that matter is (*SN: 9/2/17, p. 32*). The results are consistent with those from the cosmic microwave background — light emitted billions of years earlier.

To make the comparison, cosmologists took the measurements from the cosmic microwave background, early in the universe, and used simulations to extrapolate to what galaxies should look like later in the universe's history. It's like taking a baby's photograph, precisely computing the number and size of wrinkles that should emerge as the child ages and finding that your picture agrees with a snapshot taken decades later. The matching results so far confirm cosmologists' standard picture of the universe — dark energy and all.

"So far, it has not yet been important for the measurements that we've made to actually include general relativity in those simulations," says Risa Wechsler, a cosmologist at Stanford University and a founding member of the Dark Energy Survey. But, she says, for future measurements, "these effects could become more important." Cosmologists are edging closer to Princess and the Pea territory.

Those future surveys include the Dark Energy Spectroscopic Instrument, DESI, set to kick off in 2019 at Kitt Peak National Observatory near Tucson; the European Space Agency's Euclid satellite, launching in 2021; and the Large Synoptic Survey Telescope in Chile, which is set to begin collecting data in 2023.

If cosmologists keep relying on simulations that don't use general relativity to account for lumps, certain kinds of measurements of weak lensing — the bending of light due to matter acting like a lens — could be off by up to 10 percent, Giblin and colleagues reported at arXiv.org in July. "There is something that we've been ignoring by making approximations," he says.

That 10 percent could screw up all kinds of estimates, from how dark energy changes over the universe's history to how fast the universe is currently expanding, to the calculations of the masses of ethereal particles known as neutrinos. "You have to be extremely certain that you don't get some subtle effect that gets you the wrong answers," Geneva's Kunz says, "otherwise the particle physicists are going to be very angry with the cosmologists."

Some estimates may already be showing problem signs, such as the conflicting estimates of the cosmic expansion rate (*SN: 8/6/16, p. 10*). Using the cosmic microwave background, cosmologists find a slower expansion rate than they do from measurements of supernovas. If this discrepancy is real, it could indicate that dark energy changes over time. But before jumping to that conclusion, there are other possible causes to rule out, including the universe's lumps.

Until the issue of lumps is smoothed out, scientists won't know how much lumpiness matters to the cosmos at large. "I think it's rather likely that it will turn out to be an important effect," Kolb says. Whether it explains away dark energy is less certain. "I want to know the answer so I can get on with my life." ■

Explore more

- Thomas Buchert *et al.* "The universe is inhomogeneous. Does it matter?" *CGQ+*. January 20, 2016. bit.ly/CGQ-universe

Athanasius Kircher, a 17th century Jesuit scholar, imagined Earth's core as a ball of fire. His and other historical and modern maps are on display at the Boston Public Library.

EXHIBIT

Maps document evolving views of Earth's interior

Much of what happens on the Earth's surface is connected to activity far below. "Beneath Our Feet," a temporary exhibit at the Norman B. Leventhal Map Center in the Boston Public Library, explores the ways people have envisioned, explored and exploited what lies underground.

"We're trying to visualize those places that humans don't naturally go to," says associate curator Stephanie Cyr. "Everybody gets to see what's in the sky, but not everyone gets to see what's underneath."

"Beneath Our Feet"
THROUGH FEBRUARY 25, 2018
BOSTON PUBLIC LIBRARY

"Beneath Our Feet" displays 70 maps, drawings and archaeological artifacts in a bright, narrow exhibit space. (In total, the library holds a collection of 200,000 maps and 5,000 atlases.) Many objects have two sets of labels: one for adults and one for kids, who are guided by a cartoon rat mascot called Digger Burrows.

The layout puts the planet's long history front and center. Visitors enter by walking over a U.S. Geological Survey map of North America that is color-coded to show how topography has changed over geologic time.

Beyond that, the exhibit is split into two main themes, Cyr says: the natural world, and how people have put their fingerprints on it. Historical and modern maps hang side by side, illustrating how ways of thinking about the Earth developed as the tools for exploring it improved.

For instance, a 1665 illustration drawn by Jesuit scholar Athanasius Kircher depicts Earth's water systems as an underground network that churned with guidance from a large ball of fire in the planet's center, Cyr says. "He wasn't that far off." Under Kircher's drawing is an early sonar map of the seafloor in the Pacific Ocean, made by geologists Marie Tharp and Bruce Heezen in 1969 (*SN: 10/6/12, p. 30*). Their maps revealed the Mid-Atlantic Ridge. Finding that rift helped to prove the existence of plate tectonics and that Earth's surface is shaped by the motion of vast subsurface forces.

On another wall, a 1794 topological-relief drawing of Mount Vesuvius — which erupted and destroyed the Roman city of Pompeii in A.D. 79 — is embellished by a cartouche of Greek mythological characters, including one representing death. The drawing hangs above a NASA satellite image of the same region, showing how the cities around Mount Vesuvius have grown since the eruption that buried Pompeii, and how volcano monitoring has improved.

The tone turns serious in the latter half of the exhibit. Maps of coal deposits in 1880s Pennsylvania sit near modern schematics explaining how fracking works (*SN: 9/8/12, p. 20*). Reproductions of maps of the Dakotas from 1886 may remind visitors of ongoing controversies with the Dakota Access Pipeline, proposed to run near the Standing Rock Sioux Reservation, and maps from the U.S. Environmental Protection Agency mark sites in Flint, Mich., with lead-tainted water.

Maps in the exhibit are presented dispassionately and without overt political commentary. Cyr hopes the zoomed-out perspectives that maps provide will allow people to approach controversial topics with cool heads.

"The library is a safe place to have civil discourse," she says. "It's also a place where you have access to factual materials and factual resources."

"Beneath Our Feet" is open through February 25. If you can't get to Boston, you can view a virtual walk-through at bit.ly/BeneathOurFeet. — *Lisa Grossman*

A. KIRCHER, COURTESY OF THE NORMAN B. LEVENTHAL MAP CENTER/BOSTON PUBLIC LIBRARY

Breakthrough technology converts phone calls to captions.

No Contract No Monthly Fee

New amplified phone lets you hear AND see the conversation.

The Hamilton® CapTel® Captioned Telephone converts phone conversations to easy-to-read captions for individuals with hearing loss.

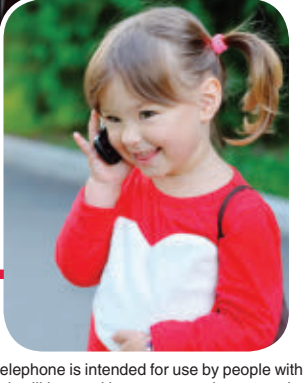
Do you get discouraged when you hear your telephone ring? Do you avoid using your phone because hearing difficulties make it hard to understand the person on the other end of the line? For many Americans the telephone conversation – once an important part of everyday life – has become a thing of the past. Because they can't understand what is said to them on the phone, they're often cut off from friends, family, doctors and caregivers. Now, thanks to innovative technology there is finally a better way.

A simple idea… made possible with sophisticated technology. If you have trouble understanding a call, captioned telephone can change your life. During a phone call the words spoken to you appear on the phone's screen – similar to closed captioning on TV. So when you make or receive a call, the words spoken to you are not only amplified by the phone, but scroll across the phone so you can listen while reading everything that's said to you. Each call is routed through a call center, where computer technology – aided by a live representative – generates voice-to-text translations. The captioning is real-time, accurate and readable. Your conversation is private and the captioning service doesn't cost you a penny. Internet Protocol Captioned Telephone Service (IP CTS) is regulated and funded by the Federal Communications Commission (FCC) and is designed exclusively for individuals with hearing loss. To learn more, visit www.fcc.gov. The Hamilton CapTel phone requires telephone service and high-speed Internet access. WiFi Capable. Callers do not need special equipment or a captioned telephone in order to speak with you.

Finally… a phone you can use again. The Hamilton CapTel phone is also packed with features to help make phone calls easier. The keypad has large, easy to use buttons. You get adjustable volume amplification along with the ability to save captions for review later. It even has an answering machine that provides you with the captions of each message.

"For years I avoided phone calls because I couldn't understand the caller… now I don't miss a thing!"

SEE what you've been missing!



See for yourself with our exclusive home trial. Try a captioned telephone in your own home and if you are not completely amazed, simply return it within 60-days for a refund of the product purchase price. It even comes with a 5-year warranty.

Captioned Telephone

Call now for our special introductory price!

Call now Toll-Free

1-888-383-2756

Please mention promotion code 107531.

The Captioning Telephone is intended for use by people with hearing loss. In purchasing a Captioning Telephone, you acknowledge that it will be used by someone who cannot hear well over a traditional phone. Hamilton is a registered trademark of Nedelco, Inc. d/b/a Hamilton Telecommunications. CapTel is a registered trademark of Ultratec, Inc.

81135

CONGRATULATIONS Broadcom MASTERS!

Broadcom Foundation and Society for Science & the Public salute the amazing young scientists and engineers nominated by their science fair judges to compete in the 2017 Broadcom MASTERS. **Congratulations to our top 30 finalists!**

Carolyn Almonte
Burlington, New Jersey

Julian Manitou Bain
Missoula, Montana

Meghna Behari
Sewickley, Pennsylvania

Noah Cain
Apple Valley, California

Andrew Chiang
Saratoga, California

Austin Crouchley
Garden City, New York

Jessie Gan
San Diego, California

Leia Gluckman
Beverly Hills, California

Zoe Gotthold
Richland, Washington

Spencer Green
Huntington Beach, California

Anthony Hill
Holladay, Utah

Herin Kang
Los Gatos, California

Mithra Karamchedu
Portland, Oregon

Sara L. Kaufman
Cooper City, Florida

Robert Kent III
Chagrin Falls, Ohio

Kathryn Kümmel
Colorado Springs, Colorado

Stephen Litt
Marietta, Georgia

Helen Lyons
New York, New York

Arjun Moorthy
Scottsdale, Arizona

Nora Navid
Pittsburgh, Pennsylvania

Rachel Pizzolato
Metairie, Louisiana

Sanjay Seshan
Pittsburgh, Pennsylvania

Cameron Sharma
Glen Allen, Virginia

Aryansh Shrivastava
Fremont, California

Pujita Tangirala
Los Gatos, California

Emily Tianshi
San Diego, California

Scott Tobin
Port Orange, Florida

Annika Viswesh
Palo Alto, California

Faris Irwin Wald
Santa Fe, New Mexico

Regan Williams
Wilmington, North Carolina

student.societyforscience.org/broadcom-masters
facebook.com/broadcommasters

Perfect Choice HD Ultra™ is simple to use, hard to see and easy to afford…

Invention of the Year

PERSONAL SOUND AMPLIFICATION PRODUCT (PSAP)

NEW Dynamic Speech Optimization

IT'S NOT A HEARING AID

Understand what people are saying... the first time

Now you see it...

Now you don't

If you are one of the 48 million Americans suffering from hearing loss, we have great news for you. An innovative team of doctors and engineers have teamed up to create a truly revolutionary personal sound amplifier. It's not a hearing aid- those require trips to the audiologist, hearing tests and can cost as much as $5,000. It's also not a cheap amplifier that just makes everything louder, making it virtually impossible to hear conversations. It's Perfect Choice HD Ultra™… and it may be the perfect solution for you.

Perfect Choice HD Ultra™ is the first PSAP that features Dynamic Speech Optimization (DSO). This technology enables the device to prioritize the spoken word over other sounds. These noises are generally in different frequencies than voices, but they can drown out the words and make conversations hard to understand. This invention targets the frequencies of the human voice and amplifies the words. It's even designed to diminish feedback even at higher volumes, so you can customize your hearing experience to meet your needs. Just imagine how great it will feel to be able to understand what people are saying… the first time they say it.

Perfect Choice HD Ultra™ is perfect for...

• Watching TV • Restaurants
• Dinner parties • Lectures
• Outdoor conversations • Sermons
…and other times where you need to turn up the volume

That's only the beginning. This unit is small and lightweight at less than an ounce, so it hides discreetly and comfortably behind your ear. The only way people will know you have it on is if you tell them. Plus, its moisture resistant coating make it durable– you could even leave it in when you take a shower! There's no fitting or hearing test required, so it's ready to use right out of the box. Once it's arrived, a helpful product expert will provide a one-on-one set up over the phone so you'll get the maximum benefit from this new technology. Call now, and you'll find out for yourself why so many people love their Perfect Choice HD Ultra™. Call now, and be sure and ask about special discounts for Seniors and Military personnel.

It's Better

COMFORT	Less than 1 ounce
SOUND QUALITY	Excellent: Optimized for speech
FITTING REQUIRED?	No
ONE-ON-ONE SETUP	Free
SENIOR AND MILITARY DISCOUNTS	Yes

Perfect Choice HD ULTRA™

Now With DSO!

Call now toll free

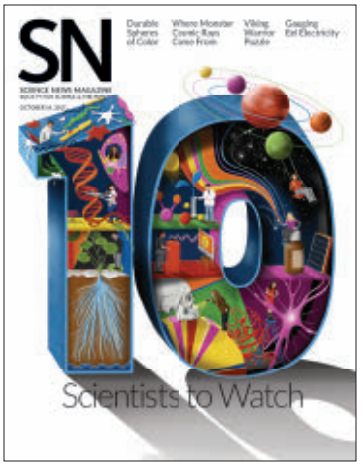
1-888-689-3044

Please mention promotional code 107530.

1998 Ruffin Mill Road,
Colonial Heights, VA 23834

Perfect Choice HD Ultra is not a hearing aid. If you believe you need a hearing aid, please consult a physician.

81184



OCTOBER 14, 2017

Current affairs

The story in the Oct. 14 issue that resonated most with online readers may shock you. In "Researcher goes all in to study eel electricity" (*SN: 10/14/17, p. 4*), **Mariah Quintanilla** reported on a biologist who recorded the electrical current traveling through his own arm during an electric eel's attack. Watch the eel in action at bit.ly/SN_EelAttack

Join the conversation

E-MAIL editors@sciencenews.org

MAIL Attn: Feedback
1719 N St., NW
Washington, DC 20036

Connect with us

Wanting more

For the third year in a row, Science News *profiled 10 early- and mid-career innovators who are transforming their fields in "The SN 10: Scientists to watch"* (SN: 10/14/17, p. 16).

The profiles left some readers inspired, intrigued and wanting to know more about these scientists' research.

"Really enjoying these portraits, thanks, SN!" online reader **Maia** commented on the profile of SN 10 scientist **Lena Pernas**. A postdoctoral fellow at the University of Padua in Italy, **Pernas** studies an infectious parasite called *Toxoplasma gondii*. The parasite and its host's energy-producing mitochondria fight over fuel, **Pernas** has found (*SN: 10/14/17, p. 16*). An image featured in the profile that shows *T. gondii* in a host-cell vacuole surrounded by a chain of mitochondria "felt somehow iconic," **Maia** wrote. It reminded her of the proposed endosymbiotic theory, "of how mitochondria themselves (formerly free bacteria) got their start inside eukaryotic cells, possibly as a kind of limited parasite, then in the détente that followed, both cells found a way to share the food and contribute to each other's well-being."

Computer scientist **M. Ehsan Hoque** of the University of Rochester in New York, and one of this year's scientists to watch, programs emotionally attuned digital assistants that can help people improve their social interactions and public speaking (*SN: 10/14/17, p. 19*). Artificial intelligence has "focused on humanlike features and applications. I'm not underrating these social and business applications," **Uolevi Kattun** wrote online. "Emotionless and unbiased" AI is still the front-runner, he wrote. **Kattun** thought that emotionally equipped AI may not be well-suited for scientific research.

SN 10 scientist **Kerwyn Casey Huang** of Stanford University is a physicist by training who uses that knowledge to explore the challenges that bacterial cells face. **Huang's** research addresses fundamental questions about the rules bacteria live by — for instance, what determines their shape and how different wavelengths of light affect the movement of photosynthetic microbes (*SN: 10/14/17, p. 17*). Online reader **Jim Stangle Dvm** enjoyed learning about **Huang**, but wanted to know more about his research. "How about it *Science News*?"

There's no shortage of research to report on when it comes to the young scientists that *Science News* profiles in the annual SN 10, says features editor **Cori Vanchieri**. "We will keep an eye on their work and the work of the many scientists who are trying to understand the world. Reporting on their discoveries is what we do."

Robots among us

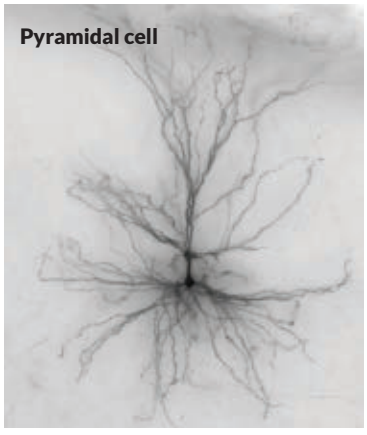
Researchers trained a self-driving robot to abide by social protocols — keep right, pass left, don't follow someone too closely — as it navigates among human pedestrians, ***Maria Temming*** *reported in "Courteous robot gets around"* (SN: 10/14/17, p. 5).

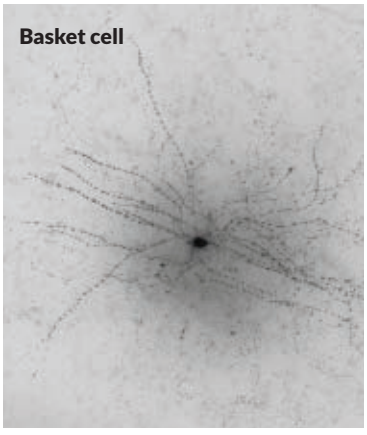
Online reader **Maia** wondered what these robots could be used for, and suspected that less-than-polite humans may clash with the bots more than the bots bump into humans.

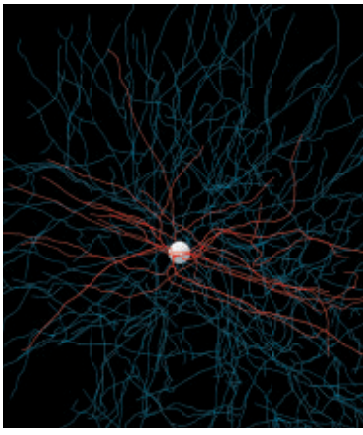
This kind of machine could wend its way through office buildings to deliver packages, quickly carry patients through bustling hospital hallways or perform any other duty that requires deftly navigating pedestrian hubs, says **Jonathan How**, an engineer at MIT and cocreator of the robot.

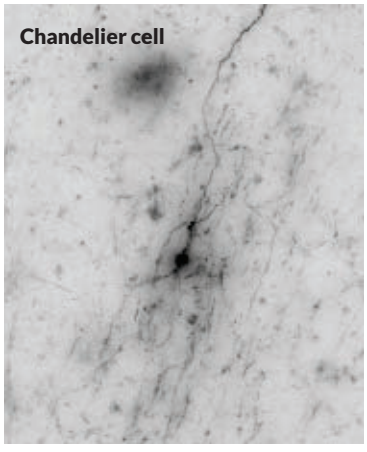
As for robot-human interactions, the researchers aren't too concerned about people attacking pedestrian bots. "Most people either ignore the robot, stop and wave at it or stop and try to get in its way to see if it can avoid them," says MIT mechanical engineer **Michael Everett**. "I'm not sure what someone stands to gain from jumping a robot. I suspect the penalties would be similar to damaging any other type of property." And a robot like this has onboard sensors to make it easy to identify the attacker, he says.

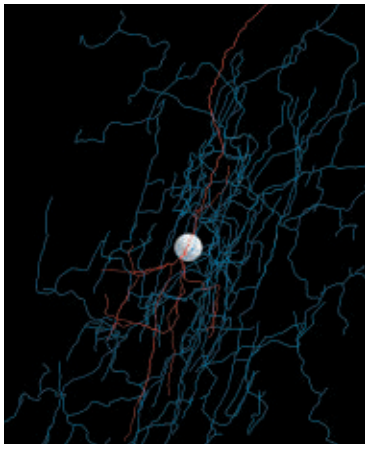
K. CATANIA

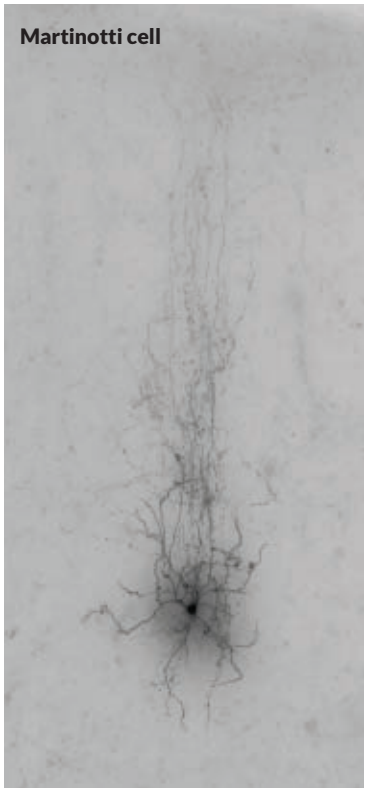


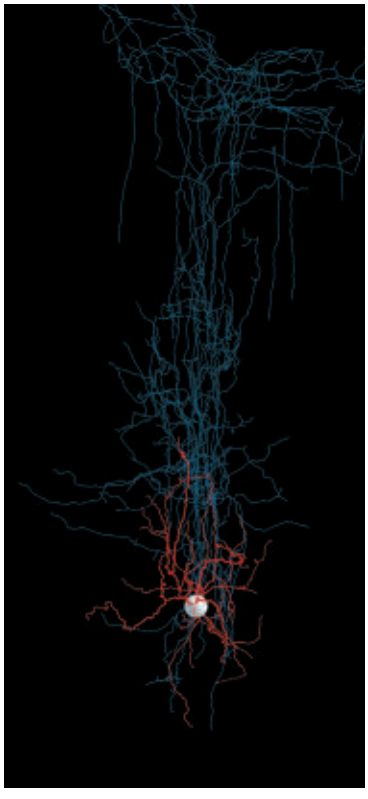












Meet the cells in your brain

The human brain is teeming with diversity. By plucking out delicate, live tissue during neurosurgery and studying the resident cells, researchers have revealed a partial cast of neural characters that give rise to our thoughts, dreams and memories.

So far, scientists with the Allen Institute for Brain Science in Seattle have described the intricate shapes and electrical properties of about 100 nerve cells taken from the brains of 36 patients as they underwent surgery for conditions such as brain tumors or epilepsy. To reach the right spot, surgeons had to remove a small hunk of brain tissue, which is usually discarded as medical waste. In this case, the tissue was promptly packed up and sent — alive — to the researchers.

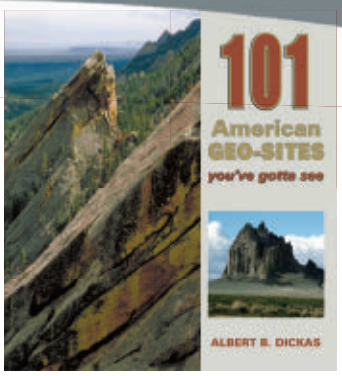
The Allen Institute released the first publicly available database of these neurons on October 25. Detailed microscopy of a selection of cells reveals intricate branching structures and a wide array of shapes. A neuron called a pyramidal cell, for instance, has a bushy branch of dendrites (orange in 3-D reconstruction) reaching up from its cell body (white circle). Those dendrites collect signals from other neural neighbors. Other dendrites (red) branch out below. The cell's axon (blue) sends signals to other cells that spur them to action.

In another neuron called a chandelier cell, vertical branches of its signal-sending axon (blue), which serves to quiet other cells, dangle around the cell body. A Martinotti cell also quiets other cells with messages from its tangled, tall axon, which spans several layers of the brain's cortex — the wrinkly, outer layer involved in higher-level thought. And in a basket cell, axon branches, which allow the neuron to send messages to other nerve cells, cluster densely around the cell body.

Because the cells play different roles in the brain, the new collection could help researchers figure out the details of those diverse jobs. Similar data exist for cells taken from the brains of other animals, such as mice, but until now, data on live cells from people have been scarce. "These neurons are amazingly beautiful," says Ed Lein, a neuroscientist at the Allen Institute who works on the project. "They look like trees. They're much more complex than similar cells in a mouse." — *Laura Sanders*

ALL: ALLEN INSTITUTE FOR BRAIN SCIENCE

GEOLOGIC ROAD TRIP OF THE MONTH



EXCERPT FROM
101 American Geo-Sites You've Gotta See
264 pages • 8⅜x9 • color
$24.00, paper • Item #370
ISBN 978-0-87842-587-7
Ebook available:
ISBN 978-0-87842-613-3

BOULDER FLATIRONS, COLORADO

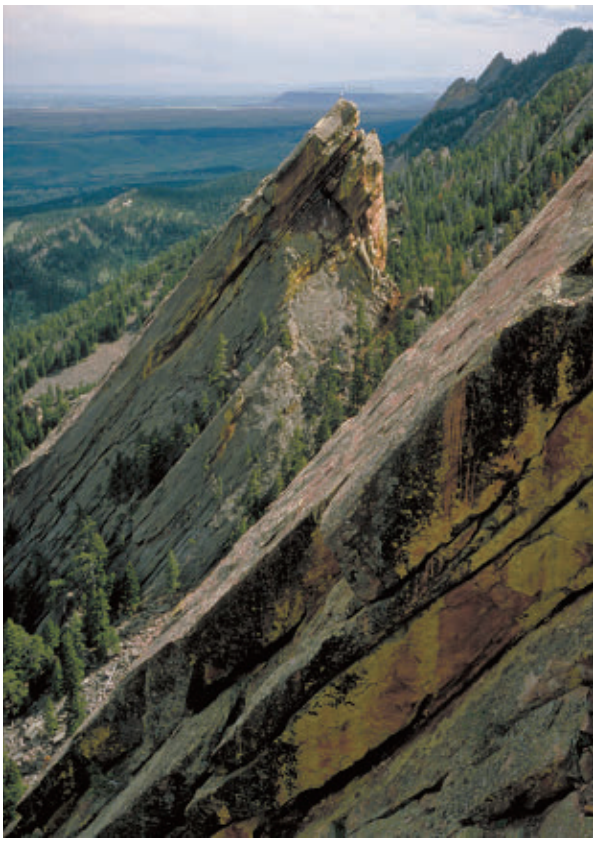
"Turn! Turn! Turn!" the often-quoted song presented by the rock group The Byrds in 1965, based on verses from the book of Ecclesiastes, includes the phrase "a time to build up, a time to break down." In Colorado, another "rock narration," centered upon the five ramparts that identify the Front Range of the Rocky Mountains outside Boulder, offers dramatic evidence of just such a time occurring during a long span of geologic history.

A time to build up: For 3,000 million years Earth experienced its rites of passage of birth, adolescence, and middle age. A brittle crust enveloped a near-molten mantle, surrounding a molten core. Volcanoes belched forth lava and ash, and earthquakes transformed the early topography. Once the early poisonous atmosphere was neutralized, life responded positively. Critters crawled from the oceans, scampered about the protocontinents, and assumed amphibian habits through evolution. Proto–North America slowly collided with proto–South America and Africa, resulting in a tectonic fender bender—the uplifting of the ancestral Rockies—that stretched from Wyoming to New Mexico.

A time to break down: Rivers transported floods of debris off the ancestral Rockies. The first deposit, the Fountain Formation, lay directly on the Precambrian basement. The deposition of three more formations followed: the Lyons, representing desert conditions marked by sand dunes; and the Lykins and Morrison, both floodplain deposits. As the Morrison Formation was deposited, both herbivores and carnivores sallied across the marshy lowlands in search of mates and food. Preserved footprints and fossilized bones of more than seventy species attest to this being the Age of Dinosaurs.

Change was under way. Throughout the Cretaceous period, waters of the Western Interior Seaway advanced and retreated, altering the environment from terrestrial to marine and resulting in three more sequences of strata, together measuring 10,000 feet thick. The Benton and Pierre formations, mostly shale deposited in offshore conditions and sands deposited in nearshore waters, are separated by the Niobrara, a limestone deposited in deep water. Around 65 million years ago generous volumes of magma invaded and uplifted the Precambrian basement, along with the overlying, younger sedimentary rock, which was bent into complex folds that extended for hundreds of miles. Gold, silver, lead, and tungsten precipitated from the hot waters of the magma and formed the world-class Colorado Mineral Belt. Dinosaurs died out and mammals dominated, setting the stage for the evolution of humankind. The modern Rockies were born.

Over time, erosion partially removed the blanket of younger strata from the cap of the Rockies, leaving the Precambrian granite core flanked by the remains of the sedimentary cover. A juxtaposition of topographic high and low identified the Front Range, the geographic contact of prairie and mountain. Finally, river torrents created adjoining canyons in Boulder (and other areas along the Front Range), sculpting the massive layer of red-hued Fountain Formation into triangle-shaped ramparts. The 50-degree angle of the resulting five Flatirons is ample and overwhelming evidence of the prodigious power of continental-scale mountain building, considering that the Fountain Formation had been deposited in horizontal layers. The soaring, imposing, and stark slablike appearance of the Flatirons is nature's way of emphasizing this dramatic story of long-term geologic development. The Boulder Flatirons are the true rock-stars of time and geologic processes.



The Boulder Flatirons form the east flank of Green Mountain.
—Courtesy of John Karachewski, www.geoscapesphotography.com

The Next Great Italian Masterpiece

Raffinato™ Italy

The Argento Byzantine Necklace is an impeccable work of art with a price unmatched by any in its class.

Da Vinci's Mona Lisa, David by Michealangelo, Madame Butterfly by Puccini. Italy has produced some of the world's greatest masterpieces. And, it's no secret it is the epicenter of the best metalworking on earth. Which is why we sought out one the best artisans to ever melt precious metals to create yet another great Italian masterpiece. For over two decades, our designer has pursued his passion for making jewelry of great beauty inspired by the Tuscan countryside. The ***Argento Necklace*** is his latest masterpiece. ***And, you can own it for under $80!***

Each necklace is meticulously made by hand from pure sterling silver and celebrates the traditional woven Byzantine design— an intricate array of woven links that forms a flexible and elegant drape. Passing the test of time and surpassing the definition of beauty, the ***Argento Byzantine Necklace*** is perfect for the lady who appreciates fine art. And, priced for those who appreciate a fine value.

The difference between priceless & overpriced. High-end design should not carry a high price just because it comes from a big name retailer, where you'll find a similar necklace going for four times as much. We prefer to keep our costs low so we can bring you the very best in Italian design at a cutting edge price.

Masterpiece, not mass produced. It takes months to create just one of these necklaces which means we have a select number available.

No questions asked, 30-day money back guarantee. We want you glowing with satisfaction. You have nothing to lose, except the opportunity to own a masterpiece. Call today!

The classic Byzantine chain pattern has stood the test of time for over 2,500 years

What our Italian jewelry expert Daniele Zavani is saying about the **Raffinato™ Argento Necklace:**

Bellissimo!
Stupendo!
Magnifico!

Raffinato™
Argento Byzantine Necklace
Stunningly affordable **$79** + S&P

- ***Made in Arezzo, Italy***
- ***.925 sterling silver***
- ***18" necklace; lobster clasp***

Also available *Raffinato™* **Argento Byzantine Bracelet** Stunningly well-priced at **$39** + S&P

Call today. There's never been a better time to let your elegance shine. 1-888-444-5949
Offer Code: RFC211-01. You must use the offer code to get our special price.

Raffinato™ 14101 Southcross Drive W., Dept. RFC211-01, Burnsville, Minnesota 55337 www.raffinatoitaly.com

A collection of impeccable design & craftsmanship from Italy.