SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
FEBRUARY 17, 2018

Monkeys Get Dolly Treatment

New Spin on Data Storage

Lessons in DNA Packing

When Humans Left Africa

# Forget Fantasy

## At playtime, kids might prefer real-world tasks

*"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.*

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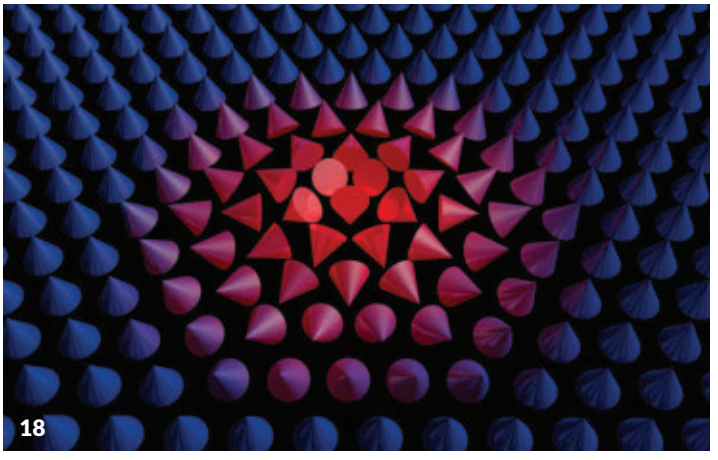
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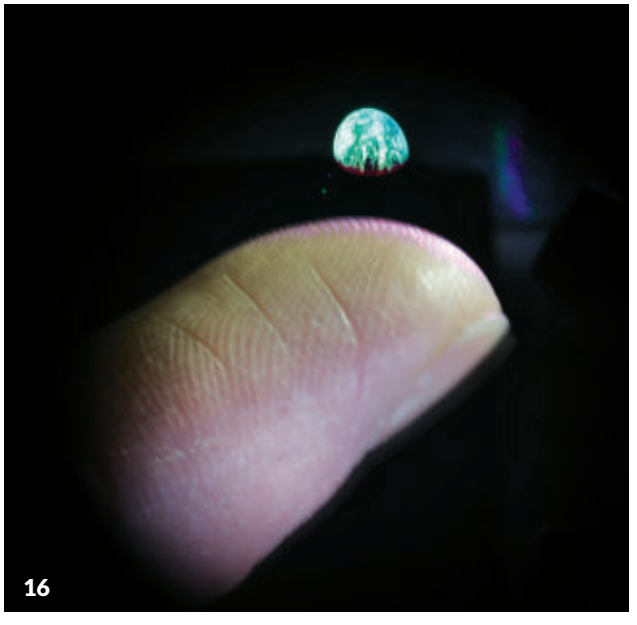
## Features



## News

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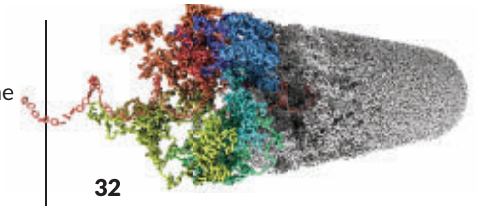
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## Departments



**SOCIETY UPDATE**
Recent stories from *Science News for Students*

**COVER** Given a choice, many youngsters go for real-life practice over fantasy play. *Lisegagne/iStockphoto*

CLOCKWISE FROM TOP: ELLA MARU STUDIO; A. GOLOBORODKO AND J. GIBCUS, WITH INPUT FROM K. SAMEJIMA, B. EARNSHAW, L. MIRNY AND J. DEKKER; D.E. SMALLEY *ET AL/NATURE* 2018

# In play, kids and scientists take big mental leaps

I know a lot of adults who don't like to cook, but I've never met a child who doesn't enjoy playing with a toy kitchen — or one who doesn't want to help chop vegetables for dinner. Other versions of practical play: A cousin, at the age of just 4 or 5, asked for only one thing for Christmas — a snow brush. And on a beach trip last year, I witnessed a duo of 2-year-olds squealing with joy at the idea of sweeping the floor.

On Page 22, behavioral sciences writer Bruce Bower explores some science related to my observations. "Kids like to do real things because they want a role in the real world," psychologist Angeline Lillard told Bower. Though toy stores may burst with futuristic robots, magical dolls and all things fantastical, research suggests reality play might be a favored form of make-believe.

What couldn't be addressed in a handful of pages, and would require a tome thicker than *Joy of Cooking*, is the great variety of ways kids play. Volumes 2 and 3 would cover more of what motivates kids to play, and how they benefit. Bower has previously written about whether action video games can benefit kids with dyslexia (*SN Online: 2/28/13*), how children take turns during researcher-directed play (*SN: 7/26/14, p. 16*) and how babbling play between parent and baby might reveal an innate musical sense (*SN: 8/14/10, p. 18*). Back in 2007, Bower reported evidence that some of the Stone Age curving and crisscrossing lines on the ceilings of caves were created by children, suggesting that this "finger fluting" might have been a prehistoric form of finger painting (*SN: 4/28/07, p. 264*).

Play is also an occasional topic on *Growth Curve*, a *Science News* parenting blog by Laura Sanders (www.sciencenews.org/growthcurve). She has written about the importance of unstructured play and, recently, about how too many toys can disrupt a child's focus. Conversations about play are often intertwined with deep and serious matters: building physical skills, problem-solving, exercising creativity, learning to socialize and process emotions, and enhancing resilience.

And not just in children. Adult play is rich and varied, too — whether it's sports, the arts, puzzles, the trendiest gaming apps or, a favorite around here, puns. A lot of scientists are expert players. Anyone who has spent enough time in a research laboratory knows that just playing around can be a crucial step to scientific success. Evidence is slim that Albert Einstein ever said, "Playing is the highest form of research." But he did emphasize the importance of "combinatory play" in "productive thought" — essentially, that a remixing of basic ideas from various fields not obviously connected can lead to valuable insights. Creativity comes when the mind takes leaps, filling in the gaps.

It's easy to imagine how such playfulness might have contributed to research reported in this issue. How do you mix and match materials to create unusual magnetic properties (Page 18)? Could life have survived on an early, bombarded Earth (Page 16)? How do we make free-floating, 3-D images (Page 16)? What about ultraquick robots made of DNA (Page 5)? And what are the key ingredients in successful cloning (Page 7)? Though differing in degree of sophistication, these questions are similar in spirit to a young child at a play kitchen asking: What will I cook today? — *Elizabeth Quill, Acting Editor in Chief*





*Science News*
1719 N Street NW, Washington, DC 20036
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**Advertising/Sponsor content:** ads@societyforscience.org
*Science News* (ISSN 0036-8423) is published biweekly except twice in September and monthly in January and April by the Society for Science and the Public, 1719 N Street, NW, Washington, DC 20036.
**Print, online and tablet access:** Activate your subscribing member account, including digital access, at www.sciencenews.org/activate
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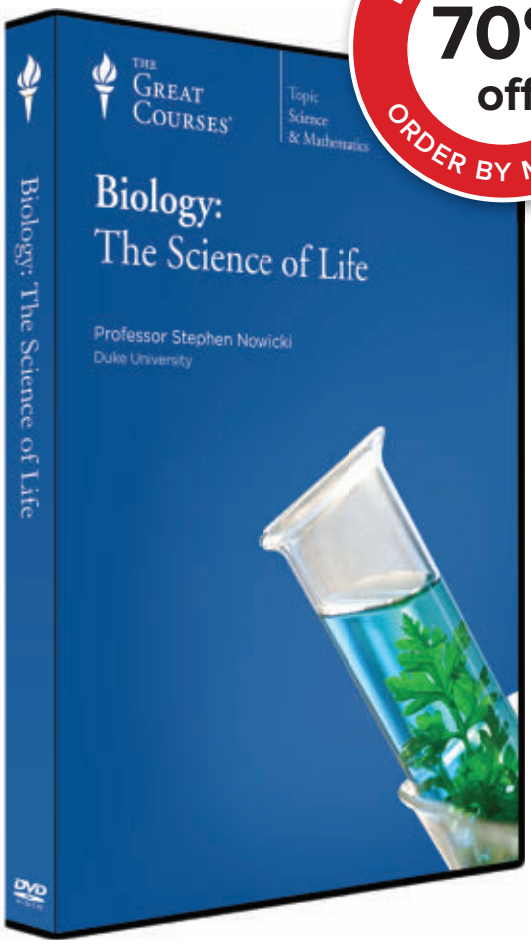


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18. Natural Selection in Action
19. Reconciling Darwin and Mendel
20. Mechanisms of Evolutionary Change
21. What Are Species and How Do New Ones Arise?
22. More on the Origin of New Species
23. Reconstructing Evolution
24. The History of Life, Revisited
25. From Cells to Organisms
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27. Control of Gene Expression II
28. Getting Proteins to the Right Place
29. Genetic Engineering and Biotechnology
30. How Cells Talk—Signals and Receptors
31. How Cells Talk—Ways That Cells Respond
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Excerpt from the February 17, 1968 issue of *Science News*

50 YEARS AGO

## Power within 30 years

Controlled thermonuclear fusion is moving so well that full-scale development could begin within five years, says Dr. David J. Rose.... It might take 20 to 30 years beyond that before fusion could move into the power grid, though, he predicts.

**UPDATE:** Governments and private-sector start-ups are still trying to wrangle thermonuclear fusion — the process that lights up stars and ignites hydrogen bombs — for clean energy, with limited progress (*SN: 2/6/16, p. 18*). One of the biggest ongoing projects is ITER in France, an international effort to build the first magnetic fusion reactor that pumps out more energy than it consumes. ITER plans to flip on the machine in 2025. Optimistic estimates put the first fusion power plants on the grid no sooner than 2040.

Baby saiga antelope mew to attract the attention of their moms.

THE SCIENCE LIFE

## Saiga die-off explained

Spring calving season for the saiga antelope of central Kazakhstan is a delight for the researchers who keep tabs on the critically endangered animals. During the day, thousands of newborn saigas lie quiet, hidden within a sea of waving grass. Mothers return twice daily to feed the youngsters. "At dawn and dusk, it's magical," says E.J. Milner-Gulland, a conservation biologist at the University of Oxford who has studied saigas for 27 years. "You hear this mewing noise, and all the babies come rushing up to the females."

The sight that greeted Milner-Gulland's colleagues in 2015, however, was horrific. Mothers and calves, behaving normally one day, suddenly became lethargic. Weakness, collapse and death soon followed. "It was like a switch was turned on in each animal," says wildlife veterinarian Richard Kock of the Royal Veterinary College at the University of London. Mothers died first. Helpless calves, obviously distressed, tried to suckle from their dead mothers, but eventually succumbed hours later. In three short weeks, more than 200,000 carcasses littered the steppes.

Even before the mystery illness, saigas (*Saiga tatarica tatarica*) had been under assault, their populations in steep decline from poachers who wanted the animals' horns and meat. Habitat loss and migration-route obstructions from fences and new railways didn't help.

Now, Milner-Gulland, Kock and more than a dozen Kazak and international colleagues say they've found the reason for the massive die-off. Based on necropsy evidence and pathogen sampling, the team concluded the animals died of hemorrhagic septicemia, a fatal blood poisoning, caused by *Pasteurella multocida* type B bacteria, the researchers report January 17 in *Science Advances*.

*P. multocida* is a normal inhabitant of the bulbous saiga snout. The antelope "have it naturally in their noses, just like we all have various bacteria living harmlessly in our bodies," Milner-Gulland says. Even newborn saigas carry the bacteria, probably passed on from the mothers, she says.

Higher than normal temperature and humidity are partly to blame for causing the microbes to multiply and become deadly, according to the researchers' statistical analysis. Milner-Gulland sees the results as a cautionary note on the saigas' future in a changing climate.

Around 107,000 saigas remain in central Asia, Kock estimates based on a summer 2017 tally. But Milner-Gulland remains optimistic about the antelope's future. As cofounder of the Saiga Conservation Alliance, she has a soft spot for these strange creatures, which migrate long distances, live in harsh conditions and have no evolutionarily close relatives. Plus, she says, "emotionally speaking, they are just beautiful." — *Lesley Evans Ogden*

In central Kazakhstan in 2015, normally benign microbes killed more than 200,000 critically endangered saiga antelope.

FROM TOP: NATURE PICTURE LIBRARY/ALAMY STOCK PHOTO; JOINT SAIGA HEALTH MONITORING TEAM IN KAZAKHSTAN/ ASSOC. FOR THE CONSERVATION OF BIODIVERSITY OF KAZAKHSTAN, BIOSAFETY INST., GVARDESKIY RK, ROYAL VETERINARY COLLEGE IN LONDON

TEASER

## New textile weathers temperature shifts

Weather changes, but thanks to a new high-tech textile, someday you may not have to switch out your outfit.

Materials scientists and engineers at Stanford University have developed a multilayered textile that traps body heat on one side and passively radiates heat away from the body when flipped inside out. The material kept artificial skin within a comfortable range of 32° to 36° Celsius as the ambient temperature fluctuated by up to 9 degrees, the researchers reported November 10 in *Science Advances*.

Under a microscope, the textile looks like a gnarly sandwich. Layers of nanoporous polyethylene, or nanoPE, hug two layers: a rough, porous carbon and a smoother, tighter copper. When the carbon faces away from the body and a thin nanoPE layer is near the skin, the textile is in cooling mode. Body heat can easily escape through the carbon structure. In experiments, the textile lowered the temperature of artificial skin by about 3 degrees.

To warm the body, the fabric is reversed so that the copper layer — which doesn't let body heat easily escape — faces out, and a thick nanoPE layer is near the skin. In warming mode, the artificial skin heated up by about 4 degrees. This sandwich design adds heating and refined cooling capabilities to nanoPE, a cooling fabric that the Stanford team developed in 2016 (*SN: 10/1/16, p. 9*). Though the new plastic-based material is not ready to wear, the team is developing a fiber-based version "that has a much similar touch and feeling to traditional textiles," says mechanical engineer and study coauthor Po-Chun Hsu. *— Mariah Quintanilla*

Copper (metallic) and carbon (black) layers sandwiched between nanoporous plastic trap body heat or let it escape depending on which side is closest to the skin.

INTRODUCING

## A pod of 18 new species of pelican spiders

Despite their name, pelican spiders aren't fish-eating monstrosities. In fact, the spiders in the family Archaeidae are shorter than a grain of rice and are a threat only to other spiders.

Identifying a new species of these tiny spiders is tough, but arachnologist Hannah Wood has done it 18 times. Wood, of the Smithsonian National Museum of Natural History in Washington, D.C., and Nikolaj Scharff of the University of Copenhagen analyzed the genes and anatomy of live pelican spiders and museum specimens to identify the new species, describing them January 11 in *ZooKeys*.

Like other pelican spiders, the new species, from Madagascar, have an elongated "neck" and beaklike pincers, or chelicerae. The way pelican spiders use those long chelicerae to strike from a distance earned the group another name: assassin spiders. Once impaled, helpless prey dangles from those meat hooks until a spider's venom does its work (*SN: 3/22/14, p. 4*).

Probing the spiders' tiny anatomy under a microscope, the researchers looked for hints to distinguish one species from another. Arachnologists often look to spiders' genitals: Males and females of the same species typically evolved specially shaped organs to mate. If the "lock" doesn't fit the "key," the spiders are probably different species.

Now, 18 more species of pelican spiders — some previously misclassified — have names. *Eriauchenius rafohy* honors a 16th century Madagascar queen, and *E. wunderlichi,* an eminent arachanologist. Wood says she expects there are still more species to find. Perhaps an *E. woodi*? *— Dan Garisto*

*Eriauchenius milajaneae*, less than a centimeter long, is a species of pelican spider named for arachnologist Hannah Wood's daughter, Mila Jane.

FROM TOP: YI CUI GROUP/STANFORD UNIV.; H. WOOD/SMITHSONIAN

THE –EST

## DNA robotic arm moves at dizzying speeds

A new robotic arm made of DNA is the fastest piece of DNA machinery yet.

The DNA nanobot is shaped like a gearshift: An extendible arm, 25 to more than 400 nanometers long, is attached to a 55-by-55-nanometer platform. Researchers remotely control the device, described in the Jan. 19 *Science,* with electric fields that tug on charged molecules in the arm. Those electric fields help the arm move 100,000 times as quickly as existing DNA robots, which move via chemical interactions between DNA molecules (*SN: 9/11/10, p. 18*).

Friedrich Simmel, a biophysicist at the Technical University of Munich, and colleagues could swivel the DNA robotic arm 360 degrees in a matter of milliseconds. To lock the arm down in one position, the team built single-stranded DNA latches into the platform. Such quick, efficient DNA nanobots could someday help move tiny cargo in a nanofactory that manufactures new types of materials. *— Maria Temming*

HUMANS & SOCIETY

# Fossil hints at early exit out of Africa

## Purported human jaw in Israel is at least 177,000 years old

This partial upper jaw dating to nearly 200,000 years ago suggests that *Homo sapiens* left Africa earlier than previously thought, scientists argue.

I. HERSHKOVITZ/TEL AVIV UNIV.

**BY BRUCE BOWER**

Misliya Cave on Israel's Mount Carmel has yielded a fossil that its discoverers regard as a partial *Homo sapiens* jaw with an estimated age of between about 177,000 and 194,000 years old. That age indicates humans could have left Africa and reached the Middle East around 60,000 years earlier than many scientists had assumed. A description and analysis of the fossil appear in the Jan. 26 *Science*.

Until now, the oldest known *H. sapiens* fossils discovered outside of Africa, at Israel's Skhul and Qafzeh caves, date to between approximately 90,000 and 120,000 years ago.

The Misliya jawbone "provides the clearest evidence yet that our ancestors first migrated out of Africa much earlier than we previously believed," says paleoanthropologist Rolf Quam of Binghamton University in New York. Quam — along with Israel Hershkovitz of Tel Aviv University and Gerhard Weber of the University of Vienna — led the new study.

After originating in Africa possibly around 300,000 years ago and inhabiting areas close to the Middle East (*SN: 7/8/17, p. 6*), *H. sapiens* probably first reached the Middle East more than 200,000 years ago, the researchers propose. Age estimates for the Misliya jaw jibe with a study of ancient DNA published last year in *Nature Communications*. That research concluded that *H. sapiens* left Africa and interbred with Neandertals in Europe between around 460,000 and 219,000 years ago.

Excavations directed by Hershkovitz at Misliya Cave ran from 2001 to 2010. The fossil jaw was discovered in 2002. Stone artifacts unearthed in the same sediment as the jaw included chunks of rock from which sharp flakes were pounded off and used as cutting tools. Some stone flakes found at Misliya Cave were burned, perhaps during the tool-making process.

Three dating methods, conducted in three different labs, yielded an age estimate for the jaw. These procedures calculated ages for teeth, sediment that clung to the jaw and burned stone tools.

Hershkovitz suspects that Misliya people's surprisingly early arrival in the Middle East set the stage for interactions with Neandertals. Although researchers usually attribute the Skhul and Qafzeh finds to *H. sapiens* that arrived directly from Africa, Hershkovitz thinks that those groups were instead the descendants of interbreeding between Misliya people and Neandertals. It's also possible that other humanlike populations, not yet known from fossils, interbred at this geographic crossroads, Hershkovitz says.

Investigators have assumed for decades that, before 120,000 years ago, only Neandertals lived in Israel and other parts of western Asia. In that scenario, African *H. sapiens* replaced Neandertals in the Middle East from roughly 120,000 to 90,000 years ago. Other fossil finds suggest Neandertals returned to the region around 80,000 years ago.

The Misliya jaw "doesn't fit in that long-established picture," says paleoanthropologist John Hawks of the University of Wisconsin–Madison. But opinions differ on whether the Misliya fossil comes from a *H. sapiens*.

The fossil — which includes a partial upper jaw, intact teeth, part of the cheekbone, the roof of the mouth and the bottom of the nasal opening — displays a few features in common with Neandertals and other ancient *Homo* groups. Yet several of the fossil's dental traits appear only in *H. sapiens*, Quam says. "That is why we feel confident in our diagnosis."

Rainy periods in western Asia between 244,000 and 190,000 years ago may have attracted humans from Africa and Neandertals from Europe, suggest paleoanthropologists Chris Stringer and Julia Galway-Witham, both of the Natural History Museum in London. In a commentary in the same issue of *Science*, the two agree that the jaw represents a *H. sapiens* individual, "suggesting that our species had already left Africa by around 180,000 years ago."

Hawks isn't so sure the jaw belongs to *H. sapiens*. Interbreeding between *H. sapiens*, Neandertals and perhaps other *Homo* species in the Middle East could have produced a hybrid Misliya population characterized by humanlike jaws connected to bulkier, Neandertal-style bodies (*SN: 10/15/16, p. 22*), Hawks suggests.

Or a *Homo* species closely related to *H. sapiens* — but not known from any previous fossils — may have traveled to Misliya Cave, Hawks speculates. "This new discovery from Misliya Cave raises more questions than answers." ■

GENES & CELLS

# Macaques cloned like Dolly the Sheep

## In a first, primates are created via somatic cell nuclear transfer

**BY DAN GARISTO**

Meet Zhong Zhong and Hua Hua, the first primates cloned by reprogramming mature cells.

Two decades after Dolly the Sheep was successfully cloned (*SN: 3/1/97, p. 132*), Chinese researchers have used the same technique — somatic cell nuclear transfer — to clone two healthy baby macaque monkeys. The results, reported online January 24 in *Cell*, could lead to more efficient cloning and a better way to study genetic diseases in primates.

"This could be it — the next step in cloning," says Jose Cibelli, a geneticist at Michigan State University in East Lansing who was not involved with the research.

Over 20 species of mammals have been cloned via somatic cell nuclear transfer, including cats, dogs, rats and even a camel (*SN: 3/23/02, p. 189*). This cloning technology has improved since Dolly's birth in 1996. Back then, she was the only sheep born from 277 attempts. By 2014, researchers were using the cloning technique to routinely create successful pregnancies in pigs. Despite gradual advances, successful cloning of primates has long eluded researchers.

A rhesus macaque "clone" was created in 1999 through embryo splitting, a technique that divides a single embryo into genetically identical embryos. But this type of cloning has little in common with somatic cell nuclear transfer.

In somatic cell nuclear transfer, a nucleus from a mature body cell is transplanted into an egg cell without a nucleus. The egg cell must then reprogram the nucleus's DNA, basically stripping the body cell of its identity and returning it to an embryonic state. With no set identity, this cell can beget any kind of cell in the body.

> "This could be it — the next step in cloning."
> JOSE CIBELLI

Previous failures in reprogramming primate cells probably happened because the egg ran into roadblocks — portions of the body cell's DNA known as reprogramming-resistant regions. In these regions, DNA is so tightly wrapped around proteins called histones that the egg can't reprogram those bits. So Mu-ming Poo, director of the Institute of Neuroscience at the Chinese Academy of Sciences in Shanghai, and his colleagues added two molecules aimed at loosening the DNA's packaging.

Cloned primates made the same way as these baby monkeys may prove useful in biomedical research.

QIANG SUN AND M.-M. POO/CHINESE ACADEMY OF SCIENCES

Zhong Zhong and Hua Hua, the first primates successfully cloned via somatic cell nuclear transfer, are healthy, playful and, so far, completely normal for baby macaques.

The team tried this method with two types of body cells: ovarian cells from an adult and connective tissue cells from a fetus. Although 22 out of 42 monkeys became pregnant when implanted with embryos cloned from ovarian cells, only two babies were born and neither survived long past birth. Efforts with embryos made with the fetal cells resulted in six pregnancies among 21 surrogate monkey moms and two healthy female babies.

"After 20 years of trying from the most talented groups and nothing working, finally this works," Cibelli says. "This research is going to help cloning of all species."

Cloned primates could help researchers better understand diseases in humans. Macaques are close genetic relatives to humans, making the monkeys better analogs than other lab animals. And clones remove the need to account for genetic variation when studying diseases or testing drugs.

The sisters, just a few weeks old, appear normal, but the scientists will watch for any problems as Zhong Zhong and Hua Hua grow and play, Poo said at a news conference January 23.

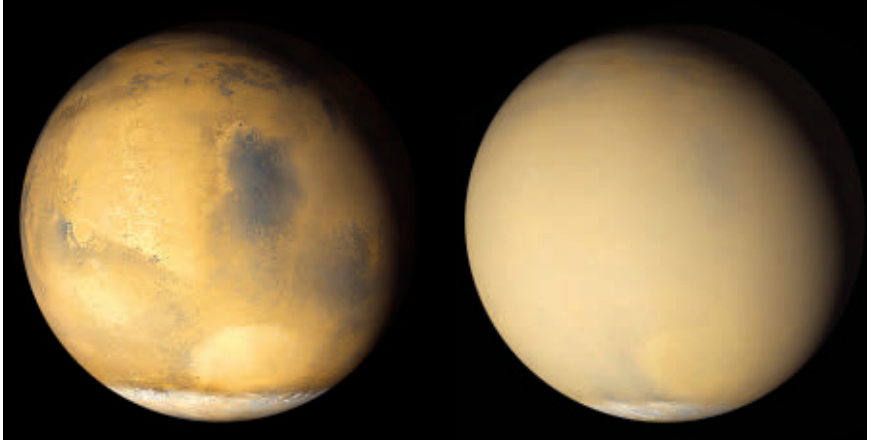
"The monkeys are in good health and very active," he said. "There are no signs they are unhealthy." ■

ATOM & COSMOS

# Dust storms rob Mars of water

## Mechanism may help explain how planet originally dried out

**BY DAN GARISTO**



A dust storm imaged by the Mars Global Surveyor in 2001 swirls over much of Mars (as seen before, left, and during the event). These storms help hydrogen from water vapor escape.

Storms of powdery soil are contributing to the loss of Mars' remaining water.

This mechanism for water loss, proposed January 22 in *Nature Astronomy*, might also hint at how Mars originally became dehydrated. Scientists used over a decade of data taken by NASA's Mars Reconnaissance Orbiter to investigate the composition of the Red Planet's frequent dust storms, some of which are vast enough to circle the planet for months.

During one massive storm in 2006–2007, signs of water vapor were found at unusually high altitudes, nearly 80 kilometers up. That water vapor rose within "rocket dust storms" — storms with rapid vertical movement — on convection currents similar to those in some storm clouds on Earth, says study coauthor Nicholas Heavens, an astronomer at Hampton University in Virginia.

At altitudes above 50 kilometers, ultraviolet light from the sun easily penetrates the Red Planet's thin atmosphere and breaks down water's chemical bonds between hydrogen and oxygen. Left to its own devices, lightweight hydrogen slips free into space, leaving the planet with less of a vital ingredient for water. "Hydrogen loss is measurable from Earth, too, but we have so much water that it's not a big deal," Heavens says.

This is the first study to identify dust storms as a mechanism for water loss. The total effect of dust storms could account for about 10 percent of Mars' current hydrogen loss, Heavens says.

Previous studies have indicated that Mars, which may have once had oceans of water, lost the bulk of its water through hydrogen escape. Whether dust storms contributed to this past loss is up in the air. Extrapolating back billions of years ago, when Mars was warm and wet, isn't so easy. Scientists don't know how dust storms would have worked in a wetter climate or a thicker atmosphere.

"Variations over weeks or months don't really tell you anything about the 1,000-year timescale that governs hydrogen," says astronomer Kevin Zahnle of NASA's Ames Research Center in Moffett Field, Calif. But Zahnle agrees that, right now, storms are helping to bleed Mars dry. ■

ATOM & COSMOS

# Origin of cosmic oddities proposed

## Black hole jets may spawn trio of high-energy particles

**BY LISA GROSSMAN**

It's three for the price of one. A trio of enigmatic high-energy particles could all have the same source: active black holes embedded in galaxy clusters, researchers suggest January 22 in *Nature Physics*.

Scientists have been unable to figure out the origins of the three types of particles — gamma rays that give a background glow to the universe, cosmic neutrinos and ultrahigh energy cosmic rays. Each carries a huge amount of energy, from about a billion electron volts for a gamma ray to 100 billion billion electron volts for some cosmic rays.

Strangely, each particle type seems to contribute the same total amount of energy to the universe as the other two. That's a clue that all three may be powered by the same engine, says physicist Kohta Murase of Penn State. "We can explain the data of these three messengers with one single picture," he says.

First, a black hole accelerates charged particles to extreme energies in a powerful jet. These jets "are one of the most promising candidate sources of ultrahigh energy cosmic rays," Murase says. The most energetic cosmic rays escape the jet and immediately plow through a sea of magnetized gas within the galaxy cluster.

Some of these cosmic rays get trapped in the cluster for up to a billion years. There, the rays interact with the gas and create high-energy neutrinos that then escape the galaxy cluster. Other cosmic rays escape the gas and zip toward Earth. En route through intergalactic space, these rays interact with photons to produce the glow of gamma rays.

Computer simulations of this scenario lined up with the observed rate of cosmic rays, neutrinos and gamma rays that reach Earth, Murase and astrophysicist Ke Fang of the University of Maryland in College Park found.

"It's a nice piece of unification of many ideas," says Francis Halzen, a physicist at the University of Wisconsin–Madison who works with the IceCube Neutrino Observatory in Antarctica, where the highest-energy neutrinos have been observed (*SN: 12/28/13, p. 6*).

But there are other possible sources for the particles. For one, IceCube has already traced an especially high-energy neutrino to a single active black hole that may not be in a cluster (*SN Online: 4/7/16*). IceCube could eventually trace neutrinos back to galaxy clusters. "That's the ultimate test," Halzen says. ■

JPL-CALTECH/NASA, MSSS

BODY & BRAIN

# Cilia play surprising roles in the brain

## Nerve cell 'hairs' may help prevent obesity, among other jobs

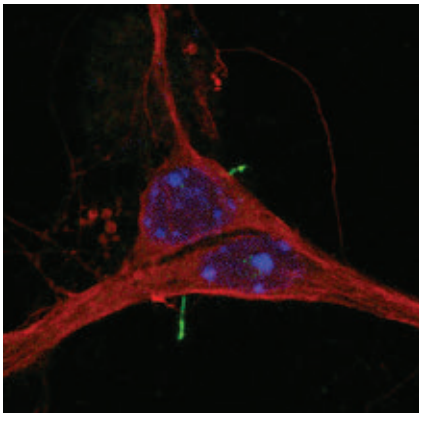
**BY LAURA SANDERS**

Nerve cells in the brain make elaborate connections and exchange lightning-quick messages that captivate scientists. But these cells also sport simpler, hairlike protrusions called cilia. Long overlooked, the little stubs may actually have big jobs in the brain.

Researchers are turning up roles for nerve cell cilia in a variety of brain functions. In a region of the brain linked to appetite, for instance, cilia appear to play a role in preventing obesity, researchers report January 8 in three papers in *Nature Genetics*. Cilia perched on nerve cells, or neurons, may also contribute to brain development, neuron communication and possibly even learning and memory, other research suggests.

"Perhaps every neuron in the brain possesses cilia, and most neuroscientists don't know they're there," says cell biologist Kirk Mykytyn of Ohio State University College of Medicine in Columbus. "There's a big disconnect there."

Most cells in the body — including those in the brain — possess what's called a primary cilium, made up of lipid molecules and proteins. The functions that these appendages perform in parts of the body are starting to come into focus (*SN: 11/3/12, p. 16*). Cilia in the nose, for example, detect smell molecules, and cilia on rod and cone cells in the eye help with vision. But cilia in the brain are more mysterious.



RUCHI BANSAL, N. BERBARI

Mouse nerve cells (red) grown in a dish each sport a hairlike filament called a primary cilium (green). New research is revealing the many jobs cilia may perform in the brain.

The new research offers some clarity. In one study, molecular geneticist Christian Vaisse of the University of California, San Francisco and colleagues examined mutations in a protein called MC4R that are known to cause severe obesity in people. Experiments in mice showed that MC4R normally resides within the cilia on appetite-controlling neurons. But in cells in dishes, several of the mutations prevented MC4R from reaching those cells' cilia from elsewhere in the cells. And one of these mutations prevented MC4R from reaching neuron cilia in the brains of mice.

When the researchers interfered with ADCY3, a protein in the cilia that helps MC4R regulate appetite, the resulting mice gained weight. Those findings suggest that MC4R must reach the cilia in order to interact with ADCY3 and work properly. In the other two new papers, scientists link the *ADCY3* gene to obesity in people, providing more evidence that cilia are involved in obesity.

That link had already been found in rare cases. Mutations that affect cilia can cause severe obesity, as seen with diseases such as Bardet-Biedl syndrome. But the new results hint that abnormal cilia may be more widely involved in obesity. Earlier genetic studies tied obesity to the *MC4R* gene, which the mouse study now shows to be important in cilia. It's possible that many of the common genetic obesity culprits may actually be tinkering with the primary cilia, Vaisse says.

It's not yet clear why MC4R protein needs to reach the cilia to control appetite, Mykytyn says. Perhaps the appendages possess the right mix of helper proteins that aid MC4R in its job. Or maybe cilia change the way the protein works, allowing it to be more efficient.

Although many questions remain, the new research "opens up the window a little more" on what cilia actually do in the brain — how they function, and what can happen when they don't, says cell biologist Nick Berbari of Indiana University–Purdue University Indianapolis.

It's possible that cilia have even broader roles in memory, learning and perhaps mental health, Berbari says. Mice without normal cilia in parts of the brain had trouble remembering a painful shock and recognizing familiar objects, Berbari and colleagues reported in *PLOS One* in 2014. Impaired cilia signaling may even be involved in disorders such as depression and schizophrenia, the researchers speculated.

Cilia are getting assigned a role in other brain functions, too. Mykytyn and colleagues have found a protein in cilia that detects the chemical messenger dopamine, a signal that helps certain neurons operate. And like the obesity-related MC4R protein, this dopamine detector needs to be in a cilium to work properly.

The stubby appendages may also be involved in more sophisticated communication than previously thought. Cilia have reputations as little antennae that sense signals outside of neurons. But cilia may actually be able to send messages themselves, scientists suggested in 2014 in *Current Biology*. Those researchers reported that neuron cilia in *C. elegans* worms could float little packets containing chemical messages into the space between cells. Those signals may have a role in the worms' behavior, the researchers proposed.

Examining the various roles of cilia in the brain is difficult, Mykytyn says. There is no simple way to separate cilia from the rest of cells' outer membranes. The challenges are greater with elaborate neurons, where cilia can be relatively small.

But advances in microscopy and genetic tricks that allow scientists to manipulate specific aspects of cilia may reveal more about how these "underappreciated appendages" work, Berbari says — and offer clues into the mysterious brain. ■

HUMANS & SOCIETY

# Foragers show off superior smell skills

## Hunter-gatherers name odors better than nearby farmers do

**BY BRUCE BOWER**

Smell has a reputation as a second-rate human sense. But that assumption stinks once hunter-gatherers enter the picture.

Semaq Beri hunter-gatherers, who live in tropical forests of Southeast Asia's Malay Peninsula, name various odors as easily as colors, say psycholinguist Asifa Majid and linguist Nicole Kruspe. Yet Semelai rice farmers, who live in forest outposts near the Semaq Beri and speak a closely related language, find odors more difficult to name than colors, the researchers report online January 18 in *Current Biology*.

By including farmers who inhabit a common environment and speak a similar language, the study indicates that the cultural practices of hunter-gatherers help enhance their odor-naming ability — and possibly their smell-detection skills — relative to settled peoples.

Previous research has found that like Semelai farmers, Westerners describe colors far more easily than smells and often talk about odors by resorting to analogies, such as "It smells like banana."

Semaq Beri hunter-gatherers usually used specific terms for a range of odors and colors, say Majid, of Radboud University in Nijmegen, the Netherlands, and Kruspe, of Lund University in Sweden. The forest dwellers are attuned to odor by virtue of their lifestyle and culture, the investigators propose.

That idea seems likely, since hunter-gatherers spend their lives deploying their sense of smell to hunt and avoid danger, says psychologist and clinical neuroscientist Johan Lundström of the Karolinska Institute in Stockholm. Majid and Kruspe's study adds to evidence that "the more we use our sense of smell, the better it gets," he says.

Among the Semaq Beri, 18 individuals completed an odor-naming task for the study, and 16 of them also did a color-naming task. Twenty-one Semelai participants did both tasks. Odor participants sniffed markers that emitted a total of 16 smells, including orange, leather and fish. Color participants viewed 80 differently hued chips and named 20 of them. Kruspe asked volunteers either "What smell is this?" or "What color is this?"

Hunter-gatherers used specific terms for odors (such as one translating as "musty") 86 percent of the time. Colors elicited specific terms (such as "blue") nearly as often, 80 percent of the time.

In contrast, farmers used specific odor words 56 percent of the time, versus specific color words 78 percent of the time.

Smells carry practical and spiritual importance for the Semaq Beri, Majid says. For instance, foragers must recognize the scent of tiger urine, a sign that the predators are nearby. Hunters avoid killing certain prey that exude smells associated with pregnancy, so that the animals won't die out. Semaq Beri religious beliefs hold that certain smells cause illness and others cure ailments. Brothers and sisters should not sit too close together because their smells will mix. "This is considered a sort of incest," Majid says.

Majid has also documented extensive vocabularies for smells in two other Malay Peninsula hunter-gatherer groups as well as among Mexican villagers who, until recently, hunted and gathered.

"Based on our results," Majid says, "I would predict that other contemporary hunter-gatherers also show better odor naming than non–hunter-gatherers do."

Genes are known to influence humans' ability to distinguish odors. But it's unclear whether the Semaq Beri have distinctive genes that enhance their whiffing skills or if growing up in a foraging society boosts the activity of odor-related genes found in other human populations.

Researchers need to examine whether childhood exposure to words that specify many odors strengthens hunter-gatherers' scent-naming skills as adults, Lundström says. ■

GENES & CELLS

# Secret to strong biofilms revealed

## Molecular add-on makes *E. coli* cellulose different from plants'

**BY LAUREL HAMERS**

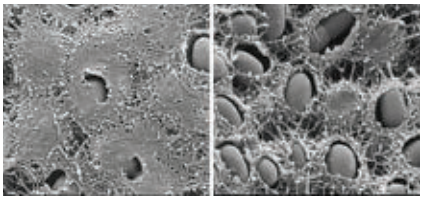
To build resilient colonies, some bacteria make a surprising tweak to a common substance found in cells.

A biochemical addition to the cellulose produced by *E. coli* and other species of bacteria helps them create colonies that are resistant to disruption, researchers report in the Jan. 19 *Science*. Called biofilms, these microbial colonies can cause problems when they form on medical devices or inside the body, leading to hard-to-treat infections that can resist antibiotics. Figuring out how to weaken these films by altering bacteria's cellulose could lead to new treatments.

Cellulose is the most abundant biopolymer on the planet. The substance makes celery stringy and plants' cell walls rigid. The basic structure of cellulose is simple: a bunch of copies of the sugar glucose — the exact number can vary — strung together like beads on a string.

Though the polymer is most associated with plants, some bacteria make cellulose, too. The microbes secrete it and use it to build scaffolding around cells that supports the growth of biofilms. In a biofilm, cellulose is like "the mortar to hold together all the bricks," says study coauthor Lynette Cegelski, a chemical biologist at Stanford University.

When Cegelski and colleagues used a technique called solid-state nuclear magnetic resonance spectroscopy to



*E. coli* bacteria normally secrete a modified form of cellulose that helps build a tightly woven structure (left, scanning electron microscope view). Without the modification to cellulose, the biofilm is less substantial (right).

W. THONGSOMBOON *ET AL*/*SCIENCE* 2018

analyze the biofilm around samples of *E. coli*, the researchers got a surprise. The cellulose made by the bacteria was different from the cellulose made by plants.

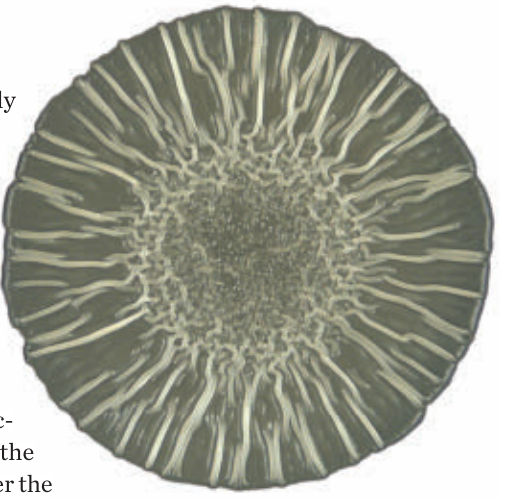
Instead of being only a string of glucose units, bacterial cellulose also had an appendage containing nitrogen and phosphorus. *E. coli*'s appendage add-on affects the way the bacteria form colonies, experiments showed. Normally, bacterial cellulose spins into long tendrils that — along with a different kind of sticky, protein-based fiber — form basketlike structures that cradle individual bacteria and tie them together into an elastic web. But when the researchers genetically engineered the bacteria to produce unmodified cellulose, the cellulose formed shorter fibers. Those fibers made the biofilm matrix weaker. The resulting film also appeared less resistant to microorganisms that produce cellulose-destroying enzymes.

Other studies have looked at bacterial cellulose before. But nobody had realized that it was different from plants' version. That's because a commonly used method for examining biofilms involves dissolving the materials in an acid at one step of the process, which breaks down the cellulose modification.

The new study also pins down the role of a gene that researchers knew was somehow involved in cellulose production in bacteria. This gene, called *bcsG*, gives instructions for an enzyme that attaches the appendage to the glucose chain after the chain is produced, altering the cellulose just before it leaves the cell. Targeting the gene or enzyme responsible for this modification could eventually be a way to weaken biofilms, Cegelski says.

The process by which bacteria make cellulose and secrete it to build biofilms is already quite complex, regulated by more than a dozen genes working together. Adding an enzyme that can "sneak into this machinery" and tack on an appendage makes the story even more complicated, says Jean-Marc Ghigo, a microbial geneticist at the Institut Pasteur in Paris who wasn't involved in the study. "I think it's cool."

Other types of bacteria, such as *Salmonella*, also produce the modified cellulose, Cegelski and colleagues found. She plans to do a wider survey of bacteria to figure out just how widespread it is. ■



This colony of *E. coli* bacteria gets its wrinkly look thanks to tendrils of cellulose used to build a supertight, sticky web. A new view of the microbe's cellulose shows that it's different from the kind found in plants.

L. CEGELSKI

BODY & BRAIN

# Scientists build new kind of flu vaccine

## Approach that revs up body's antiviral system shows potential

**BY AIMEE CUNNINGHAM**

Sometimes an old fight needs a new hero. With the United States in the midst of a tough flu season — and with evidence that the current flu shot is only 10 percent effective against the strains responsible for most illnesses — a new approach to flu vaccine development may do the trick.

Traditional vaccines stimulate antibodies to block viruses. For influenza viruses, this strategy can fall short: Influenza antibodies are specific to one strain, which may not be among those causing illness in an outbreak. Now, UCLA virologist Ren Sun and colleagues have developed a vaccine that could ensure flu viruses can't escape the body's first line of defense, an antiviral system that enlists a cadre of immune proteins and cells.

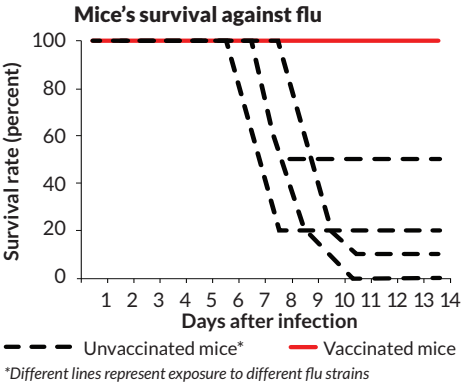
"Because the virus is more visible to the host immune system, it stimulates a very strong immune response," Sun says.

Mice vaccinated with a newly designed flu virus — hyper-interferon-sensitive, or HIS, virus — survived exposure to lethal doses of several influenza A strains. Most mice exposed but not vaccinated died, Sun's team reports in the Jan. 19 *Science*.

"This was a tour de force study," says John Teijaro, a viral immunologist at the Scripps Research Institute in La Jolla, Calif., who coauthored a perspective that accompanied the report. The team exploited vulnerabilities in the genetic material of flu viruses to create a weakened virus that can still kick-start the immune system.

The vaccine targets the body's type I interferon system. When a virus invades a cell, type I interferon proteins rev up the production of proteins that fight the virus. Immune cells called T cells, which kill infected cells, are also activated.

Viruses have proteins that inhibit type I interferons. Sun's team looked for influenza strains that were sensitive to the antiviral machinery and identified mutations responsible for the susceptibility. The researchers combined eight of these mutations into one HIS virus.




**Flu fight** Mice given a new kind of vaccine survived lethal doses of the flu while most mice given only saline died after exposure.

Sun's team vaccinated 40 mice with the HIS virus. After 28 days, those mice and another 40 not vaccinated were exposed to lethal doses of one of four influenza A strains. All vaccinated mice survived; most of the other mice died, depending on which flu strain they had.

T cells are thought to provide protection across different flu strains because the bits of influenza virus that T cells recognize don't mutate as much as influenza surface proteins, the target of antibodies. Future work will need to verify that breadth of protection, Teijaro says. ■

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LIFE & EVOLUTION

# Night light may aid virus' spread

## West Nile lingers in sparrows exposed to artificial glows

**BY SUSAN MILIUS**

SAN FRANCISCO — Even moderate light pollution can roughly double the time a house sparrow remains a risk for passing along the worrisome West Nile virus.

House sparrows, about as widespread across the United States as artificial lighting itself, make a useful test species for a first-of-its-kind study of how night illumination might contribute to disease spread, said Meredith Kernbach, an ecoimmunologist at the University of South Florida in Tampa. *Passer domesticus* brought into the lab and kept dimly illuminated at night were slower in fighting off West Nile infections than lab sparrows allowed full darkness, Kernbach reported January 7 at a meeting of the Society for Integrative and Comparative Biology.

Sparrows kept under a dim night light typically had enough virus in their bloodstreams for at least four days to turn biting mosquitoes into disease spreaders, Kernbach said. Sparrows housed in darkness had high virus concentrations for only about two days. Doubling the time a bird can pass along a big dose of virus to a mosquito that can bite a person could in theory increase the likelihood that a disease will spread.

The broader question of whether light pollution affects human health has been a concern for shift workers. Researchers have also looked at possible changes in reproduction and other behavior in wildlife (*SN: 12/26/15, p. 29*).

Kernbach's project opens new territory by testing light's effects on physiological factors that control how diseases might hopscotch among animals, says Jenny Ouyang of the University of Nevada, Reno. As light pollution studies go, "I don't know of anything like this," says Ouyang, an integrative physiologist.

Kernbach based much of her test on real-world conditions. The viral dose she gave the birds was strong enough to kill about 40 percent of them, and it was well within what a mosquito might pick up vampirizing birds or mammals. She used white incandescent lighting, which is still common despite inroads by LED lighting.

What lights do to birds is only part of the story, notes ecophysiologist Davide Dominoni of the Netherlands Institute of Ecology in Wageningen. Researchers also need to look for effects on the virus itself — and on the mosquitoes. ■

Y. DU *ET AL*/*SCIENCE* 2018

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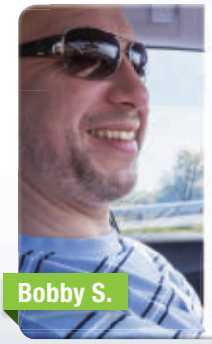
- Heel Pain
- Back/Knee Pain
- Bunions
- Heel Spurs
- Arthritis
- Neuropathy

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EARTH & ENVIRONMENT

# Rising $CO_2$ threatens lake food webs

## High levels of the gas may interfere with water fleas' defenses

**BY CAROLYN GRAMLING**

Rising carbon dioxide levels could leave some tiny lake dwellers defenseless. Like the oceans, some lakes are experiencing increasing levels of the greenhouse gas, a new study shows. And too much dissolved $CO_2$ in the water may leave water fleas, an important part of many lake food webs, too sleepy to fend off predators.

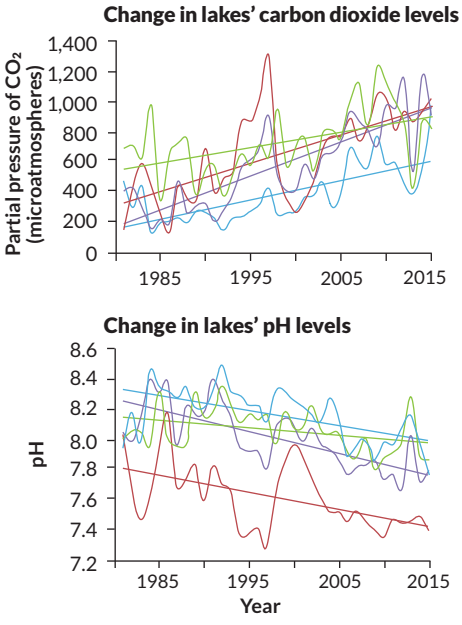
Detailed observations of lake chemistry over long time periods are rare. But data from 1981 through 2015 from four reservoirs in Germany allowed researchers to calculate how much $CO_2$ levels had risen. The data also revealed how much pH levels, measures of acidity in the water, had dropped, the scientists report in the Jan. 22 *Current Biology*.

Increasing $CO_2$ in Earth's atmosphere has boosted levels of the gas dissolved in the oceans, making those waters more acidic (*SN: 5/27/17, p. 11*). Studies show that ocean acidification alters marine species' behaviors. It's less clear how rising atmospheric $CO_2$ levels are affecting freshwater, or how its denizens are coping, says aquatic ecologist Linda Weiss of Ruhr University Bochum in Germany.

Comparing the data from the four reservoirs, Weiss and colleagues found that, in those 35 years, the average $CO_2$ level across all lakes rose by about 500 microatmospheres, a unit of pressure. In one case, $CO_2$ levels increased from 155 to 1,023 microatmospheres. For pH, the lakes' average dropped from 8.13 to 7.82.

In the lab, the scientists examined how high $CO_2$ affected the behavior of two species of pinhead-sized water fleas of the genus *Daphnia*. The crustaceans are at the base of many freshwater food webs. When predators such as the larvae of phantom midges feed on *Daphnia*, the predators release a chemical signal that cues various species of water fleas to arm themselves with an array of defenses. Some raise forbidding neck spikes; others grow giant "helmets" that make the critters tougher to swallow.

But the water fleas' sense of danger seemed to be dulled in waters with high $CO_2$ levels. The team tested *Daphnia* in waters containing both chemical predator cues and $CO_2$ at partial pressures of 2,000, 11,000 and 16,000 microatmospheres. Although 2,000 microatmospheres is considered high — and higher than the German lake levels — it is now common




**Oversaturated** Average carbon dioxide levels increased in four German lakes over 35 years (straight lines in top graph, each color is a different lake). Each lake also showed an overall decrease in pH (bottom).

BODY & BRAIN

# 'Slow' childbirth can be normal

## Rethinking labor could lead to fewer unnecessary C-sections

**BY AIMEE CUNNINGHAM**

A long-standing "rule" for women in labor has been challenged again.

During labor, the cervix, the narrow lower part of the uterus, dilates to allow for a baby's birth. For decades, the guidance has been that the cervix should dilate by at least one centimeter per hour. But a study in two African countries finds a slower dilation rate for many women who had healthy, vaginal births, researchers report January 16 in *PLOS Medicine*.

The study reinforces findings from research on pregnant women in the United States, Japan and elsewhere. Yet some doctors still wrongly classify slower labor as abnormal, researchers say, leading to unnecessary, potentially risky interventions such as cesarean delivery.

"It takes repetitive studies and consistent findings to change long-held beliefs," says Aaron Caughey, a maternal-fetal specialist at Oregon Health & Science University in Portland. "Clinicians need to understand there is great variability in labor length."

For the new study, Olufemi Oladapo, a medical officer in the World Health Organization's Department of Reproductive Health and Research, and colleagues gathered data on more than 5,500 laboring women admitted to 13 hospitals in Nigeria and Uganda. All of the women had gone into labor naturally, had been pregnant with single babies positioned headfirst, and had healthy, vaginal births.

For both first-time mothers and those who had given birth previously, it often took longer than one hour for the cervix to dilate by one centimeter. Overall, dilation was slower until the cervix had expanded to five centimeters, after which it progressed more quickly. Individual labor times varied. Some first-time mothers had their cervix expand from four to five centimeters within two hours; for others, it took up to seven hours.

"There are several aspects to labor progression, and cervical dilation is just one of them," Oladapo says. As long as the vital signs of the mother and baby are fine and the baby's head is descending, a dilation rate of less than one centimeter per hour is not a sufficient reason to intervene, he says. Instead, clinicians

L.C. WEISS *ET AL*/*CURRENT BIOLOGY* 2018

enough in lakes that the team used it as the control case. Both species were less able to defend themselves at 11,000 and 16,000 microatmospheres (considered worst-case scenarios for many lakes) — displaying fewer neck spikes or developing smaller helmets.

Further tests revealed that the elevated $CO_2$ was responsible, rather than the reduced pH. The researchers suggest that elevated $CO_2$ lowers *Daphnia*'s defenses by acting as a narcotic and blunting the water fleas' senses.

Variability between lakes in terms of setting and chemistry makes it difficult to draw firm conclusions from the findings, Weiss says. Many lakes are warming (*SN: 5/13/17, p. 18*). And many are already saturated in $CO_2$ and expelling it into the atmosphere. Others are absorbing the gas and becoming more acidic.

It's also unclear how other freshwater species might be affected at different $CO_2$ levels and in different environments, says Caleb Hasler, an organismal biologist at the University of Winnipeg in Canada. "There's been a bit of work done on phytoplankton, some on zooplankton, freshwater fishes and mussels. If anything, the effect seems to be highly variable." ■

should support the laboring woman by providing food, drink, pain relief and the freedom to move and find a position in which she is comfortable, he says.

A 2014 report on preventing unnecessary cesarean deliveries gives similar advice. The report, coauthored by Caughey, called for changing how abnormally progressing labor is defined. C-sections come with a higher risk of maternal death and complications than vaginal delivery. Yet about 1 in 4 first-time, low-risk pregnancies still resulted in a C-section in the United States in 2015, according to the U.S. Centers for Disease Control and Prevention.

"My sense is that there have been some changes" in how physicians approach the progression of labor, Caughey says. "But I think there is still great heterogeneity in practice in the U.S." ■

HUMANS & SOCIETY

# DNA solves mummy brothers mystery

## Two ancient Egyptians entombed together shared a mother

**BY BRUCE BOWER**

A pair of ancient Egyptian mummies, known for over a century as the Two Brothers, were actually half brothers.

The high-ranking men shared a mother but not a father, say archaeogeneticist Konstantina Drosou of the University of Manchester in England and colleagues. That family tie came to light thanks to the retrieval of two types of DNA from the mummies' teeth, the scientists report in the February *Journal of Archaeological Science: Reports*. The finding highlights the importance that Egyptians placed on maternal lines of descent, Drosou's group contends.

Questions have swirled about the mummies since they were found in 1907. Their tomb dates to Egypt's 12th Dynasty, between 1985 B.C. and 1773 B.C. Coffin inscriptions name a woman, Khnum-Aa, as the men's mother. Both mummies are described as sons of an unnamed local governor. It has been unclear if those inscriptions refer to the same man, but discoverers decided the mummies were full brothers because they were buried together and had the same mother.

Over time, differences discovered in the men's skull and skeletal features raised suspicions that the Two Brothers were not biologically related at all. Some researchers argued that the inscriptions about the mother were misleading.

Adding to those doubts, a 2014 paper reported differences between the two mummies' mitochondrial DNA, suggesting one or both had no biological link to Khnum-Aa. Mitochondrial DNA typically gets inherited only from the mother.

But that study took DNA from liver and intestinal samples using a method susceptible to contamination with modern DNA, Drosou's team argues. In the new work, the team isolated and assembled short pieces of mitochondrial and Y chromosome DNA from both mummies' teeth using methods that minimize potential contamination. The Y chromosome gets passed from father to son.

The DNA "proves the hieroglyphic text to be accurate," at least about the mummies' mom, says study coauthor Campbell Price, an Egyptologist at the Manchester Museum in England.

The inscriptions, he says, must refer to different fathers who were considered peripheral family members and thus left unnamed. "Power may have been transferred down the female line rather than simply by a son inheriting [high rank] from his father," Price says. Khnum-Aa's background, social standing and genetic makeup remain a mystery.

The conclusions from the genetic analyses make sense, says Egyptologist Joann Fletcher of the University of York in England. Many ancient Egyptian texts show precedence to the maternal line, "from the official lists of Egypt's early kings whose names are accompanied by those of their mothers to nonroyal individuals, who likewise cite only their mother's name," Fletcher explains. ■

Ancient Egyptian mummies entombed together and found in these coffins were half brothers, DNA evidence indicates.

MANCHESTER MUSEUM/UNIV. OF MANCHESTER

MATH & TECHNOLOGY

# Lasers trace out floating 3-D images

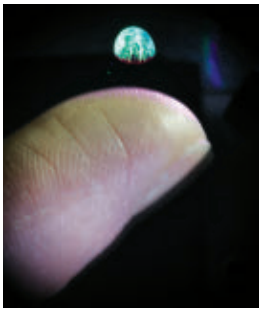
## Hologram-like pictures are visible from almost any direction

**BY MARIA TEMMING**

The 3-D displays seen in such sci-fi movies as *Star Wars* may not be so far, far away.

A new laser system renders full-color 3-D images in thin air, researchers report in the Jan. 25 *Nature*. This technology could someday make free-floating visuals for everything from air traffic control to surgical planning.

With this new technology, "you really can, in principle, achieve what everyone hopes to achieve, which is the image of Princess Leia in that scene in *Star Wars*," says Curtis Broadbent, a physicist at the University of Rochester in New York who was not involved in the work.



Researchers created a 3-D, roughly 1-centimeter-wide image of Earth (shown hovering above a fingertip) with a new laser technique.

Whereas holograms are images on flat surfaces that only appear three-dimensional because of how the light bounces off the material (*SN: 12/4/10, p. 8*), the newly created images actually take up 3-D space. This technology also differs from 2-D images of virtual performers that can be made to appear 3-D through stage tricks that involve carefully placed projectors and reflective surfaces. Like holograms, these seemingly 3-D images can be viewed only from certain angles. The new technique creates 3-D images that can be seen from almost any direction.

This system works by trapping a cellulose particle that's mere micrometers across in a beam of nearly invisible laser light. That laser repeatedly moves the particle along a specific path through the air, for example, in the shape of a corkscrew or the outline of a butterfly. At each point on the particle's path, other lasers illuminate it with red, green or blue light, which the particle scatters in all directions. This creates a single image pixel that can be viewed from all sides.

Because the particle whizzes through the air so quickly and loops through the same path over and over again, all the pixels blur together, like the tip of a sparkler waved so fast it seems to smear into a solid line. This creates what appears to be a still image floating in the air.

Daniel Smalley, an electrical engineer at Brigham Young University in Provo, Utah, and colleagues used this method to produce graphics about the size of a postage stamp. Because the technology draws a picture with a single particle, the team could create only small images, including a high-resolution picture of Earth about 1 centimeter in diameter.

"Scaling that up to even something about the size of a computer monitor would be pretty challenging," Broadbent says.

Smalley says he is already imagining a system that manipulates 100 or even 1,000 particles at once. With those improvements, "the sky becomes the limit," he says.

Free-floating images could help doctors practice surgery before a patient goes under the knife, says physicist Barry Blundell of the University of Derby in England, whose commentary on the research appears in the same issue of *Nature*. The technology could also be used for physical therapy or improving athletic performance. People could record themselves performing various activities, like swinging a golf club, then review the footage on 3-D displays, Blundell explains. And if the images can be continually updated with real-time data, such 3-D visuals could, for example, provide air traffic controllers with dynamic maps of planes in the air.

The possibilities for advertising, education and entertainment systems are endless, Broadbent adds. ■

EARTH & ENVIRONMENT

# Life had a chance in Earth's infancy

## Asteroid barrage didn't leave planet sterile, scientists claim

**BY CAROLYN GRAMLING**

Maybe Earth's early years weren't so hellish after all.

Asteroid strikes repeatedly bombarded the planet during its first eon, but the heat released by those hits wasn't as sterilizing as once thought. New simulations indicate that after the first few hundred million years of bombardment, the heat from the impacts had dissipated enough that 10 to 75 percent of the top kilometer of the subsurface was hospitable to some microbes. If so, the planet may have been habitable much earlier than previously thought, researchers report in the March 1 *Earth and Planetary Science Letters*.

Earth's earliest eon, the Hadean, spans the period from about 4.6 billion years ago, when the planet was born, to 4 billion years ago. The name, for the Greek god of the underworld, reflects the original conception of the age: dark and hellish and inhospitable to life. But little direct evidence of Hadean asteroid impacts exists, limiting scientists' understanding of how those collisions affected the planet's habitability.

"There has been an assumption that the Hadean was mostly an uninteresting slag heap until the sky stopped falling and life could take hold," says geologist Stephen Mojzsis of the University of Colorado Boulder. Conditions were dramatic during Earth's first 150 million years. But after that, things probably settled down considerably, says Mojzsis, who was not part of the new study.

For example, scientists have found signs of liquid water and even faint hints of possible life dating back 4.1 billion years (*SN: 11/28/15, p. 16*). Other researchers have contested the idea that Earth was continually bombarded by asteroids through much of the Hadean, or that a last barrage of asteroids shelled the planet 3.9 billion years ago

D.E. SMALLEY *ET AL*/*NATURE* 2018



Watch lasers form 3-D images at **bit.ly/SN_hologram**

in what has been called the Late Heavy Bombardment, killing any incipient life.

In the new study, geophysicist Robert Grimm and planetary scientist Simone Marchi, both of the Southwest Research Institute in Boulder, Colo., estimated how hot it would have been just a few kilometers beneath the planet's surface during the Hadean. To do so, the scientists used an estimated rate of asteroid bombardment, as well as a measure of how much heat the projectiles would have added to the subsurface and how much that heat would have dissipated over time. The pair also considered whether microbial life could have withstood those conditions. The research built on earlier work, including Marchi's own finding that asteroid impacts became smaller and less frequent with time (*SN: 8/23/14, p. 13*).

Asteroid impacts did heat the subsurface, according to the simulations, but even the heaviest bombardment scenarios were not intense enough to sterilize the planet. And if the rate of bombardment did decrease as the eon progressed, the heat that the asteroids delivered would also have had time to dissipate. As a result, the subsurface zone of habitability would have increased over time.

A Late Heavy Bombardment, if it occurred, would have been tougher for microbes, because the heat wouldn't have had time to dissipate with such a rapid barrage. But that just would have meant the habitable zone didn't increase, the researchers say. Microbes known as mesophiles, which live in temperatures of 20° to 50° Celsius, could still have inhabited at least 20 percent of the top kilometer of subsurface.

Mojzsis says he has come to similar conclusions in his work. "For a long time people said, with absolutely no data, that there could be no biosphere before 3.9 billion years ago," he says. But "after the solar system settled down, the biosphere could have started on Earth 4.4 billion years ago."

That's not to say that there was definitely life, Grimm notes. Although the heat from impacts may not have been a limiting factor for life, asteroid bombardment introduced numerous other challenges, affecting the climate, surface or even convection of the mantle. Still, the picture of Earth's earliest days is undergoing a sea change. As Grimm says, "An average day in the Hadean did not spell doom." ■

NEWS IN BRIEF

LIFE & EVOLUTION

## Key ingredient in potent centipede venom identified

Knocking out an animal 15 times your size — no problem. A newly identified toxin in the venom of a tropical centipede helps the arthropod overpower a mouse in about 30 seconds.

Insight into how this venom overwhelms lab mice could lead to an antidote for people who suffer excruciatingly painful, reportedly even fatal, centipede bites, an international research team reports online January 22 in *Proceedings of the National Academy of Sciences*.

In Hawaii, centipede bites account for about 400 emergency room visits a year, according to data from 2004 to 2008. The main threat there is *Scolopendra subspinipes*, an agile species almost as long as a human hand.

The subspecies *S. subspinipes mutilans* starred in studies at the Kunming Institute of Zoology in China and collaborating labs. Researchers there found a small peptide, now named "spooky toxin," largely responsible for venom misery.

This toxin blocks a molecular channel that normally lets potassium flow through cell membranes. A huge amount of the biochemistry of staying alive involves potassium, so clogging some of what are called KCNQ channels caused mayhem in mice: slow and gasping breath, high blood pressure, frizzling nerve dysfunctions and so on. Administering the epilepsy drug retigabine to mice opened the potassium channels and counteracted much of the toxin's effects, raising hopes for a treatment for these bites. — *Susan Milius*

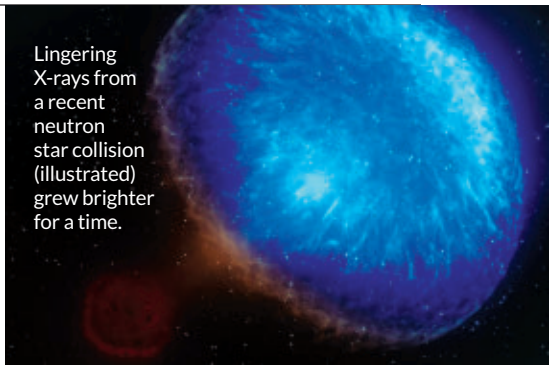
ATOM & COSMOS

## X-ray glow from neutron star collision puzzles scientists

More than 100 days after two neutron stars slammed together, merging into one, new telescope images have revealed that the collision's lingering X-ray light show has gotten brighter. And scientists don't fully understand why.

On August 17, 2017, gravitational waves from the cataclysm reached Earth (*SN: 11/11/17, p. 6*). Fifteen days later, NASA's orbiting X-ray telescope, Chandra, picked up the X-rays. The merged remnant then spent several months too close to the sun for its X-rays to be seen.

When the remnant reemerged from the sun's veil on December 4, the glow was about four times brighter than when it was last spotted, astronomer Daryl Haggard of McGill University in Montreal and her colleagues report in the Jan. 20 *Astrophysical Journal Letters*.



Lingering X-rays from a recent neutron star collision (illustrated) grew brighter for a time.

CI LAB/NASA'S GODDARD SPACE FLIGHT CENTER

The glow may be tapering off. On December 29, the XMM-Newton space telescope found that the X-ray signal may be starting to weaken, a European research team reported January 18 at arXiv.org.

"The plot is about to thicken," says Haggard. Chandra has collected new data to look for a drop in brightness.

Scientists are debating how to explain the enduring X-rays. Neutron star collisions are expected to emit bright jets of material, creating X-rays that fade quickly. The long-lasting X-rays might be explained by a "cocoon" of debris (*SN Online: 12/20/17*), among other possibilities. — *Emily Conover*

# MAGNETIC KNOTS

## Swirls called skyrmions could transform data storage

**By Emily Conover**

Like sailors and spelunkers, physicists know the power of a sturdy knot.

Some physicists have tied their hopes for a new generation of data storage to minuscule knotlike structures called skyrmions, which can form in magnetic materials. Incredibly tiny and tough to undo, magnetic skyrmions could help feed humankind's hunger for ever-smaller electronics.

On traditional hard drives, the magnetic regions that store data are about 10 times as large as the smallest skyrmions. Ranging from a nanometer to hundreds of nanometers in diameter, skyrmions "are probably the smallest magnetic systems ... that can be imagined or that can be realized in nature," says physicist Vincent Cros of Unité Mixte de Physique CNRS/Thales in Palaiseau, France.

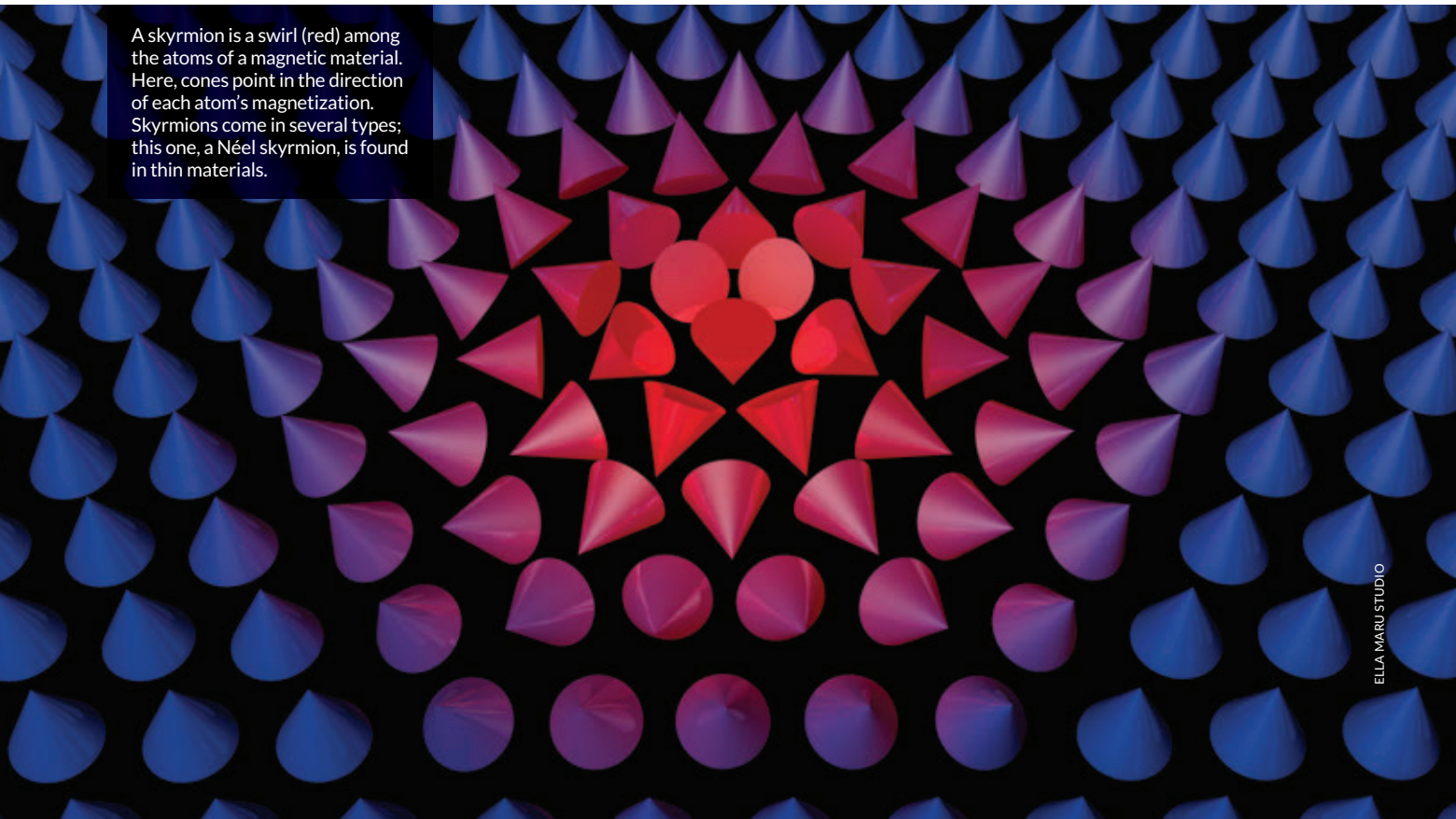
What's more, skyrmions can easily move through a material, pushed along by an electric current. The magnetic knots' nimble nature suggests that skyrmions storing data in a computer could be shuttled to a sensor that would read off the information as the skyrmions pass by. In contrast, traditional hard drives read and write data by moving a mechanical arm to the appropriate region on a spinning platter (*SN: 10/19/13, p. 28*). Those moving parts tend to be fragile, and the task slows down data recall. Scientists hope that skyrmions could one day make for more durable, faster, tinier gadgets.

One thing, however, has held skyrmions back: Until recently, they could be created and controlled only in the frigid cold. When solid-state physicist Christian Pfleiderer and colleagues first reported the detection of magnetic skyrmions, in *Science* in 2009, the knots were impractical to work with, requiring very low temperatures of about 30 kelvins (–243° Celsius). Those are "conditions where you'd say, 'This is of no use for anybody,' " says Pfleiderer of the Technical University of Munich.

Skyrmions have finally come out of the cold, though they are finicky and difficult to control. Now, scientists are on the cusp of working out the kinks to create thawed-out skyrmions with all the desired characteristics. At the same time, researchers are chasing after new kinds of skyrmions, which may be an even better fit for data storage. The skyrmion field, Pfleiderer says, has "started to develop its own life."

### Memories in magnets

In a magnetic material, such as iron, each atom acts like a tiny bar magnet with its own north and south poles. This magnetization arises from spin, a quantum property of the atom's

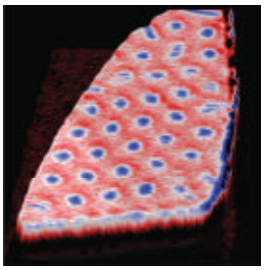


A skyrmion is a swirl (red) among the atoms of a magnetic material. Here, cones point in the direction of each atom's magnetization. Skyrmions come in several types; this one, a Néel skyrmion, is found in thin materials.

ELLA MARU STUDIO

electrons. In a ferromagnet, a standard magnet like the one holding up the grocery list on your refrigerator, the atoms' magnetic poles point in the same direction (*SN Online: 5/14/12*).

Skyrmions, which dwell within such magnetic habitats, are composed of groups of atoms with their magnetic poles oriented in whorls. Those spirals of magnetization disrupt the otherwise orderly alignment of atoms in the magnet, like a cowlick in freshly combed hair. Within a skyrmion, the direction of the atoms' poles twists until the magnetization in the center points in the opposite direction of the magnetization outside. That twisting is difficult to undo, like a strong knot (*SN Online: 10/31/08*). So skyrmions won't spontaneously disappear — a plus for long-term data storage.



A grid of skyrmions (blue circled by white) is revealed in an ultrathin film of palladium and iron, in this image from a scanning tunneling microscope.

Using knots of various kinds to store information has a long history. Ancient Incas used khipu, a system of knotted cord, to keep records or send messages (*SN Online: 5/8/17*). In a more modern example, Pfleiderer says, "if you don't want to forget something then you put a knot in your handkerchief." Skyrmions could continue that tradition.

## On the right track

Skyrmions are a type of "quasiparticle," a disturbance within a material that behaves like a single particle, despite being a collective of many individual particles. Although skyrmions are made up of atoms, which remain stationary within the material, skyrmions can move around like a true particle, by sliding from one group of atoms to another. "The magnetism just twists around, and thus the skyrmion travels," says condensed matter physicist Kirsten von Bergmann of the University of Hamburg.

In fact, skyrmions were first proposed in the context of particles. British physicist Tony Skyrme, who lends his name to the knots, suggested about 60 years ago that particles such as neutrons and protons could be thought of as a kind of knot. In the late 1980s, physicists realized the math that supported Skyrme's idea could also represent knots in the magnetization of solid materials.

Such skyrmions could be used in futuristic data storage schemes, researchers later proposed. A chain of skyrmions could encode bits within a computer, with the presence of a skyrmion representing 1 and the absence representing 0.

In particular, skyrmions might be ideal for what are known as "racetrack" memories, Cros and colleagues proposed in *Nature Nanotechnology* in 2013. In racetrack devices, information-holding skyrmions would speed along a magnetic nanoribbon, like cars on the Indianapolis Motor Speedway.

Solid-state physicist Stuart Parkin proposed a first version of the racetrack concept years earlier. In a 2008 paper in *Science*, Parkin and colleagues demonstrated the beginnings of a racetrack memory based not on skyrmions, but on magnetic features called domain walls, which separate regions with different directions of magnetization in a material. Those domain walls could be pushed along the track using electric currents to a sensor that would read out the data encoded within. To maximize the available space, the racetrack could loop straight up and back down (like a wild Mario Kart ride), allowing for 3-D memory that could pack in more data than a flat chip.

"When I first proposed [racetrack memories] many years ago, I think people were very skeptical," says Parkin, now at the Max Planck Institute of Microstructure Physics in Halle, Germany. Today, the idea — with and without skyrmions — has caught on. Racetrack memories are being tested in laboratories, though the technology is not yet available in computers.

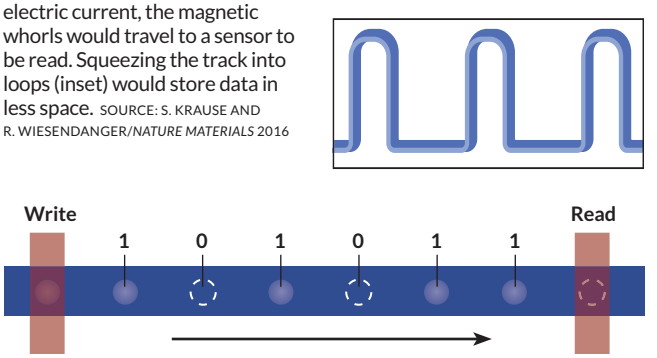
To make such a system work with skyrmions, scientists need to make the knots easier to wrangle at room temperature. For skyrmion-based racetrack memories to compete with current technologies, skyrmions must be small and move quickly and easily through a material. And they should be easy to create and destroy, using something simple like an electric current. Those are lofty demands: A step forward on one requirement sometimes leads to a step backward on the others. But scientists are drawing closer to reining in the magnetic marvels.

## Heating up

Those first magnetic skyrmions found by Pfleiderer and colleagues appeared spontaneously in crystals with asymmetric structures that induce a twist between neighboring atoms. Only certain materials have that skyrmion-friendly asymmetric structure, limiting the possibilities for studying the quasiparticles or coaxing them to form under warmer conditions.

Soon, physicists developed a way to artificially create an asymmetric structure by depositing material in thin layers. Interactions between atoms in different layers can induce a twist in the atoms' orientations. "Now, we can suddenly use ordinary magnetic materials, combine them in a clever way with

**Drive it** In a "racetrack" memory, skyrmions could be created to represent a 0 or 1. Pushed by an electric current, the magnetic whorls would travel to a sensor to be read. Squeezing the track into loops (inset) would store data in less space. SOURCE: S. KRAUSE AND R. WIESENDANGER/*NATURE MATERIALS* 2016




FROM TOP: K. VON BERGMANN; T. TIBBITTS

other materials, and make them work at room temperature," says materials scientist Axel Hoffmann of Argonne National Laboratory in Illinois.

Scientists produced such thin film skyrmions for the first time in a one-atom-thick layer of iron on top of iridium, but temperatures were still very low. Reported in *Nature Physics* in 2011, those thin film skyrmions required a chilly 11 kelvins (–262° C). That's because the thin film of iron loses its magnetic properties above a certain temperature, says von Bergmann, who coauthored the study, along with nanoscientist Roland Wiesendanger of the University of Hamburg and colleagues. But thicker films can stay magnetic at higher temperatures. And so, "one important step was to increase the amount of magnetic material," von Bergmann says.

To go thicker, scientists began stacking sheets of various magnetic and nonmagnetic materials, like a club sandwich with repeating layers of meat, cheese and bread. Stacking multiple layers of iridium, platinum and cobalt, Cros and colleagues created the first room-temperature skyrmions smaller than 100 nanometers, the researchers reported in May 2016 in *Nature Nanotechnology*.

> "It is a technology that combines the best of multiple worlds."
> **MATHIAS KLÄUI**

By adjusting the types of materials, the number of layers and their thicknesses, scientists can fashion designer skyrmions with desirable properties. When condensed matter physicist Christos Panagopoulos of Nanyang Technological University in Singapore and colleagues fiddled with the composition of layers of iridium, iron, cobalt and platinum, a variety of skyrmions swirled into existence. The resulting knots came in different sizes, and some were more stable than others, the researchers reported in *Nature Materials* in September 2017.

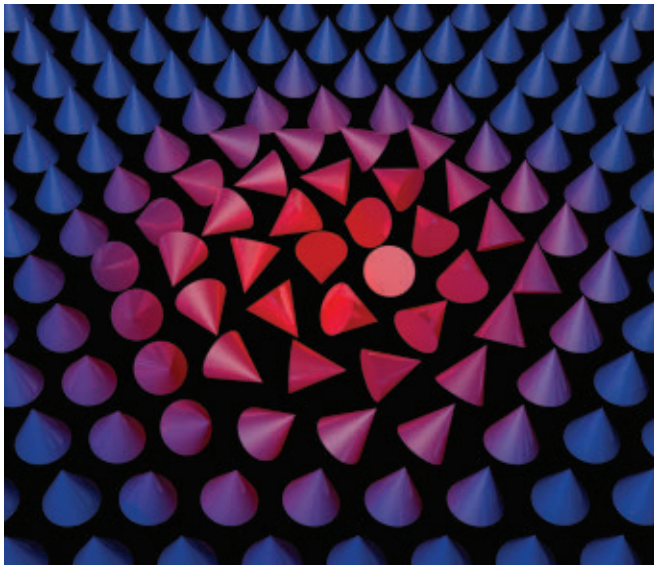
Although scientists now know how to make room-temperature skyrmions, the heat-tolerant swirls, tens to hundreds of nanometers in diameter, tend to be too big to be very useful. "If we want to compete with current state-of-the-art technology, we have to go for skyrmionic objects [that] are much smaller in size than 100 nanometers," Wiesendanger says. The aim is to bring warmed-up skyrmions down to a few nanometers.

As some try to shrink room-temp skyrmions down, others are bringing them up to speed, to make for fast reading and writing of data. In a study reported in *Nature Materials* in 2016, skyrmions at room temperature reached top speeds of 100 meters per second (about 220 miles per hour). Fittingly, that's right around the fastest speed NASCAR drivers achieve. The result showed that a skyrmion racetrack might actually work, says study coauthor Mathias Kläui, a condensed matter physicist at Johannes Gutenberg University Mainz in Germany. "Fundamentally, it's feasible at room temperature." But to compete against domain walls, which can reach speeds of over 700 m/s, skyrmions still need to hit the gas.

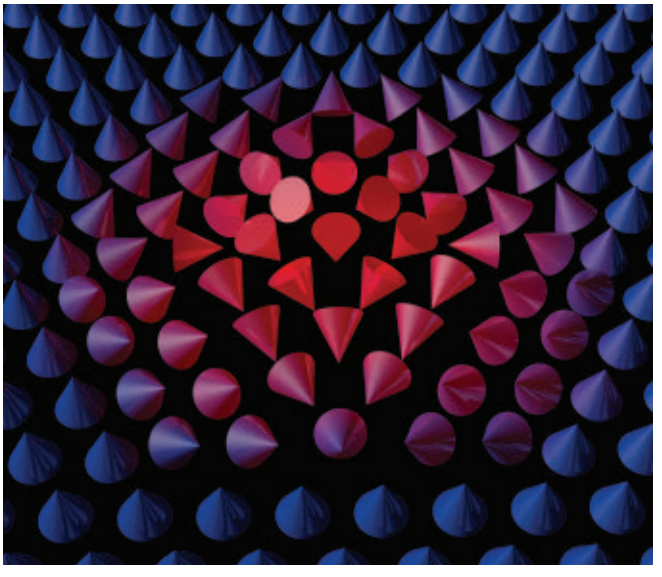
Despite progress, there are a few more challenges to work out. One possible issue: A skyrmion's swirling pattern makes it behave like a rotating object. "When you have a rotating object moving, it may not want to move in a straight line," Hoffmann says. "If you're a bad golf player, you know this." Skyrmions don't move in the same direction as an electric current, but at an angle to it. On the racetrack, skyrmions might hit a wall instead of staying in their lanes. Now, researchers are seeking new kinds of skyrmions that stay on track.

## A new twist

Just as there's more than one way to tie a knot, there are several different types of skyrmions, formed with various shapes



**Bloch skyrmion** The first type of skyrmion detected, called a Bloch skyrmion, appears in asymmetric crystals. The magnetic poles tilt around the circle instead of outward, as they do in a Néel skyrmion (Page 18).



**Antiskyrmion** Newly discovered antiskyrmions are like a cross between Néel and Bloch skyrmions, and may have some advantages for memory devices, such as tolerating a range of temperatures.

BOTH: ELLA MARU STUDIO

of magnetic twists. The two best known types are Bloch and Néel. Bloch skyrmions are found in the thick, asymmetric crystals in which skyrmions were first detected, and Néel skyrmions tend to show up in thin films.

"The type of skyrmions you get is related to the crystal structure of the materials," says physical chemist Claudia Felser of the Max Planck Institute for Chemical Physics of Solids in Dresden, Germany. Felser studies Heusler compounds, materials that have unusual properties particularly useful for manipulating magnetism. Felser, Parkin and colleagues detected a new kind of skyrmion, an antiskyrmion, in a thin layer of such a material. They reported the find in August 2017 in *Nature*.

Antiskyrmions might avoid some of the pitfalls that their relatives face, Parkin says. "Potentially, they can move in straight lines with currents, rather than moving to the side." Such straight-shooting skyrmions may be better suited for racetrack schemes. And the observed antiskyrmions are stable at a wide range of temperatures, including room temperature. Antiskyrmions also might be able to shrink down smaller than other kinds of skyrmions.

Physicists are now on the hunt for skyrmions within a different realm: antiferromagnetic materials. Unlike in ferromagnetic materials — in which atoms all align their poles — in antiferromagnets, atoms' poles point in alternating directions. If one atom points up, its neighbor points down. Like antiskyrmions, antiferromagnetic skyrmions wouldn't zip off at an angle to an electric current, so they should be easier to control. Antiferromagnetic skyrmions might also move faster, Kläui says.

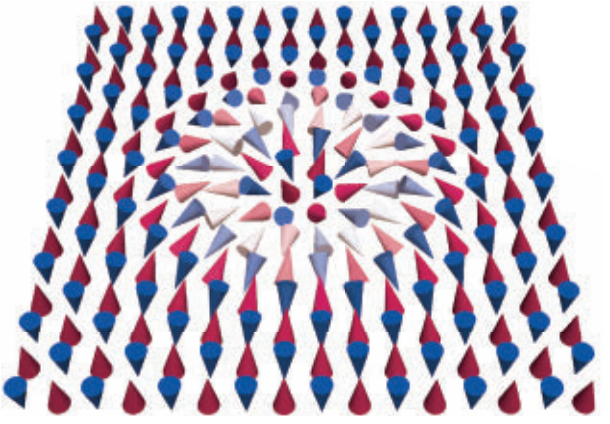
Materials scientists still need to find an antiferromagnetic material with the necessary properties to form skyrmions, Kläui says. "I would expect that this would be realized in the next couple of years."

## Finding the knots' niche

Once skyrmions behave as desired, creating a racetrack memory with them is an obvious next step. "It is a technology that combines the best of multiple worlds," Kläui says — stability, easily accessible data and low energy requirements. But Kläui and others acknowledge the hurdles ahead for skyrmion racetrack memories. It will be difficult, these researchers say, to beat traditional magnetic hard drives — not to mention the flash memories available in newer computers — on storage density, speed and cost simultaneously.

"The racetrack idea, I'm skeptical about," Hoffmann says. Instead, skyrmions might be useful in devices meant for performing calculations. Because only a small electric current is required to move skyrmions around, such devices might be used to create energy-efficient computer processors.

Another idea is to use skyrmions for biologically inspired computers, which attempt to mimic the human brain (*SN: 9/6/14, p. 10*). Brains consume about as much power as a lightbulb, yet can perform calculations that computers still can't match, thanks to large interconnected networks of nerve cells. Skyrmions could help scientists achieve this kind of computation in the lab, without sapping much power.



**In theory** If found, antiferromagnetic skyrmions would move in a straight line when pushed by electric current. They would arise in materials with atoms that have alternating magnetic poles.

A single skyrmion could behave like a nerve cell, or neuron, electrical engineer Sai Li of Beihang University in Beijing and colleagues suggest. In the human body, a neuron can add up signals from its neighbors, gradually building up a voltage across its membrane. When that voltage reaches a certain threshold, ions begin shifting across the membrane in waves, generating an electric pulse. Skyrmions could imitate this behavior: An electric current would push a skyrmion along a track, with the distance traveled acting as an analog for the neuron's increasing voltage. A skyrmion reaching a detector at the end would be equivalent to a firing neuron, the researchers proposed in July 2017 in *Nanotechnology*.

By combining a large number of neuron-imitating skyrmions, the thinking goes, scientists could create a computer that operates something like a brain.

Additional ideas for how to use the magnetic whirls keep cropping up. "It's still a growing field," von Bergmann says. "There are several new ideas ahead."

Whether or not skyrmions end up in future gadgets, the swirls are part of a burgeoning electronics ecosystem. Ever since electricity was discovered, researchers have focused on the motion of electric charges. But physicists are now fashioning a new parallel system called spintronics — of which skyrmions are a part — based on the motion of electron spin, that property that makes atoms magnetic (*SN Online: 9/26/17*). By studying skyrmions, researchers are expanding their understanding of how spins move through materials.

Like a kindergartner fumbling with shoelaces, studying how to tie spins up in knots is a learning process. ■

## Explore more


- Christopher H. Marrows. "Viewpoint: an inside view of magnetic skyrmions." *Physics*. May 1, 2015.
- Stefan Krause and Roland Wiesendanger. "Spintronics: Skyrmionics gets hot." *Nature Materials*. April 26, 2016.


X. ZHANG, Y. ZHOU, M. EZAWA/*SCIENTIFIC REPORTS* 2016. ADAPTED BY E. OTWELL

# The Realities of **Play**

## Practical pursuits send kids' fantasy games to the time-out corner

**By Bruce Bower**

Young children travel to fantasy worlds every day, packing just imaginations and a toy or two.

Some preschoolers scurry across ocean floors carrying toy versions of cartoon character SpongeBob SquarePants. Other kids trek to distant universes with miniature replicas of *Star Wars* robots R2-D2 and C-3PO. Throngs of youngsters fly on broomsticks and cast magic spells with Harry Potter and his Hogwarts buddies. The list of improbable adventures goes on and on.

Parents today take for granted that kids need toys to fuel what comes naturally — outlandish bursts of make-believe. Kids' flights of fantasy are presumed to soar before school and life's other demands yank the youngsters down to Earth.

Yet some researchers call childhood fantasy play — which revolves around invented characters and settings with no or little relationship to kids' daily lives — highly overrated. From at least the age when they start talking, little ones crave opportunities to assist parents at practical tasks and otherwise learn how to be productive members of their cultures, these investigators argue.

New findings support the view that children are geared more toward helping than fantasizing. Preschoolers would rather perform real activities, such as cutting vegetables or feeding a baby, than pretend to do those same things, scientists say. Even in the fantastical realm of children's fiction books, reality may have an important place. Young U.S. readers show signs of learning better from human characters than from those ever-present talking pigs and bears.

Studies of children in traditional societies illustrate the dominance of reality-based play outside modern Western cultures. Kids raised in hunter-gatherer communities, farming villages and herding groups rarely play fantasy games. Children typically play with real tools, or small replicas of tools, in what amounts to practice for adult work. Playgroups supervised by older children enact make-believe versions of what adults do, such as sharing hunting spoils.

These activities come much closer to the nature of play in ancient human groups than do childhood fantasies fueled by mass-produced toys, videos and movies, researchers think.

P_PONOMAREVA/ISTOCKPHOTO

Handing over household implements to toddlers and preschoolers and letting them play at working, or allowing them to lend a hand on daily tasks, generates little traction among Western parents, says psychologist Angeline Lillard of the University of Virginia in Charlottesville. Many adults, leaning heavily on adult-supervised playdates, assume preschoolers and younger kids need to be protected from themselves. Lillard suspects that preschoolers, whose early helping impulses get rebuffed by anxious parents, often rebel when told to start doing household chores a few years later.

"Kids like to do real things because they want a role in the real world," Lillard says. "Our society has gone overboard in stressing the importance of pretense and fantasy for young children."

## Keep it real

Lillard suspects most preschoolers agree with her.

More than 40 years of research fails to support the widespread view that playing pretend games generates special social or mental benefits for young children, Lillard and colleagues wrote in a 2013 review in *Psychological Bulletin*. Studies that track children into their teens and beyond are sorely needed to establish any beneficial effects of pretending to be other people or acting out imaginary situations, the researchers concluded.

Even the assumption that kids naturally gravitate toward make-believe worlds may be unrealistic. When given a choice, 3- to 6-year-olds growing up in the United States — one of many countries saturated with superhero movies, video games and otherworldly action figures — preferred performing real activities over pretending to do them, Lillard and colleagues reported online June 20 in *Developmental Science*.

One hundred youngsters, most of them white and middle class, were tested either in a children's museum, a preschool or a university laboratory. An experimenter showed each child nine pairs of photographs. Each photo in a pair featured a boy or a girl, to match the sex of the youngster being tested. One photo showed a child in action. Depicted behaviors included cutting vegetables with a knife, talking on a telephone and bottle-feeding a baby. In the second photo, a different child pretended to do what the first child did for real.

When asked by the experimenter whether they would rather, say, cut real vegetables with a knife like the first child or pretend to do so like the second child, preschoolers chose the real activity almost two-thirds of the time. Among the preschoolers, hard-core realists outnumbered fans of make-believe, the researchers found. Whereas 16 kids always chose real activities, only three wanted to pretend on every trial. Just as strikingly, 48 children (including seven of 26 of the 3-year-olds) chose at least seven real activities of the nine depicted. Only 14 kids (mostly the younger ones) selected at least seven pretend activities.

Kids often said they liked real activities for practical reasons, such as wanting to learn how to feed babies to help mom. Hands-on activities also got endorsed for being especially fun or novel. "I've never talked on the real phone," one child explained. Reasons for choosing pretend activities centered on being afraid of the real activity or liking to pretend.

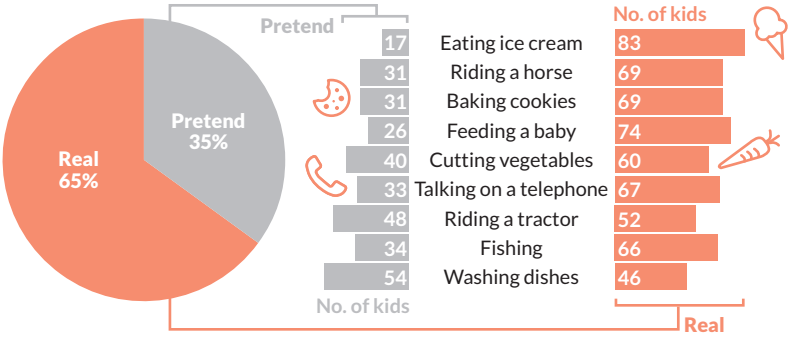
In a preliminary follow-up study directed by Lillard, 16 girls and boys, ages 3 to 6, chose between playing with 10 real objects, such as a microscope, or toy versions of the same objects. During 10-minute play periods, kids spent an average of about twice as much time with real items. That preference for real things increased with age. Three-year-olds spent nearly equal time playing with genuine and pretend items, but the older children strongly preferred the real deal.

Lillard's findings illustrate that kids want and need real experiences, says psychologist Thalia Goldstein of George Mason University in Fairfax, Va. "Modern definitions of childhood have swung too far toward thinking that young children should live in a world of fantasy and magic," she maintains.

But pretend play, including fantasy games, still has value in fostering youngsters' social and emotional growth, Goldstein and Matthew Lerner of Stony Brook University in New York reported online September 15 in *Developmental Science*. After participating in 24 play sessions, 4- and 5-year-olds from poor families were tested on

**Just do it** In a recent study of 100 U.S. 3- to 6-year-olds, the kids frequently wanted to cut vegetables or perform other actual activities rather than pretend to do those same activities. SOURCE: J. TAGGART *ET AL/DEVELOPMENTAL SCIENCE* 2017

**Preference for real or pretend activities among 3- to 6-year-olds**




C. CHANG

When given a choice, youngsters often used a drawing of a realistic school bus (above, left), rather than a futuristic or magical one, to end stories containing futuristic or magical themes.

empathy and other social skills. Those who played dramatic pretend games (being a superhero, animal or chef, for instance) were less likely than kids who played with blocks or read stories to become visibly upset upon seeing an experimenter who the kids believed had hurt a knee or finger, the researchers found. Playing pretend games enabled kids to rein in distress at seeing the experimenter in pain, the researchers proposed.

It's not known whether fantasy- and reality-based games shape kids' social skills in different ways over the long haul, Goldstein says.

## True fiction

Even on the printed page, where youngsters gawk at Maurice Sendak's goggle-eyed Wild Things and Dr. Seuss' mustachioed Lorax, the real world exerts a special pull.

Consider 4- to 6-year-olds who were read either a storybook about a little raccoon that learns to share with other animals or the same storybook with illustrations of human characters learning to share. Both versions told of how characters felt better after giving some of what they had to others. A third set of kids heard an illustrated storybook about seeds that had nothing to do with sharing. Each group consisted of 32 children.

Only kids who heard the realistic story displayed a general willingness to act on its message, reported a team led by psychologist Patricia Ganea of the University of Toronto in a paper published online August 2 in *Developmental Science*. On a test of children's willingness to share any of 10 stickers with a child described as unable to participate in the experiment, listeners to the tale with human characters forked over an average of nearly three stickers, about one more than the kids had donated before the experiment.

Children who heard stories with animal characters became less giving, sharing an average of 1.7 stickers after having originally donated an average of 2.3 stickers. Sticker sharing declined similarly among kids who heard the seed story. These results fit with several previous studies showing that preschoolers more easily apply knowledge learned from realistic stories to the real world, as opposed to information encountered in fantasy stories.

Even for fiction stories that are highly unrealistic, youngsters generally favor realistic endings, say Boston University psychologist Melissa Kibbe and colleagues. In a study from the team published online June 15 in *Psychology of Aesthetics, Creativity and the Arts*, an experimenter read 90 children, ages 4 to 6, one of three illustrated versions of a story. In the tale, a child gets lost on the way to a school bus. A realistic version was set in a present-day city. A futuristic science fiction version was set on the moon. A fantasy version occurred in medieval times and included magical characters. Stories ended with descriptions and illustrations of a child finally locating either a typical school bus, a futuristic school bus with rockets on its sides or a magical coach with dragon wings.

When given the chance, 40 percent of kids inserted a typical school bus into the ending for the science fiction story and nearly 70 percent did so for the fantasy tale. "Children have a bias toward reality when completing stories," Kibbe says.

## Hands on

Outside Western cultures, children's bias toward reality takes an extreme turn, especially during play.

Nothing keeps it real like a child merrily swinging around a sharp knife as adults go about their

Among South America's Matsés hunter-gatherers, adults allow young children, such as this girl, to play with knives.

FROM TOP: M. KIBBE *ET AL/PSYCH. OF AESTHETICS, CREATIVITY AND THE ARTS* 2017; KHALED HAKAMI

business. That's cause for alarm in Western households. But in many foraging communities, children play with knives and even machetes with their parents' blessing, says anthropologist David Lancy of Utah State University in Logan.

Lancy describes reported instances of youngsters from hunter-gatherer groups playing with knives in his 2017 book *Raising Children*. Among Maniq foragers inhabiting southern Thailand's forests, for instance, one researcher observed a father looking on approvingly as his baby crawled along holding a knife about as long as a dollar bill. The same investigator observed a 4-year-old Maniq girl sitting by herself cutting pieces of vegetation with a machete.

In East Africa, a Hadza infant can grab a knife and suck on it undisturbed, at least until an adult needs to use the tool. On Vanatinai Island in the South Pacific, children freely experiment with knives and pieces of burning wood from campfires.

Yes, accidents happen. That doesn't mean hunter-gatherer parents are uncaring or indifferent

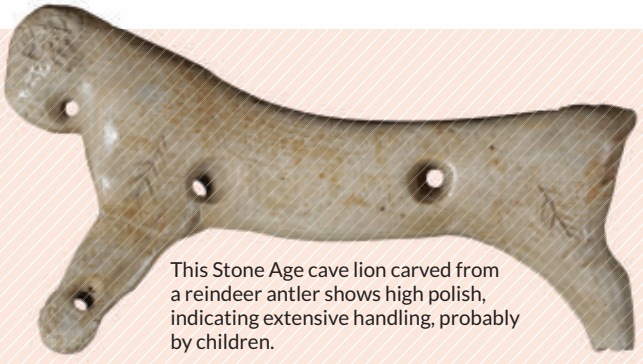
## Hunting for ancient toys

Youngsters have probably been playing their way into cultural competence for at least tens of thousands of years. So why are signs of children largely absent from the archaeological record?

A cartoon that Biblical scholar Kristine Garroway taped up in her college dorm helps to explain kids' invisibility at ancient sites: Two men in business suits stare intently at an unidentifiable round object sitting on a table. "Hey, what's this?" asks the first guy. "I dunno, probably a toy … or a religious object," says the second. Archaeologists have long tended to choose the second option, says Garroway, now a visiting scientist at Hebrew Union College–Jewish Institute of Religion in Los Angeles. Ambiguous finds, such as miniature pottery vessels and small figurines, get classified as ritual or decorative objects. Some of these artifacts undoubtedly were used in ceremonies. But not all of them, Garroway argues.

Of 48 miniature clay vessels excavated from inside roughly 3,650- to 4,000-year-old houses at Israel's Tel Nagila site, 10 retained fingerprints the size of children's that were made during the shaping of soft clay, before the clay was heated and hardened, archaeologists reported in 2013. Kids must have made those somewhat unevenly shaped jars and bowls, each easily held within a child's hand, concluded Joe Uziel of the Israel Antiquities Authority in Jerusalem and independent Israeli researcher Rona Avissar Lewis in *Palestine Exploration Quarterly*.

Unusual finds in Israel dating to around 3,000 years ago also represent children's early attempts to mimic adult craftwork, Garroway said in a November 18 presentation in Boston at the annual meeting of the American Schools of Oriental Research. Numerous rounded clay disks, each pierced with two holes, have mystified investigators for nearly a century. As early as 1928, an archaeologist suggested that these button-sized objects were toys. After passing a string through both of a disk's holes and tying the ends together, a youngster could swing the string to wind up the toy and then pull both ends of the string to make the disk spin. Clay disks from six Israeli sites can be separated into those made by skilled artisans and others — featuring rough edges and unevenly spaced holes — made by novices, including children, Garroway proposes. If those items were toys, sloppy execution may have partly resulted from children's impatience to play with the final product, she suspects.



This Stone Age cave lion carved from a reindeer antler shows high polish, indicating extensive handling, probably by children.

Garroway's proposal appears likely, especially in light of evidence that more than 10,000 years earlier, people in France and Spain made similar spinning disks decorated with animals that appeared to move as the toy twirled (*SN: 6/30/12, p. 12*), says archaeologist Michelle Langley of Griffith University in Brisbane, Australia.

Western European finds from as early as 14,000 to 21,000 years ago also may have gone unrecognized as children's toys, Langley suggests in a paper published this month in the *Oxford Journal of Archaeology*. One specimen, a cave lion carved out of a reindeer's antler, displays so much polish from handling that children may have played with the item for years, she says. Some bone spearpoints with broken tips bear signs of unskilled repair, suggesting adults gave the damaged weapons to children to practice bone-working skills and perhaps play with, she adds. — *Bruce Bower*

A reconstruction of a spinning disk from about 14,000 to 21,000 years ago in Western Europe shows an animal in different positions on each side. As the disk is twirled on a string, the creature appears to move.

FROM TOP: M. LANGLEY/MAN, ST-GERMAIN-EN-LAYE; M. AZÉMA AND F. RIVÈRE, © PASSÉ SIMPLE, *ANTIQUITY* 2012

In Africa, children of Aka hunter-gatherers build a figure of a forest spirit out of plants. Such play activities introduce the youngsters to adults' religious world.

toward their children, Lancy says. In these egalitarian societies, where sharing food and other resources is the norm, parents believe it's wrong to impose one's will on anyone, including children. Hunter-gatherer adults assume that a child learns best through hands-on, sometimes risky, exploration on his or her own and in groups with other kids. In that way, the adults' thinking goes, youngsters develop resourcefulness, creativity and determination. Self-inflicted cuts and burns represent learning opportunities.

In many societies, adults make miniature tools for children to play with or give kids cast-off tools to use as toys. For instance, Inuit boys have been observed mimicking seal hunts with items supplied by parents, such as pieces of sealskin and miniature harpoons. Girls in Ecuador's Conambo tribe mold clay balls provided by their mothers into various shapes as a first step toward becoming potters.

Childhood games and toys in foraging groups and farming villages, as in Western nations, reflect cultural values. Hunter-gatherer kids rarely engage in rough-and-tumble or competitive games. In fact, competition is discouraged. These kids concoct games with no winners, such as throwing a weighted feather in the air and flicking the feather back up as it descends. Children in many farming villages and herding societies play basic forms of marbles, in which each player shoots a hard object at similar objects to knock the targets out of a defined area. The rules change constantly as players decide among themselves what counts and what doesn't.

Children in traditional societies don't invent fantasy characters to play with, Lancy says. Consider imaginative play among children of Aka foragers in the Central African Republic. These kids may pretend to be forest animals, but the animals are creatures from the children's surroundings, such as antelope. The children aim to take the animals' perspective to determine what route to follow while exploring, says anthropologist Adam Boyette of Duke University. Aka youngsters sometimes pretend to be spirits that adults have told the kids about. In this way, kids become familiar with community beliefs and rituals.

Aka childhood activities are geared toward adult work, Boyette says. Girls start foraging for food within the first few years of life. Boys take many years to master dangerous tasks, such as climbing trees to raid honey from bees' nests (*SN: 8/20/16, p. 10*). By around age 7, boys start to play hunting games and graduate to real hunts as teenagers.

In 33 hunter-gatherer societies around the world, parents typically take 1- to 2-year-olds on foraging expeditions and give the youngsters toy versions of tools to manipulate, reported psychologist Sheina Lew-Levy of the University of Cambridge and her colleagues in the December *Human Nature*. Groups of children at a range of ages play make-believe versions of what adults do and get in some actual practice at tasks such as toolmaking. Youngsters generally become proficient food collectors and novice toolmakers between ages 8 and 12, the researchers conclude. Adults, but not necessarily parents, begin teaching hunting and complex toolmaking skills to teens. For the report, Lew-Levy's group reviewed 58 papers on childhood learning among hunter-gatherers, most published since 2000.

"There's a blurred line between work and play in foraging societies because children are constantly rehearsing for adult roles by playing," Boyette says.

Children in Western societies can profitably mix fantasy with playful rehearsals for adult tasks, observes George Mason's Goldstein, who was a professional stage actor before opting for steadier academic work. "My 5-year-old son is never happier than when he's helping to check us out at the grocery store," she says. "But he also likes to pretend to be a robot, and sometimes a robot who checks us out at the grocery store."

Not too far in the future, preschoolers pretending to be robots may encounter real robots running grocery-store checkouts. Playtime will never be the same. ■

## Explore more

■ David Lancy. *Raising Children: Surprising Insights from Other Cultures*. Cambridge University Press, 2017.

A. BOYETTE

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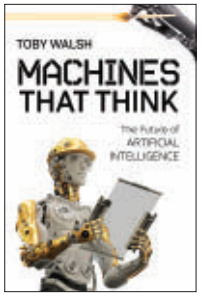


**Machines That Think**
*Toby Walsh*
PROMETHEUS BOOKS, $16

BOOKSHELF

## Artificial intelligence: past, present and future

Movies and other media are full of mixed messages about the risks and rewards of building machines with minds of their own. For every manipulative automaton like *Ex Machina*'s Ava (*SN: 5/16/15, p. 26*), there's a helpful *Star Wars* droid. And while some tech titans such as Elon Musk warn of the threats artificial intelligence presents, others, including Mark Zuckerberg, dismiss the doomsayers.

AI researcher Toby Walsh's *Machines That Think* is for anyone who has heard the hype and is seeking a critical assessment of what the technology can do — and what it might do in the future. Walsh's conversational style is welcoming to nonexperts while his endnotes point readers to opportunities for deeper dives into specific aspects of AI.

Walsh begins with a history of AI, from Aristotle's foundation of formal logic to modern facial-recognition systems. Excerpts from computer-composed poetry and tales of computers trouncing humans at strategy games (*SN: 11/11/17, p. 13*) are a testament to how far AI has come. But Walsh also highlights weaknesses, such as machine-learning algorithms' reliance on so much data to master a single task.

This 30,000-foot view of AI research packs a lot of history, as well as philosophical and technical explanation. Walsh personalizes the account with stories of his own programming experiences, anecdotes about AI in daily life — like his daughter's use of Siri — and his absolute, unapologetic love of puns.

Later in the book, Walsh speculates about technical hurdles that may curb further AI development and legal limits that society may want to impose. He also explores the societal impact that increasingly intelligent computers may have.

For instance, Walsh evaluates how likely various jobs are to be outsourced to AI. Some occupations, like journalist, will almost certainly be automated, he argues. Others, like oral surgeon, are probably safe. For future job security, Walsh recommends pursuing careers that require programming acumen, emotional intelligence or creativity.

AI also has the potential to revolutionize warfare. "Like Moore's law, we are likely to see exponential growth in the capabilities of autonomous weapons," Walsh writes. "I have named this 'Schwarzenegger's law' to remind us of where it will end." Walsh isn't resigned to a *Terminator*-like future, though. If governments ban killer robots and arms developers use automation to enhance defensive equipment, he believes military AI could actually save many lives.

In fact, Walsh argues, all aspects of AI's future impacts are in our hands. "Artificial intelligence can lead us down many different paths, some good and some bad," he writes. "Society must choose which path to take." — *Maria Temming*

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**Death: A Graveside Companion**
*Joanna Ebenstein (ed.)*
THAMES & HUDSON, $40

BOOKSHELF

## *Death* offers outlet for your morbid curiosity

*Death: A Graveside Companion* makes for an unusual coffee-table book, with its coppery etched Grim Reaper on the cover. Yet you may be surprised by how much fun it is to pore through the book's lavish artwork of skulls, cadavers and fanciful imaginings of the afterlife.

There is, after all, a reason for the term "morbid curiosity." It's only natural for people to try to understand and come to terms with their inevitable demise, and as the book reveals, it is only in modern Western society that the topic of death has become so taboo. Even as recently as Victorian times, the book notes, the dead were laid out in the family parlor, their hair cut off and twisted to make decorative mementos to hang on the wall.

As a founder of New York City's now-closed Morbid Anatomy Museum, Joanna Ebenstein has set out to help change modern attitudes, by giving us permission to let our morbid curiosity loose. "It is my hope that this book might act as a gesture towards redeeming death, to invite it back into our world in some small way," she writes. "It is precisely by keeping death close at hand and coming to terms with its inevitability that we are able to lead full rich lives."

She brings together 1,000 images of historical artwork, illustrations and artifacts showcasing humankind's ongoing quest to imagine and find meaning in death, along with 19 essays by a diverse set of writers, art experts and scientific thinkers. The writings cover spiritual and symbolic aspects of death, such as the origins of Mexico's Day of the Dead, and the surprising variety of death-themed amusements over the years. An early Coney Island attraction, for instance, re-created the experience of being buried alive. Some essays delve into scientific history, such as miniature crime scenes used in forensic science and the history of cadavers in the study of anatomy.

While the essays are illuminating, the illustrations and photographs, along with informative captions, provide most of the book's substantial heft, as well as its heart. Only by browsing through still life paintings called vanitas, popular in the 16th and 17th centuries, for instance, will you truly grasp what these symbolic masterpieces are meant to convey: the transience of beauty and earthly pursuits.

If I have any quibble with this compendium, it's that the essays (but thankfully not captions) are printed in sepia tones that make them hard to read without good lighting. But given the subject, this book may be best read while sitting next to a sunny window anyway. — *Erika Engelhaupt*



See macabre art featured in *Death* at **bit.ly/SN_deathimages**

**Science News for Students**

***Science News for Students*** **(sciencenewsforstudents.org)** is an award-winning, free online magazine that reports daily on research and new developments across scientific disciplines for inquiring minds of every age — from middle school on up.

## Changing toothpastes? Change your toothbrush

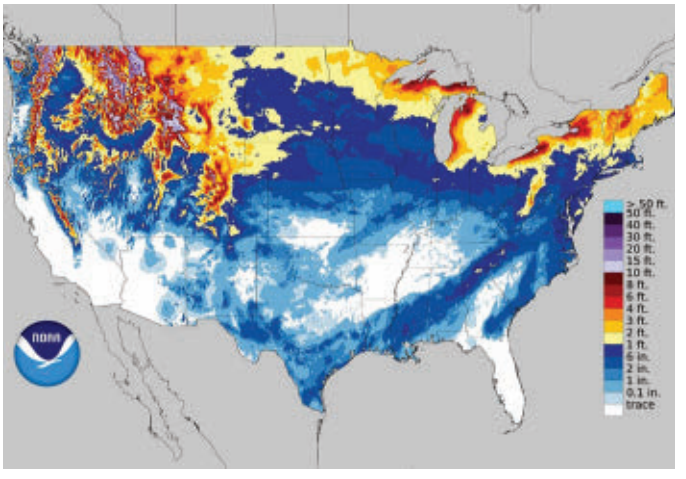
When the U.S. government banned the germ-killer triclosan from soaps and other cleaning products, many people decided to avoid items that still had it, such as toothpastes. But changing toothpastes may not help people avoid the chemical. Why? Triclosan can stick around in an old toothbrush, exposing people again even after using a new toothpaste. The good news: New data show that some types of toothbrushes pose less risk of exposing people to stored triclosan. — *Alison Pearce Stevens*

**Read more: www.sciencenewsforstudents.org/toothpaste**

## Wacky winter dumps snow on every single U.S. state

This map illustrates the total snowfall for the lower 48 U.S. states from the start of winter through January 4. (Alaska and Hawaii had snow too.) An overly wavy jet stream pulled a surge of cold air into the Deep South and northern Gulf of Mexico, bringing thundersnow to South Texas. As storms blew east, near-record snow accumulated from Florida to New England. Arctic warming, due to climate change, may have played some role, scientists say. How? Climate change slowed the jet stream, allowing it to meander and bring cold air into typically warm states. — *Matthew Cappucci*

**Read more: www.sciencenewsforstudents.org/wacky-winter**




## Hot on the trail of Antarctic meteorites

Up to 84,000 meteorites pelt Earth each year. Most are nearly impossible to find, having landed in water or been hidden by plants. But in the vast emptiness of Antarctica, spotting these space rocks can be as easy as black on white. That's why teams of scientists — including astronaut Stan Love, pictured here — brave Antarctica's extreme conditions each year to hunt for meteorites. This story follows the trek of a space rock from its discovery in an ice field to a lab, where researchers probe the rock's origins (perhaps some asteroid or the moon) and then send bits of the meteorite to a library. — *Beth Geiger*

**Read more: www.sciencenewsforstudents.org/meteorites**

FROM TOP: TOMFREEZE/ISTOCKPHOTO; NOAA; ANSMET/CASE WESTERN UNIV.

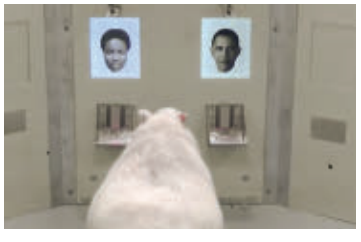

DECEMBER 9, 2017


DECEMBER 23, 2017 & JANUARY 6, 2018

SOCIAL MEDIA

## Ewe look familiar

Scientists trained sheep to recognize pictures of celebrity faces including those of Barack Obama, Emma Watson and Jake Gyllenhaal (experiment shown below). Results suggest that the animals have advanced face-processing abilities similar to those of humans, **Mariah Quintanilla** reported in "Sheep recognize human faces" (*SN: 12/9/17, p. 14*). One reader on Facebook joked about the celebrity-spotting flock.



So basically their performance is on a par with AI systems. I wonder which uses the most RAM.
**Kevin Pretorius**

### Join the conversation

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## Dying light

*Supernova iPTF14hls has erupted continually since its discovery in 2014, fluctuating in brightness at least five times. It may have had two other outbursts in the past,* ***Lisa Grossman*** *reported in "Odd star explodes again and again"* (SN: 12/9/17, p. 8).

Reddit user **Bobgushmore** wondered if the exploding star might actually be a supernova impostor similar to one of the biggest and brightest star systems in our galaxy, Eta Carinae, which is extremely volatile, but not a supernova.

Evidence suggests that iPTF14hls really is a supernova, says **Iair Arcavi**, an astrophysicist at the University of California, Santa Barbara. The supernova probably was "a very, very massive star that underwent eruptions" similar to those observed for Eta Carinae, **Arcavi** says. But iPTF14hls is much more energetic — about 50 to 100 times brighter than Eta Carinae's largest-known eruption. The oddball supernova's ejected material is also flying about 10 times faster, he says. **Arcavi** thinks that Eta Carinae, which isn't yet in its death throes, could someday turn into a supernova like iPTF14hls.

## Dark calculations

*The detection of gravitational waves emanating from two colliding neutron stars has implications for the mysterious dark energy that makes up about 70 percent of the universe,* ***Emily Conover*** *reported in "Cosmic mysteries unlocked in neutron star collision"* (SN: 12/23/17 & 1/6/18, p. 19).

**Charlie Baker** was confused about the amounts of dark energy and dark matter that make up the cosmos. He pointed to another story, "Antimatter excess still not explained" (*SN: 12/23/17 & 1/6/18, p. 12*), in which **Conover** wrote that most of the universe's mass is made up of dark matter. "This civilian would really appreciate some further education," **Baker** wrote.

The universe is composed of both energy and matter, **Conover** says. "We know that 70 percent of the universe is dark energy and about 30 percent is matter," she says. That matter component can be broken down into two parts: normal matter and dark matter. Normal matter makes up only a small fraction of the mass of the universe's matter.

In total, the universe is roughly 70 percent dark energy, 25 percent dark matter and 5 percent matter, according to combined data from the Planck satellite, the Dark Energy Survey and other observations, **Conover** says.

## Future versus past

*In her editor's note "Would you opt to see the future or decipher the past?"* (SN: 12/9/17, p. 2), *Acting Editor in Chief* ***Elizabeth Quill*** *asked readers what scientific answers they might seek if they had a crystal ball.*

**Roger Bennett** opted to look ahead. "I would be most interested in seeing into the future to determine what effects global warming, weather change, overpopulation and scarcity of clean drinking water [have] in store for humanity," **Bennett** wrote.

But most readers who wrote to *Science News* in response to the editor's note preferred to look back in time. **Christopher Pegues** thought that peering into the future might change it. "I'm not sure about multiple timelines [or] universes — that's a whole different story — however, I feel fairly certain that there are too many uncertainties lying ahead to make a peek worthwhile. Looking back at least may answer some unknowns, if one chooses wisely."

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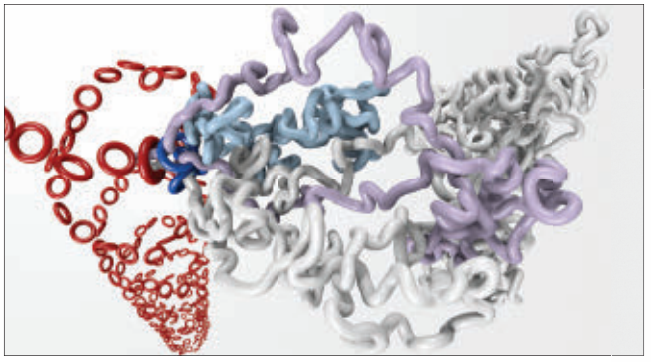


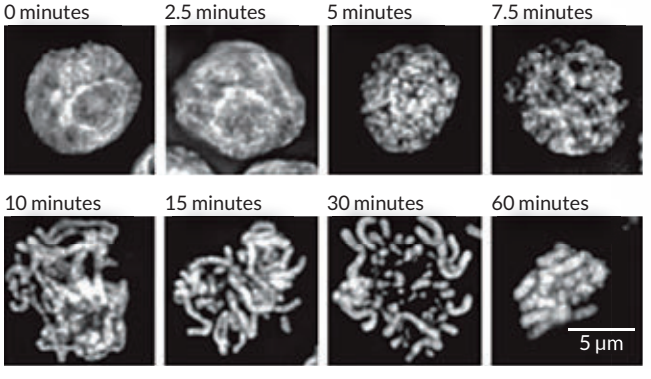
# Chromosome choreography

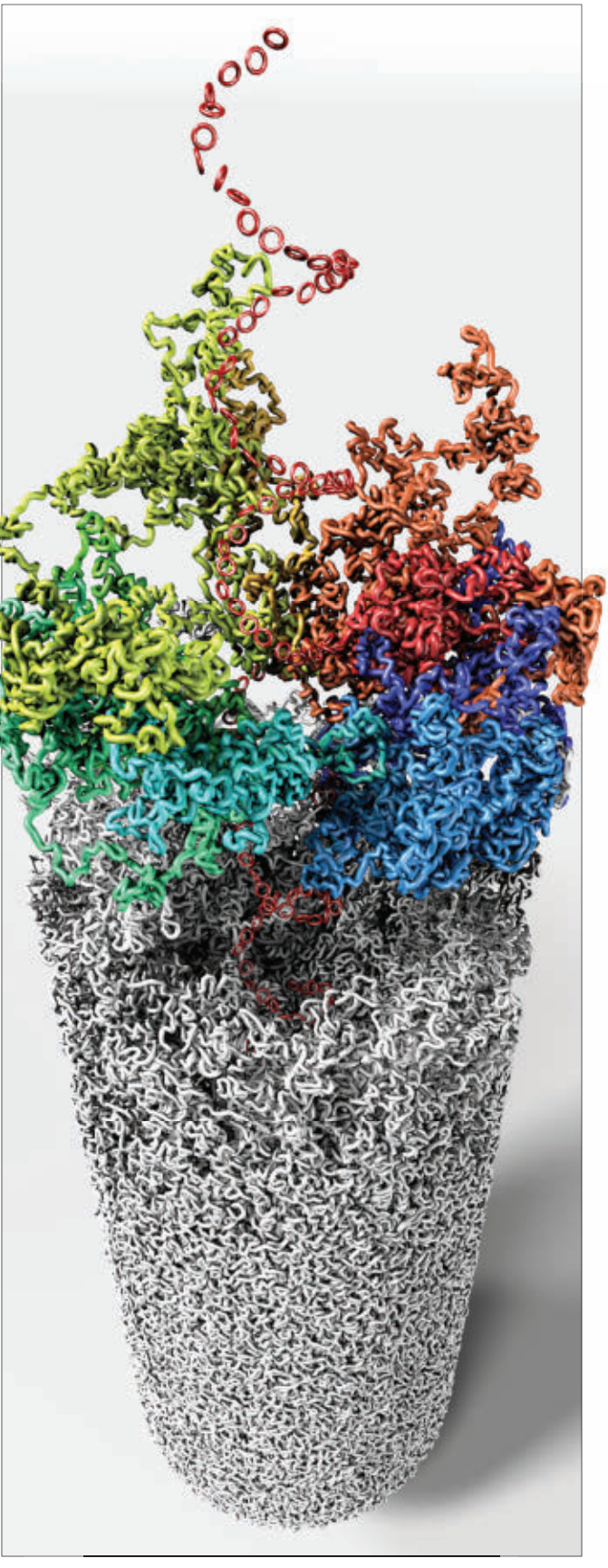
Frequent fliers, take note. Scientists have figured out how cells quickly pack long chromosomes into compact, organized bundles, a key step before cells divide. The finding unifies two competing ideas about the process: whether it involves winding chromosomes into a spiral staircase or a set of loops. It turns out cells use two different ring-shaped proteins called condensins to do both actions, imaging and simulations reveal.

Normally, chromosomes sit unspooled in a cell's nucleus. But when a cell prepares to undergo mitosis — a type of cell division — those strings of DNA must condense into easy-to-transfer cylinders. It's a formidable task: A cell must cram about two meters of DNA into microscopic packages without tangling the genetic material like a string of holiday lights.

Condensin II (red rings in simulations above and at right) shapes a chromosome into large loops and then forms a helical scaffold for the loops to wind around. Condensin I (dark blue rings above with a small piece of chromosome) subdivides larger loops (one example in purple) into smaller nested loops (light blue) that allow for compact packing.

Together, the proteins deftly stuff the chromosome into a cylinder (at right, colors are examples of individual loops), scientists report online January 18 in *Science*. Most of that condensing happens in about 15 minutes, says coauthor Job Dekker, a Howard Hughes Medical Institute investigator at the University of Massachusetts Medical School in Worcester. Microscope images (below) show the packing of chromosomes in a chicken cell's nucleus. Only minor changes happen after the first 15 minutes. — *Laurel Hamers*



SIMULATIONS: A. GOLOBORODKO AND J. GIBCUS, WITH INPUT FROM K. SAMEJIMA, B. EARNSHAW, L. MIRNY AND J. DEKKER; MICROSCOPE: J. GIBCUS *ET AL*/*SCIENCE* 2018

# GEOLOGIC ROAD TRIP OF THE MONTH

## BIG BONE LICK STATE HISTORIC SITE, KENTUCKY

A variety of enterprises have occupied the rolling lowlands of the Big Bone Creek valley, off Kentucky 338, 3 miles west of Beaverlick. An early effort involved the manufacture of salt by boiling the warm saline waters that bubbled to the surface. Around 1800 the construction of the fashionable Clay House, a spa designed to entice travelers to loiter, drink, and bathe in the sulfur-bearing springs, enhanced the area's allure. Today the area is home to the 813-acre Big Bone Lick State Historic Site, one of the most famous paleontological locales in North America.

Early accounts describe a network of 3-to-4-foot-deep paths the width of two wagons converging on the historic site's springs, which had been sculpted by generations of stomping and burrowing animals seeking a source of sodium to supplement their plant-heavy diets. Shawnee, Wyandot, Iroquois, and Delaware Indians also visited the area, hoping to kill a young, old, or diseased bison. The bison disappeared around 1800, and salt making ended in 1812, but long before then the site had accumulated a most unusual commodity: thousands of disarticulated bones described simply as big, bigger, and biggest.

*Early-nineteenth-century paleontologists, seeing a resemblance between the shape of mastodon molars and the human breast, coined the word mastodon, meaning "breast tooth."* —Courtesy of Dean Henson, Big Bone Lick State Historic Site

In 1739 the Frenchman Baron Charles de Longueuil was the first to collect bones from the area, the highlights of which were a 40-inch-long femur, three molar teeth, and a tusk. He sent the collection to Europe for study. The analyses caused a flurry of interpretation: the femur and tusk were declared those of a gargantuan elephant, and one gigantic molar was incorrectly classified a hippopotamus tooth.

George Croghan, a Pittsburgh-based federal administrator for Indian affairs sent a second collection, labeled "elephant bones," to Europe in 1767. After examining them, Benjamin Franklin, then living in London, questioned their identification, noting modern African and Asian elephants lived in hot climates, whereas the American specimens were found in a cold-climate region. As the eighteenth century drew to a close, the fossils were a continuing source of dissension and controversy: Did the bones represent one or more species, extinct or extant, herbivorous or carnivorous, elephant or elephant-like? Many experts were bothered by mutterings of extinction, a concept alien to those who believed a benign God would never allow such a thing to happen to one of his creations.

Following his epic trip to the Pacific Ocean with Meriwether Lewis, William Clark visited Big Bone Creek in 1807, collected three hundred bones, and sent them to the White House for President Thomas Jefferson, an amateur paleontologist, to examine. Jefferson shared the collection with friends for further examination, one result being the introduction of the word *mastodon* into the controversy.

*More than big bones are found at the state historic site. At least twenty thumb-sized brachiopods occupy this 1-foot-long slab of Ordovician-age limestone.* —Courtesy of Dean Henson, Big Bone Lick State Historic Site

The Big Bone Creek valley is internationally recognized as a fossil boneyard of exceptional repute and the depository of the partial remains of at least eight extinct species of mammals. Some animals, such as the humongous mastodon, became entrapped in the spongy ground, and others died of old age or from having fought to the death over a favorite drinking site. The mastodon, Harlan's ground sloth, stag-moose, woodland musk ox, and ancient bison first became known to science on the basis of local discoveries. In addition, the remains of woolly and Columbian mammoths, complex-toothed horse, and Jefferson's ground sloth have also been recovered from the Pleistocene-age soils of the region.

After a rich history of scientific investigations exceeding 275 years, the Big Bone Creek valley continues to yield a treasure trove of large vertebrate bones, a dividend of erosion. These finds add substance to its reputation as the birthplace of American vertebrate paleontology.

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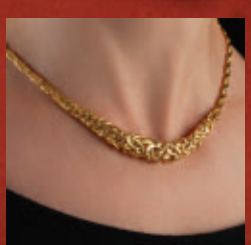

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