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SOCIETY FOR SCIENCE & THE PUBLIC
NOVEMBER 26, 2016

Dinos Get Their Hue

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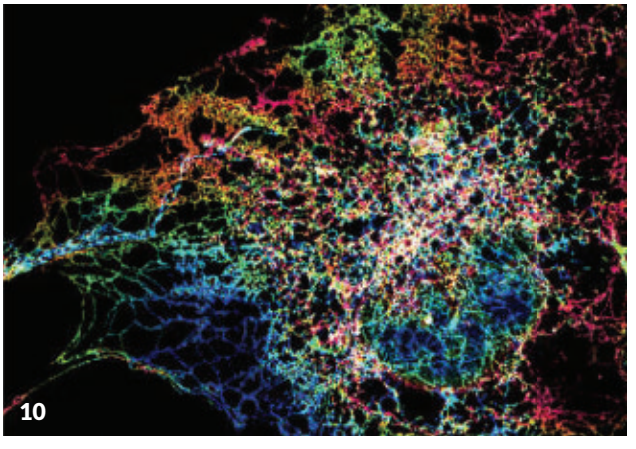
## Features



## News

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## Departments



**SOCIETY UPDATE**

Meet a few of the winners of Broadcom MASTERS

**COVER** Forests near Oregon's Mount Hood and elsewhere are rife with lichens that scientists use to monitor forest health. *Jon Bilous/Shutterstock*

# Averages can conceal how people and science learn

Picture a learning curve. Most of us imagine a smooth upward slope that rises with steady mastery. It is the ultimate image of progress.

But that image, as behavioral sciences writer Bruce Bower reports on Page 6, may well be an illusion of statistics, created when people look at averages of a group instead of how individuals actually learn. That's what scientists at the University of Cambridge found when quizzing preschoolers' developing ability to understand that other people can have false beliefs, an important milestone in the development of a theory of mind.

For many learners, the study suggests, mastery comes in fits and starts, a graphical zigzagging that denotes steps forward and back. Insight into a problem can be quick for some, but many people follow a more meandering path to knowledge and understanding.

I recognize the truth of this in my own life, be it learning about a new subject or (especially) a new skill. I see it in my 5-year-old daughter as she learns to read. If you are not struck by a single dramatic aha! you can still make it work by moving forward, then back, aiming for progress and mastery.

Scientific advances also do not always follow a smooth upward curve. As staff writer Meghan Rosen writes on Page 24, paleontologists did have a fairly sudden insight into how to get clues about the colors that decorated dinosaur skin: Look for pigment-containing structures called melanosomes. But identifying these microscopic structures in well-preserved fossils of soft tissue, while distinguishing them from bacteria that might have feasted on the fresh dead dino skin, has been a bit of a zigzag. There's an ongoing back-and-forth critique between those scientists who claim they've discovered melanosomes and those who question such claims. It may be a long time before we know whether we will be able to truly repaint dinosaurs' colors accurately, or use that information to better understand their lifestyles or habitats (as many scientists working in the field hope). But current investigations are already taking us closer to that goal, even if via a meandering path.

The danger of looking at the average, as evidenced in Bower's news story, is also at play in Amy McDermott's story on lichens on Page 20. Lichens are very sensitive to air pollution, a quality exploited for decades to monitor the air quality of forests and alert forest managers to looming issues. But if you were to look at overall lichen abundance you might not see any problem. Air pollution tends to encourage some species while discouraging others — a subtlety that a lichen average growth rate might miss. With on-the-scene reporting in the Pacific Northwest, McDermott details the history of lichen use in environmental quality studies and the new effort to use lichens as an indicator of climate change in forests.

Looking at averages can tell you part of a story, but it rarely tells you the whole story. What you may miss is the rich variety found in the real world — be it in students or lichens or even scientific perspectives.

*— Eva Emerson, Editor in Chief*





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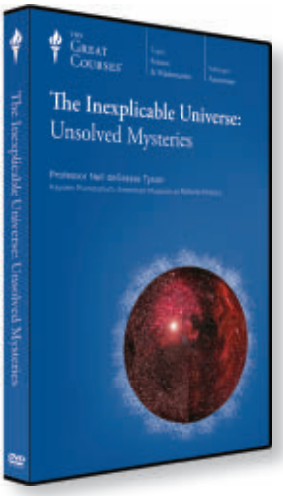


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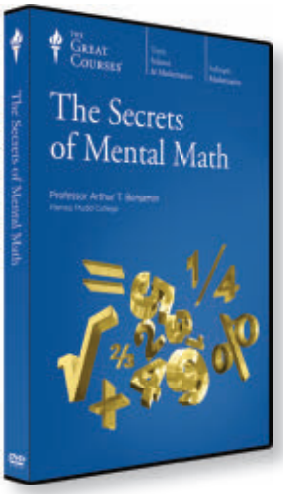


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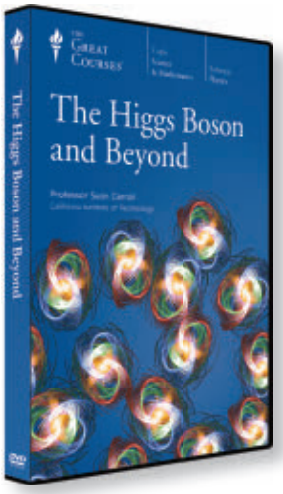


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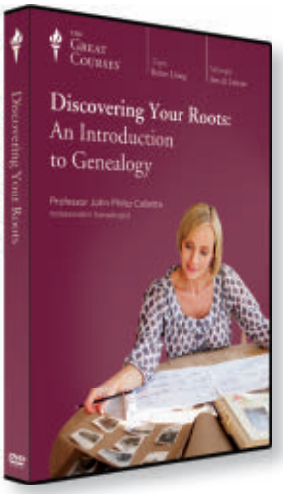


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Excerpt from the November 5, 1966 issue of *Science News*

50 YEARS AGO

## Fluoridation lessens disease in adults

Antifluoridationists ... not only "have little concern for the preservation of children's teeth," but "are contributing to the ill health of all of us, young and old alike," [said] Dr. D. Mark Hegsted, professor of nutrition at Harvard's School of Public Health.... [An] adequate intake of fluoride can keep bones healthy and prevent soft tissues from calcifying.

**UPDATE:** The role of fluoride in bone health has been much less clear than its benefit for teeth. Studies in the 1980s showed treatment with a calcium-fluoride mix increased bone mass (*SN: 1/21/89, p. 36*) and reduced fracture risk in women with osteoporosis. But an analysis of 25 studies in 2008 showed fluoride doesn't ease fracture risk. In 1951, only 3.3 percent of the U.S. population had fluoridated water; by 2014, that rate was up to 66.3 percent. Fluoridated drinking water may not help bones, but it does reduce cavities by 25 percent in both adults and children.

Yes, a short-beaked echidna is a mammal — warm-blooded with fur and mother's milk — but with quirks.

IT'S ALIVE

## Mixed-up mammal mixes soil Down Under

With no nipples and reptilelike eggs, short-beaked echidnas look like a first draft of a mammal. Yet, as Australia's other digging mammals decline from invasive predators, the well-defended echidna is getting new love as an ecosystem engineer.

The only mammals today that lay eggs are the four echidna species and the duck-billed platypus. Eggs are probably a hold-over from the time before mammals split from reptiles. Each year or so, the short-beaked echidna (*Tachyglossus aculeatus*) lays one leathery egg "about the size of a grape," says Christine Cooper of Curtin University in Perth. Instead of constructing a nest, mom deposits the egg in her version of a kangaroo pouch and waddles around with it.

When the egg hatches about 10 days later, two patches of pores in mom's pouch ooze milk, and the baby laps it off her skin. The puggle, as a baby echidna is called, hitchhikes for weeks as mom forages. The ride ends, however, when the puggle starts growing spines. "Then mum's like, 'Nope, no more,' and she will put [baby] into a burrow," Cooper says.

Puggles live in mom's pouch until they get prickly.

Foraging echidnas claw around and poke their snouts into termite or ant nests, flicking out a long gooey tongue to flypaper up insects. The goo comes from unusually large salivary glands, but a quick echidna lick doesn't slime. When Cooper wears sandals to visit captive echidnas, she says, "it's 'ooh, that tickles!'"

Echidnas' toes point backward on their hind paws but forward on the front, and their short legs slant outward in a bit of a reptile sprawl, says Christofer Clemente of University of the Sunshine Coast in Sippy Downs, Australia. They rock side to side as they walk, moving both left, then both right feet. They can't run, but they're strong diggers, Clemente says. They not only claw around for food, but also defend their soft undersides by quick-digging into the ground, spikes up.

Acceleration-sensing instruments strapped onto short-beaked echidnas show they spend about 12 percent of their day excavating, researchers report in the Oct. 15 *Journal of Experimental Biology*. Over a year, a single echidna churns up some 204 cubic meters of soil, the scientists calculate, as it hunts for insects or scrabbles for shelter. That's enough to bury more than 100 full-sized fridges.

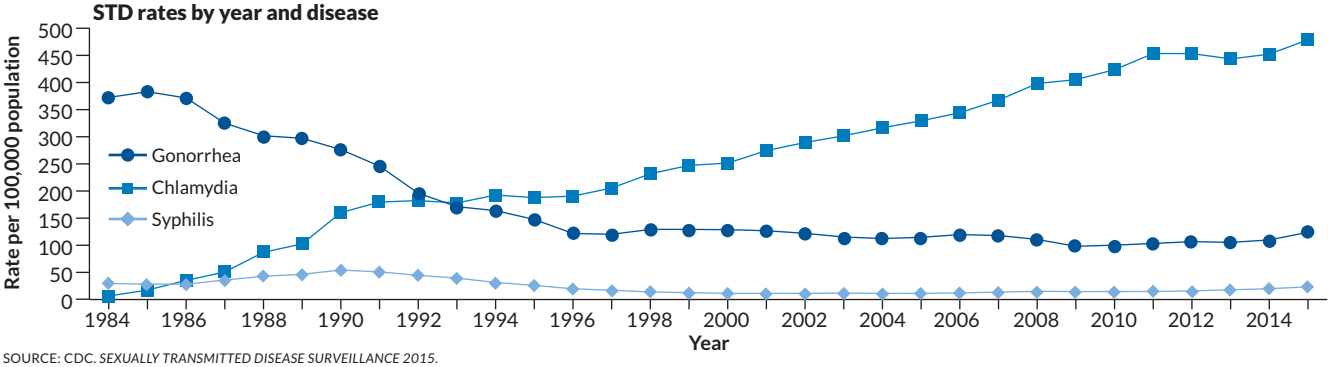
That digging benefits the echidna's unusual diversity of habitat — from rainforest to desert. Echidnas don't need to bury fridges, but soil turnover and nutrient mixing keep ecosystems humming along. — *Susan Milius*

FROM TOP: COURTESY OF C. CLEMENTE; BEN NOTTIDGE/ALAMY STOCK PHOTO

SCIENCE STATS

## Progress against STDs backslides

Three common sexually transmitted diseases reached a combined 20-year high in 2015, according to a report released October 19 by the Centers for Disease Control and Prevention. U.S. teenagers and young adults account for nearly two-thirds of the more than 1.5 million reported cases of chlamydia and half of the roughly 400,000 gonorrhea diagnoses. Syphilis, the least prevalent of the three, rose almost 18 percent from 2014 to 2015. "The 2015 data make clear that many Americans are not getting the preventative services they need," Eloisa Llata, a medical epidemiologist with the CDC and coauthor of the report, wrote in an e-mail. — *Cassie Martin*



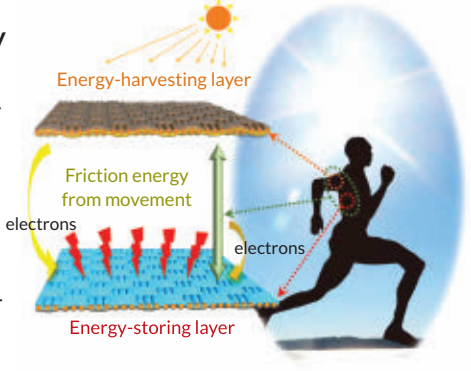

SOURCE: CDC. *SEXUALLY TRANSMITTED DISEASE SURVEILLANCE 2015.*

TEASER

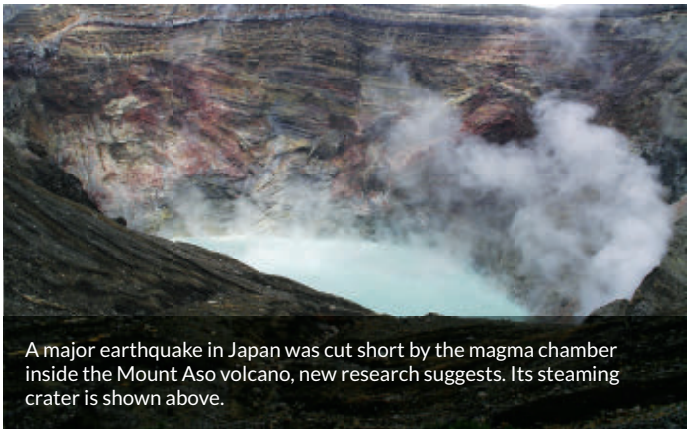
## Textile to charge devices from sun and movement

A self-charging textile captures both solar and mechanical energy to power wearable electronic devices — no bulky batteries needed. The top layer contains thin, flexible solar cells woven into a material that harvests energy from the sun. The bottom layer is made from similarly pliable supercapacitors that store the energy for later use, researchers report October 26 in *Science Advances*.

Here's the cool part: As the person wearing the material moves, the two layers of fabric rub together and build up static electricity. The supercapacitors stockpile that energy, too. Harnessing two energy sources provides more consistent power than relying on solar cells alone, says study leader Zhong Lin Wang of Georgia Tech in Atlanta. The prototype textile — a 13-centimeter-square swatch — can power an LED or a digital watch, but the researchers hope it could someday charge more energy-intensive electronic devices such as fitness trackers or MP3 players. — *Laurel Hamers*




**Double duty** A two-tiered textile harvests and stores solar energy. When a person moves, the two layers rub together, producing mechanical energy that's also stored to power devices.



A major earthquake in Japan was cut short by the magma chamber inside the Mount Aso volcano, new research suggests. Its steaming crater is shown above.

HOW BIZARRE

## This volcano put an end to an earthquake

A titanic volcano stopped a mega-sized earthquake in its tracks.

In April, pent-up stress along the Futagawa-Hinagu Fault Zone in Japan unleashed a magnitude 7.1 earthquake. The rupture traveled about 30 kilometers along the fault until it reached Mount Aso, one of Earth's largest active volcanoes. That's where the quake met its demise, Aiming Lin, a geophysicist at Kyoto University in Japan, and colleagues report online October 20 in *Science*. The quake moved across the volcano's caldronlike crater and abruptly stopped, the researchers found.

Geophysical evidence suggests that a region of rising magma lurks beneath the volcano. This magma chamber created upward pressure plus horizontal stresses that acted as an impassable roadblock for the seismic slip powering the quake, the researchers propose. This rare meetup, they warn, may have undermined the structural integrity surrounding the magma chamber, increasing the likelihood of an eruption at Aso. — *Thomas Sumner*

HUMANS & SOCIETY

# Kids' learning curve not so smooth

## Preschoolers achieve false-belief milestone in fits and starts

**BY BRUCE BOWER**

Many preschoolers take a surprisingly long and bumpy mental path to the realization that people can have mistaken beliefs — say, thinking that a ball is in a basket when it has secretly been moved to a toy box. Traditional learning curves, in which kids gradually move from knowing nothing to complete understanding, don't apply to this landmark social achievement and probably to many other types of learning, a new study concludes.

Kids ranging from ages 3 to 5 often go back and forth between passing and failing false-belief tests for several months to more than a year, say psychologist Sara Baker of the University of Cambridge and colleagues. A small minority of youngsters jump quickly from always failing to always passing, the scientists say online October 20 in *Cognitive Psychology*.

"If these results are replicated, it will surprise a lot of researchers that there is such a low level of sudden insight into false beliefs," says psychologist Malinda Carpenter of the Max Planck Institute for Evolutionary Anthropology in Leipzig. Early-childhood researchers generally assume that preschoolers either fail or pass false-belief tests, with a brief transition between the two, Carpenter explains. Grasping that others can have mistaken beliefs is a key step in social thinking.

False-belief understanding may start out as something that can be indicated nonverbally but not described. Human 2-year-olds and even chimpanzees tend to look toward spots where a person would expect to find a hidden item that only the children or apes have seen moved elsewhere (*SN: 11/12/16, p. 8*).

Numerous investigations suggest that kids between ages 3 and 5 consciously appreciate when others have formed mistaken beliefs. But those studies report average scores on tests for groups of kids, leaving unexamined how individuals progress — or not — as mind readers.

Baker's team generated individual scoring profiles for 52 children repeatedly assessed for false-belief understanding between ages 3 and 5. Trials occurred over roughly one to two years. Two types of false-belief tasks were alternately presented about every two to six weeks.

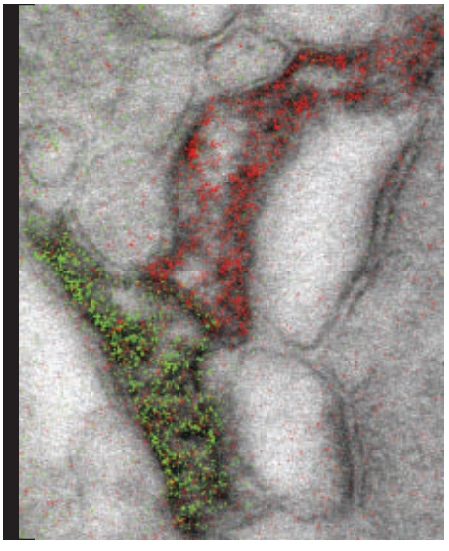
In one task, an experimenter used pictures to help describe a situation in which someone moves an object from one location to another once a friend leaves. Children were asked where the friend would later look for the object.

In the second task, children observed a container's unexpected contents, such as a sock in a crayon box. Kids reported what they originally thought was inside the container and what another person would think is inside it.

Nine kids, including some of the younger ones, passed their first three false-belief trials. All but one of the nine continued to pass trials at a high rate. The other 43 kids failed at least one of the first three trials. A statistical analysis calculated the likelihood that a series of scores for a particular kid reflected gains, losses or no change in understanding.

Five of the 43 children achieved rapid insights into false beliefs, consistently passing trials immediately after a string of failed trials. Another 22 youngsters showed different patterns of improvement, such as going from a 12 percent likelihood of passing trials to a 50 percent chance by the study's end. None moved gradually and steadily from failing to passing. Smooth learning curves are statistical illusions created by averaging group scores, the researchers suspect.

Baker's statistical method could enhance the study of how individual children develop math and other reasoning skills, says psychologist Rose Scott of the University of California, Merced. ■



S.R. ADAMS ET AL/CELL CHEMICAL BIOLOGY 2016

GENES & CELLS

## Technique shows molecular details in color

Electron microscopy is finally getting its Kodachrome moment.

The high-powered scopes can now produce images that simultaneously highlight different molecules in different colors, scientists at the University of California, San Diego report online November 3 in *Cell Chemical Biology*.

Electron microscopes build black-and-white images by shooting beams of electrons at samples. Previously, scientists added color by overlaying lower-resolution images from light microscopes. The new technique adds pizzazz without sacrificing image quality. It involves sequentially layering different metal ions on top of a sample. Each ion selectively latches on to a different target molecule. The electron beam interacts differently with each ion, yielding signature wave shapes that can be converted into colors. The researchers used the technique to show that two brain cells called astrocytes (the edges of one shown in green, the other in red) could link up to the same message-sending junction between nerve cells. — *Laurel Hamers*

GENES & CELLS

# HIV's U.S. arrival gets pushed back

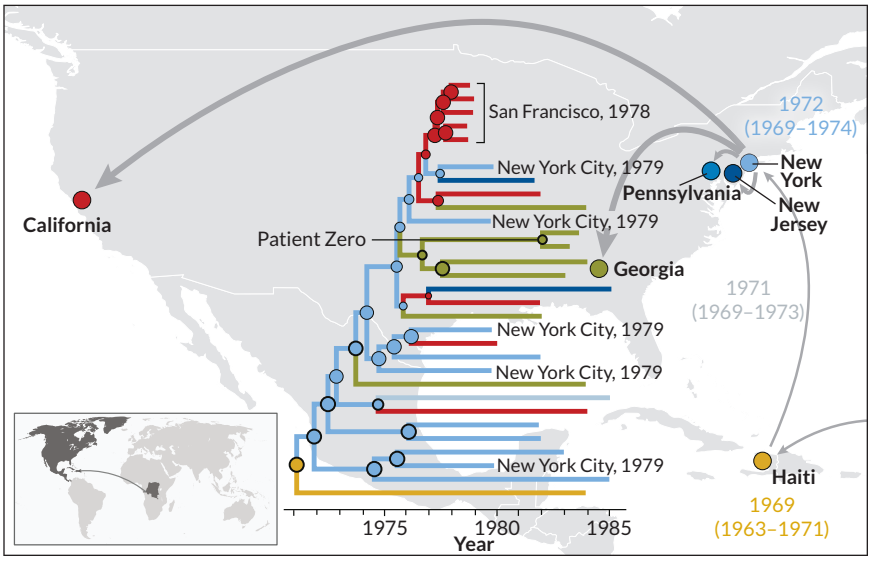
## Patient Zero was not source of AIDS epidemic, DNA shows

**BY TINA HESMAN SAEY**

A genetic study of HIV from the 1970s may finally clear the name of a man long identified as the source of the AIDS epidemic in the United States. HIV came to New York City between 1969 and 1973, long before the man known as Patient Zero became infected, researchers report in the Nov. 3 *Nature*.

Using techniques developed to decipher badly degraded ancient DNA from fossils, researchers reconstructed the genetic instruction books of eight HIV viruses from blood samples collected in 1978 and 1979 in New York City and San Francisco. The viral DNA was so genetically diverse that the viruses must have been circulating in the cities for years, picking up variations, says evolutionary biologist Michael Worobey of the University of Arizona in Tucson.

Worobey and colleagues calculate that HIV probably first jumped to the United States from Haiti in 1970 or 1971. So HIV spread for about a decade before AIDS was recognized in 1981 and found to be caused by a retrovirus in 1983.




**HIV's introduction** HIV spread from the Caribbean to New York City in the early 1970s, then to other parts of the country, a new genetic analysis reveals. A phylogenetic tree shows how HIV strains from New York (blue) and San Francisco (red) are related to a Haitian strain (yellow). HIV from Patient Zero, accused of starting the U.S. epidemic, came from a later branch (green).

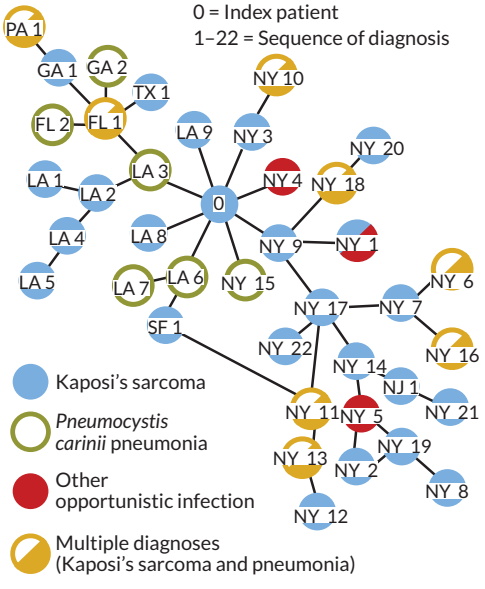
Examining the relationships between the New York City and San Francisco viruses with strains from elsewhere let researchers trace HIV's path. The eight American samples all came from the same branch of the HIV family tree as ones from the Caribbean. That suggests that HIV spread from Africa to the Caribbean, then to the United States, possibly through infected blood products. New York samples were more diverse than those from California, indicating that HIV came to New York first.

Worobey's team also examined HIV DNA from Patient Zero. He was part of a 1984 study of gay men with AIDS in Los Angeles who had a rare cancer called Kaposi's sarcoma or *Pneumocystis carinii* pneumonia, both AIDS-related complications. Scientists at the U.S. Centers for Disease Control and Prevention found that many of the men had had sexual contact with each other, helping to establish that HIV is sexually transmitted.

Later, in the book *And the Band Played On*, author Randy Shilts identified Patient Zero as Air Canada flight attendant Gaëtan Dugas. It was widely interpreted that Dugas was the first U.S. case of HIV, even though the CDC never claimed — and repeatedly refuted — that, says epidemiologist James Curran, a coauthor of the 1984 study who is now at Emory University in Atlanta. Part of the confusion may have been that Patient Zero was supposed to be identified as Patient O (for "outside of California").

Dugas began traveling to the United States shortly after he became a flight attendant in 1974, says Richard McKay, coauthor of the new study and a medical historian at the University of Cambridge. Dugas estimated that he had about 250 male sexual partners each year between 1979 and 1981. Shilts and others contended that Dugas intentionally spread the virus, though he was diagnosed with Kaposi's sarcoma in 1980 before anyone knew what AIDS was. The genetic analysis confirms that Dugas was not carrying the earliest version of HIV.

The study is a cautionary tale against pinning disease spread on a single person, says behavioral scientist Robert Remien of Columbia University Medical Center. "There's no blame or cause to be laid on any of those people in those early years." ■




**Patient Zero** A 1984 study put Gaëtan Dugas at the center of a cluster of people with AIDS, some of whom had sex with each other. Calling him the index case may have led to the idea that he brought HIV to the United States. SOURCE: D.M. AUERBACH *ET AL*/*AM. J. MED.* 1984

FROM TOP: M. WOROBEY *ET AL*/*NATURE* 2016; J. HIRSHFELD

GENES & CELLS

# Protein paints chipmunks' stripes

## Scientists find molecular architect of mammalian fur patterns

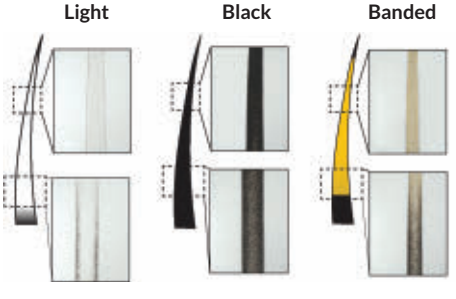
**BY TINA HESMAN SAEY**

Chipmunks and other rodents' light stripes are painted with a recycled brush, a new study suggests.

A protein previously known to guide facial development was repurposed at least twice during evolution to create light-colored stripes on rodents, scientists report November 2 in *Nature*. The protein, called ALX3, could be an important regulator of stripes in other mammals, including cats and raccoons, says Michael Levine, a developmental biologist at Princeton University.

Some research has shown how butterflies and other insects create their often elaborate wing patterns (*SN: 7/17/10, p. 28*). But scientists still don't understand the biological machinery used by mammals to generate the dots, spots, splotches and stripes that decorate their coats. Identifying that molecular equipment may illuminate the processes that help animals camouflage themselves and adapt to their environments.

In the new study, evolutionary developmental biologist Ricardo Mallarino of Harvard University and colleagues examined the multicolored stripes of African striped mice (*Rhabdomys pumilio*). Two light-colored stripes, each flanked by black stripes, run down the mice's backs. A strip of fur the same brownish color as most of the rest of the body separates the dark-light-dark striping. The patterns




**Hair of the mouse** African striped mice have three different types of hair: light (left), black (center) and banded (right). All the types have a black base.

African striped mice evolved a new trick for the protein ALX3, which helps direct development of facial cartilage. ALX3 also paints light stripes down the rodents' backs, a new study suggests.

are created by three types of hair. Hairs with banded yellow shafts growing from a black base populate the strip in the middle, while completely black hairs from base to tip are found in the black stripes. Hairs with a black base but no pigment in the shaft make up the light stripes.

Those unpigmented hairs were puzzling, says Hopi Hoekstra, the Harvard evolutionary biologist who led the new study. Usually, white hair arises because animals have a mutation that prevents cells from making pigments, she says. But since the African striped mice carry no such mutations, the mice must create the stripes in a different way.

In vertebrates, pigment-producing cells called melanocytes migrate around the body as the embryo develops. One way stripes could form is by melanocytes moving to create the pattern. Previous research in zebrafish indicated that stripes on the fish's sides form that way (*SN: 2/22/14, p. 9*). Light stripes might result if the melanocytes don't migrate into a strip of the mice's skin, the researchers reasoned. Hair would grow there, but wouldn't have any pigment.

That's the first thing Mallarino checked. He examined white stripes in the skin of striped mouse embryos a couple of days before birth. Melanocytes had no trouble infiltrating the light striped area. But once there, the cells did not mature properly and so made no pigment.

In the light stripes, the researchers found, the gene that produces ALX3 is much more active than in the brown or black stripes. That was a surprise because no one knew that ALX3 is involved in pigmentation, Hoekstra says. It was known for helping to regulate the formation of bones and cartilage in the face.

It wasn't clear whether the high levels of ALX3 caused the light stripes or not. So Hoekstra's team did experiments in lab mouse cells to find out how the protein might affect pigmentation. Raising levels of ALX3 in cells interfered with activity of a gene called *Mitf*, a master regulator of pigment production and melanocyte maturation.

It turns out that even in lab mice, more of the protein is made on the belly, which tends to be light colored. Previous pigmentation research failed to turn up ALX3 because researchers were working with white mice, Hoekstra says.

Eastern chipmunks (*Tamias striatus*), whose last shared ancestor with African striped mice lived about 70 million years ago, also made more ALX3 in the light stripes on their flanks, the researchers found. Those results suggest that different rodents independently recycled ALX3's ability to make light-colored belly fur and also used it to paint light stripes on the back. Stripes may help rodents that are active during the day blend into the background and avoid the sharp eyes of predators, Hoekstra says.

Evolution tends to be thrifty, often reusing old genes for new purposes, says Nipam Patel, an evolutionary developmental biologist at the University of California, Berkeley. The new study is "a really nice illustration that evolution isn't biased," he says. "It takes what it gets and works with that."

The researchers still don't know how ALX3 production gets turned up in the light stripes. Another protein may turn on its production, or rodents may have found other ways to dial up ALX3 production in certain places. Researchers need to discover what turns on ALX3 to pinpoint the exact evolutionary change responsible for the striped pattern, Patel says. ■

FROM TOP: ELAINE KRUER; R. MALLARINO *ET AL*/*NATURE* 2016

LIFE & EVOLUTION

# Ancient birds could achieve liftoff

## Avian flight didn't evolve from gliding, analysis suggests

**BY MEGHAN ROSEN**

Flying dinosaurs took off from the ground — no leap from the trees required.

Ancient birds and some nonavian dinosaurs could use their wings and powerful legs to launch themselves into the air, paleontologist Michael Habib reported October 26.

"That's a big deal," says Yale University ornithologist Michael Hanson, "because the classic idea was that early birds started out gliding between trees."

The origin of bird flight is a sticky subject, adds paleontologist Corwin Sullivan of the Chinese Academy of Sciences in Beijing. "There's been a long-standing controversy over whether flight evolved from the ground up or the trees down."

Scientists had thought that early birds scrambled up trees to get an altitude assist. The birds would start their flight with a jump, like a hang glider diving off a cliff. Over time, descendants of those gliding birds would have evolved larger wings and the ability to flap. Flapping "means you can push yourself forward on your own power," said Habib, of the University of Southern California in Los Angeles. That's how modern birds fly.

In recent years, several lines of evidence have begun to dismantle the trees-down approach to flight evolution. Habib's team wondered whether early birds needed an elevation boost at all — perhaps they could take off directly from the ground.

The team examined 51 fossil specimens from 37 different winged dinosaur genera that lived from 150 million to 70 million years ago, from the Late Jurassic to Late Cretaceous epochs. The sample included both avian and nonavian dinosaurs.

The specimens all had stiff, flightlike feathers on their forelimbs. But not all animals with feathered wings can fly, Habib said. He and colleagues analyzed the specimens' wing length, body mass and hind limb muscle power, among other features. Dinos that could fly by flapping their wings had to have enough leg strength to propel their bodies up and enough wing speed to carry them forward.

Just 18 specimens, representing nine of the 37 groups, had the right stuff to get off the ground: every one of the avian specimens, as well as a few of the nonavian dinos, including a tiny four-winged dinosaur called *Microraptor*. "Little guys did well," Habib said. "Anything over four to five kilograms was struggling."

Whether the early fliers could sustain flight for long distances is a different ball game, Habib said. "But there's a big difference between flying a little and not flying at all."

Early flying dinosaurs may have burst off the ground to escape from predators. This bursting behavior could have set the stage for powered flight, Habib said. Quick, powerful takeoffs "put a premium on large wings, large flight muscles and really fast wings" — all characteristics of today's best fliers. ■

MEETING NOTES

### Fossilized dinosaur brain unearthed

Dinosaur smarts may be a mystery, but their brains, at least, are now more concrete. A chunk of petrified brain tissue discovered in a tidal pool in southern England is the first reported from a dinosaur, researchers claim.

The roughly 133-million-year-old fossil preserves the brain's wrinkled topology, said paleontologist David Norman of the University of Cambridge, who described the find October 27.

The fossil includes bits of bone and the brain's tough outer layers. A microscopic analysis revealed tiny, branching tubes — blood vessels — crisscrossing the fossil's surface and penetrating what was once brain tissue.

That tissue probably belonged to an herbivorous dinosaur, perhaps *Barilium* or *Hypselospinus*, with a body about the length of a Volkswagen Beetle.

The dinosaur may have tipped headfirst into a boggy swamp, where acidic water pickled the brain, Norman said. Later, minerals would have petrified the pickled tissue. — *Meghan Rosen*

JAMIE HISCOCKS

This palm-sized fossil of bone and brain belonged to an herbivorous dinosaur that lived roughly 133 million years ago.

### Primates' common ancestor comes into focus

The earliest primate was a solitary tree dweller that liked the night life. Those are some conclusions from new reconstructions of the ancestral primate, presented October 27.

Eva Hoffman, now a graduate student at the University of Texas at Austin, and colleagues at Yale University looked at behavioral and other traits from 178 modern primate species. Examining patterns across the primate family tree, the team inferred the most likely characteristics of ancestors at different branching points — back to the common ancestor.

This ancient primate, which may have lived some 80 million to 70 million years ago, was probably no bigger than a guinea pig, lived alone and gave birth to one offspring at a time, the researchers suggest. Living in trees and active at night, the critter probably ventured out to the ends of tree branches to eat fruits, leaves and insects.

But this mix of traits probably didn't originate in primates, Hoffman said. After adding tree shrews and colugos, primates' closest living relatives, to the analysis, the team concluded these same attributes were also present in the three groups' common ancestor. So explanations of early primate evolution that rely on these features need to be reconsidered, Hoffman said. — *Erin Wayman*

LIFE & EVOLUTION

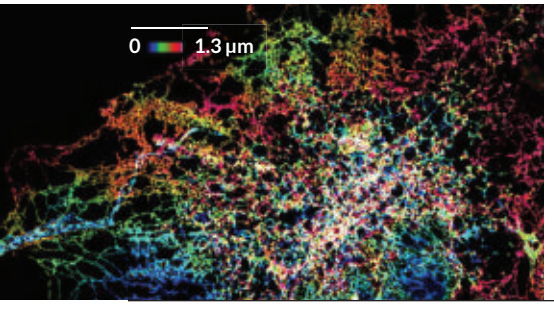
# Biggest organelle gets image update

## Surprising structure of cell's endoplasmic reticulum seen

**BY LAUREL HAMERS**

Textbook drawings of the largest organelle in most cells might need to be revised based on new images. Super-resolution shots of the endoplasmic reticulum reveal tightly packed tubes where previous pictures showed plain flat sheets, scientists report in the Oct. 28 *Science*.

Super-resolution imaging of the endoplasmic reticulum shows a tangled web of interconnected tubes, not a network of flat sheets.




The finding helps explain how the endoplasmic reticulum, or ER, reshapes itself in response to changing conditions, says study coauthor Jennifer Lippincott-Schwartz, a cell biologist at the Howard Hughes Medical Institute's Janelia Research Campus in Ashburn, Va.

A snaking network of membranes that stretches from the nucleus of the cell to its edge, the ER is a cellular jack-of-all-trades. It provides scaffolding for protein-producing ribosomes and makes sure those proteins are folded properly. It churns out lipids. And it stores and releases calcium, which sends messages within and between cells.

New super-resolution microscopy techniques reveal details just tens of nanometers wide, far smaller than what conventional microscopes can see. That resolution upgrade showed that apparently flat sheets of membranes actually consist of dense clusters of tubules.

Some past ER imaging required killing the cells, capturing their inner structure at just one moment in time, notes cell biologist Mark Terasaki of the University of Connecticut Health Center in Farmington. These new imaging techniques capture the motion of the ER in living cells, showing how the tubes rapidly vibrate and shift shapes.

Those tiny tubules come together in three-way junctions, linking into a mesh network that resembles a stretchy spider web. To move into a new part of the cell, the tubes can expand or contract. And the junctions can also slide up and down the tubes like curtains on a rod, the team found. The tubes are packed to different densities throughout the ER, perhaps reflecting the various jobs that different parts of the sprawling organelle take on.

Bona fide sheets — stacked like pancakes — were still found in the part of the ER closest to the cell's nucleus, a feature other scientists have also reported.

Endoplasmic reticulum stress or malfunction can contribute to neurodegenerative diseases such as Alzheimer's and Parkinson's. "For us to really understand disease, we need to understand what normal is," says study coauthor Craig Blackstone, a cell biologist at the National Institute of Neurological Disorders and Stroke in Bethesda, Md. ■

BODY & BRAIN

# Mice smell, share each other's pain

## Olfactory signal suspected in transmission of hurt sensitivity

**BY LAURA SANDERS**

Pain is contagious, at least for mice. After encountering bedding where mice in pain had slept, other mice became more sensitive to pain themselves. The experiment, described October 19 in *Science Advances*, shows that pain can move from one animal to another — no injury or illness required.

The results "add to a growing body of research showing that animals communicate distress and are affected by the distress of others," says neuroscientist Inbal Ben-Ami Bartal of the University of California, Berkeley.

Neuroscientist Andrey Ryabinin and colleagues didn't set out to study pain transfer. But during experiments on mice undergoing alcohol withdrawal, the researchers noticed the mice had a higher sensitivity to pokes on the foot. And surprisingly, so did these mice's perfectly healthy roommates. Bystander mice showed other signs of heightened pain sensitivity, too, such as quickly pulling their tails out of hot water.

"We realized that there was some transfer of information about pain," says Ryabinin, of Oregon Health & Science University in Portland.

Pain's contagion seemed to spread through the nose. After spending time with bedding used by mice in pain, healthy mice's pain sensitivity went up. Some olfactory signals may have been transferred from the pained mouse onto the bedding before a mouse not experiencing pain showed up and began sniffing around. Ryabinin and colleagues are looking for compounds that might carry this pain signal from mouse to mouse.

Other senses may be important, too, says neuroscientist Christian Keysers of the Netherlands Institute for Neuroscience in Amsterdam. Mice could see the distressed mice or hear pained squeaks. Still, the new paper fits with other work that shows "rodents exchange information about their states in many exciting and complex ways," he says.

Implications for people are unknown. Humans' olfactory skills fall short of those of other animals, so it's unclear whether odors can actually transmit information about pain, Ryabinin says.

But the results suggest that social factors or cues can influence pain perception, Ryabinin says. That idea may help explain the experience of some people with chronic pain, a condition that can begin mysteriously or persist long after an injury heals. ■

J. NIXON-ABELL *ET AL*/*SCIENCE* 2016

# Physicists discover 'bubble nucleus'

## Unstable silicon-34 has shortage of protons at its center

**BY EMILY CONOVER**

Scientists have found the first experimental evidence that an atomic nucleus can harbor bubbles.

The unstable isotope silicon-34 has a bubblelike center with a paucity of protons, scientists report October 24 in *Nature Physics*. This unusual "bubble nucleus" could help scientists understand how heavy elements are born in the universe and help researchers find new, ultraheavy stable isotopes.

In their quirky quantum way, protons and neutrons in a nucleus refuse to exist in only one place at a time. Instead, they are spread out across the nucleus in nuclear orbitals, which describe the probability that each proton or neutron will be found in a particular spot. Normally, due to the strong nuclear force that holds the two types of particles together, nuclei have a fairly constant density in their centers, regardless of the number of protons and neutrons they contain. In silicon-34, however, some scientists predicted that one of the proton orbitals that fills the center of the nucleus would be almost empty, creating a bubble nucleus.

But not all theories agreed. "This was the reason for doing the experiment," says study coauthor and nuclear physicist Olivier Sorlin of the National Large Heavy Ion Accelerator, GANIL, in Caen, France. "Some people didn't believe that it would exist."

In pursuit of the bubble nucleus, the scientists smashed silicon-34 nuclei into a beryllium target, which knocked single protons out of the nuclei to create aluminum-33. The resulting aluminum-33 nuclei were in excited, or high-energy, states and quickly dropped down to a lower energy by emitting photons, or light particles. By observing the energy of those photons, Sorlin and colleagues could reconstruct the orbital of the proton that had been kicked out of the nucleus.

The scientists found that they ejected few protons from the central orbital that theorists had predicted would be mostly empty. While the orbital can theoretically hold up to two protons, it held only 0.17 protons on average. In silicon-34, the central proton density is about half that of a comparable nucleus, the scientists calculated, after taking into account other central orbitals that contain normal numbers of protons. (The density of neutrons in silicon-34's center, however, is normal.)

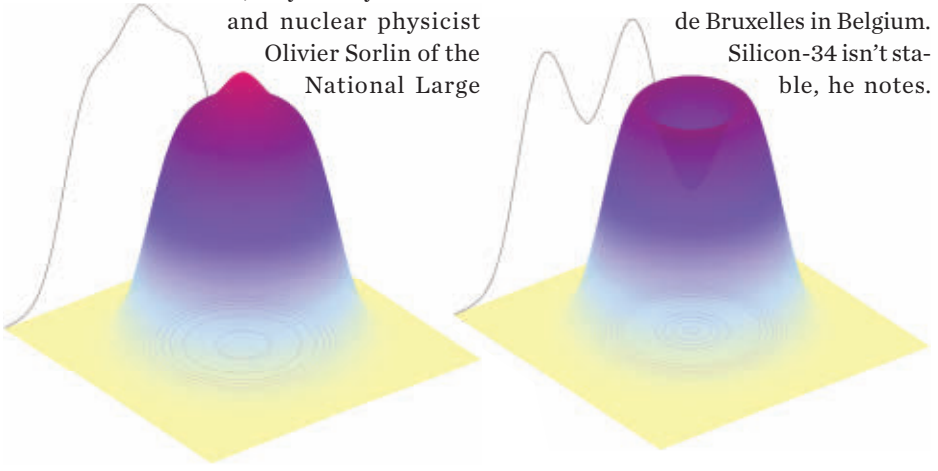
"What they are doing is extremely difficult," says theoretical nuclear physicist Paul-Henri Heenen of Université libre de Bruxelles in Belgium. Silicon-34 isn't stable, he notes. It has a half-life of less than three seconds, making it a challenge to work with.

As protons are added to nuclei, they fill orbitals in a sequential manner, according to the energy levels of the orbitals. Silicon-34 is special — it has a certain "magic" number of protons and neutrons in its nucleus. There are a variety of such magic numbers, which increase stability of atomic nuclei. A magic number of protons means that the energy needed to boost a proton into the next orbital is particularly high. This explains the bubble's origin. For a proton to jump into the unfilled central orbital, it needs significantly more energy. So silicon-34's center remains sparsely populated.

"It's an interesting paper and indeed provides evidence" for a bubble nucleus, says nuclear physicist Jiangming Yao of the University of North Carolina at Chapel Hill. But, he says, the evidence is "not direct," because it relies on nuclear models to calculate density. To directly measure the density of protons, researchers will need to use electrons to probe the inner workings of the nucleus.

Still, the research could help scientists understand the spin-orbit interaction, the interplay between a proton's angular momentum in its orbital and its intrinsic angular momentum, or spin. The effect is important for keeping heavy nuclei stable. Figuring out the impact of that interaction in this unusual nucleus could help scientists better predict the potential location of the "island of stability," a theorized region of the periodic table with heavy elements that may be stable for long periods of time (*SN: 6/5/10, p. 26*).

What's more, a better grasp of the spin-orbit interaction could also help scientists learn how elements are forged in rare cosmic cataclysms such as the merging of two neutron stars. There, nuclei undergo a complex chain of reactions, swallowing up neutrons and undergoing radioactive decay. Modeling this process requires a precise understanding of the stability of various nuclei — a property affected by the spin-orbit interaction. ■



J.-P. EBRAN

**Missing protons** Silicon-34 has a "bubble nucleus" with few protons at its core. The calculated proton density for silicon-34 (right), as a function of the distance from the center of the nucleus, is about half that of a comparable nucleus, such as sulfur-36 (left).

LIFE & EVOLUTION

# Fossil find revises history of jaws

## Placoderms may be ancestors of bony fish, land vertebrates

**BY MEGHAN ROSEN**

A freaky fish with a head like a dolphin and a body like a tank may be to thank for human jaws.

The discovery of a 423-million-year-old armored fish from China suggests that the jaws of all modern bony fish and land vertebrates originated in a bizarre group of fish called placoderms, researchers report in the Oct. 21 *Science*.

Along with a different placoderm fossil found in 2013, the new find, named *Qilinyu rostrata*, is helping rewrite the story of early vertebrate evolution, says paleontologist John Maisey of the American Museum of Natural History in New York City. "We've suddenly realized we had it all wrong."

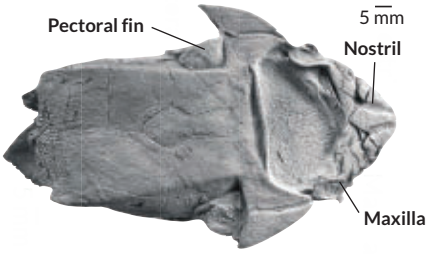
The jaws of humans — and dogs, salmon, lizards and all other bony vertebrates — contain three key bones: the maxilla and premaxilla of the upper jaw, and the dentary of the lower jaw.

"Anything from a human being to a cod has recognizably the same set of bones in the head," says study coauthor Per Ahlberg, a paleontologist at Uppsala University in Sweden. The big question, he says, is "Where did these bony jaws come from?"

More than 100 million years before dinosaurs walked the Earth, placoderms thrived. Scientists knew that these armored fish were early jawed animals, but their jaws were unusual: "They look like sheet metal cutters," Ahlberg says. "They're these horrible bony blades that slice together."

The blades, called gnathal plates, looked so peculiar that most scientists thought that the three-part jaw originated in an early bony fish and that placoderms were just a side branch in the vertebrate family tree. "The established view is that placoderms had evolved independently and that our jaw bones must have a separate origin," Ahlberg says.

A new fish fossil has characteristic placoderm body armor, as well as three jaw bones similar to those found in humans (maxilla shown).




Placoderms are a highly debated group, says paleontologist Martin Brazeau of Imperial College London. No one quite knows where to place them.

In 2013, Ahlberg and colleagues found a new clue in a 419-million-year-old fossil that had the body of a placoderm but the three-part jaw of a bony fish. That animal, called *Entelognathus primordialis*, "could never have been predicted from the fossil record," says paleontologist Gavin Young of Australian National University in Canberra.

That work bolstered the idea that placoderms didn't dead-end hundreds of millions of years ago — some were actually the ancestors of bony fish (and thus humans). But it was just one fossil, Ahlberg notes. "You don't want to draw too big of conclusions from one animal."

Two animals is a different story.

BODY & BRAIN

# Frequent lying alters brain activity

## Blunted reaction in amygdala may explain how fibs escalate

**BY LAURA SANDERS**

When small lies snowball into blizzards of deception, the brain becomes numb to dishonesty. As people tell more and bigger lies, certain brain areas respond less to the whoppers, scientists report October 24 in *Nature Neuroscience*. The results might help explain how small transgressions can ultimately set pants aflame.

The findings "have big implications for how lying can develop," says Victoria Talwar of McGill University in Montreal, who studies how dishonest behavior develops in children. "It starts to give us some idea about how lying escalates from small lies to bigger ones."

During the experiment, researchers showed 80 participants a crisp, big picture of a glass jar of pennies. Participants had to send an estimate of how much money was in the jar to an unseen partner who saw a smaller picture of the same jar. Each participant was serving as a "well-informed financial adviser tasked with advising a client who is less informed about what investments to make," study coauthor Neil Garrett of University College London said during an Oct. 20 news briefing. Researchers gave people varying incentives to lie. In some cases, intentionally overestimating the jar's contents was rewarded with a bigger cut of the money.

As the experiment wore on, the fibs started flying. People lied the most when the lie would benefit both themselves and the unseen partner. But these "financial advisers" still told self-serving lies even when it would hurt a partner.

Twenty-five participants underwent functional MRI scans while lying. When a person had previously lied, brain activity lessened in certain areas of the brain, most notably in the amygdalae, a pair of almond-shaped brain structures tightly linked to emotions. This diminished activity could even predict whether a person would lie on the next trial, results that suggest that the reduced brain activity is actually influencing the decision to lie.

The study avoids a problem that confounds other lying experiments, says neuroscientist Bernd Weber of the University of Bonn in Germany. Many tests are based on lies that people have been instructed to say, which "hardly resembles real-world behavior," he says. Here, the participants were self-motivated liars.

M. ZHU *ET AL*/*SCIENCE* 2016

*Qilinyu rostrata*, a 423-million-year-old armored fish, had a jaw that resembles those of modern bony fish and land vertebrates.

*Qilinyu*, the new fossil, had an armored skull and trunk and was probably about the length of a box of tissues. Like *Entelognathus*, *Qilinyu* had a three-part jaw, though the creature looked a bit more like a typical placoderm, Ahlberg says. The two fossils "form almost perfect intermediates" between placoderms and bony fish, he says. Ahlberg and colleagues suspect the key jaw elements of bony fish (and all land vertebrates) evolved from those bony blades of placoderms.

"This is part of our own early evolutionary history," Ahlberg says. "It shows where our own jaws came from."

Maisey puts it another way: "We are all fundamentally placoderms." ■

Without any negative consequences from their lies, participants weren't afraid of being caught. That impunity might affect activity in the amygdala, Weber says. Further experiments are needed to reveal the effects of fear of punishment.

From Ponzi schemes to current politics, case studies abound of small lies spiraling into much bigger deceits, study coauthor Tali Sharot of University College London said in the briefing. A principle called emotional adapation may contribute to this phenomenon.

It's similar to the reason why a perfume's scent becomes less noticeable over time. The first time you cheat on your taxes, you'd probably feel quite bad about it, Sharot said. That bad feeling is good, because it curbs your dishonesty. "The next time you cheat, you have already adapted," she said. "There's less negative reaction to hold you back so you might be lying more." ■

DINGHUA YANG

EARTH & ENVIRONMENT

# Climate-friendly coolants needed

## Deal will phase out refrigerants that cause global warming

**BY THOMAS SUMNER**

The hunt is on for chemicals to keep both you and the planet cool.

A new agreement will soon begin phasing out the greenhouse gases used in air conditioners, refrigerators and insulating foams. These gases, called hydrofluorocarbons, or HFCs, can cause hundreds of times more global warming per molecule than carbon dioxide. The phaseout, announced by world leaders on October 15 in Kigali, Rwanda, has scientists and chemical companies investigating new molecules to chill things with less harm to the planet. Some of these molecules are already in use, while others require more tinkering.

Hunting for eco-friendly alternatives requires careful chemistry, says Rajiv Banavali, chief technology officer of advanced materials at Honeywell International, which develops chemicals for air conditioners and refrigerators. A replacement chemical has to serve the same purpose without necessitating a major — and costly — redesign of the rest of the product, he says.

Many of the new chemicals are designed to quickly break apart through chemical reactions once in the atmosphere but function properly when contained. That short lifetime means that any molecular escapees cause warming for only a few days, rather than years or decades as many current refrigerants do.

Today's coolants arose after the 1987 Montreal Protocol banned chlorofluorocarbons, or CFCs, which were diminishing the ozone layer. But many of their replacements, including certain HFCs, are potent greenhouse gases. Right now, those replacement chemicals make up about 2 percent of greenhouse gas emissions in terms of global warming potential, but that share could increase as air conditioning becomes more prevalent in developing countries such as India.

The Rwanda deal's ultimate goal is to reduce HFC usage by 80 to 85 percent by 2047, preventing as much as 0.5 degrees Celsius of global warming by 2100.

Several replacements are in development, including hydrocarbons that trap less heat. Some prototype systems even forgo chemical refrigerants altogether and instead use sound waves to pump heat, though the technology is currently inefficient and takes up too much space, says Stephen Yurek, president of the Air-Conditioning, Heating and Refrigeration Institute in Arlington, Va. "There's a lot of opportunity for new and creative ideas on how to do this," he says.

One molecule already in use is HFO-1234yf, a refrigerant used in car air conditioners. Each molecule contains a double bond between a carbon and a fluorine atom that serves as an intentional fatal flaw, breaking the molecule apart once it leaks into the atmosphere. The result of a joint effort between Honeywell and the chemical company DuPont, HFO-1234yf's design results in a global warming potential just a few thousandths that of its HFC predecessor.

But even with a short lifetime, a chemical can still contribute to global warming. R-134a was considered as a replacement refrigerant in freezers because it has a small global warming impact once in the atmosphere. But the chemical makes the freezer more energy-hungry, says chemical engineer Paul Blowers of the University of Arizona in Tucson. In 2010 in *Environmental Science & Technology*, he calculated that using R-134a would actually increase a freezer's total climate impact due to the increased energy use.

Some potential downsides, such as reduced efficiency, can be tested before implementation, but others can't, says Blowers. CFCs were invented decades before their link to ozone depletion was established. "Will we make some bad decisions along the way? Yes. Will we fix them? Hopefully faster than we have before," he says. "This regulation is good because it moves us forward." ■

GENES & CELLS

# Cigarettes cause telltale DNA damage

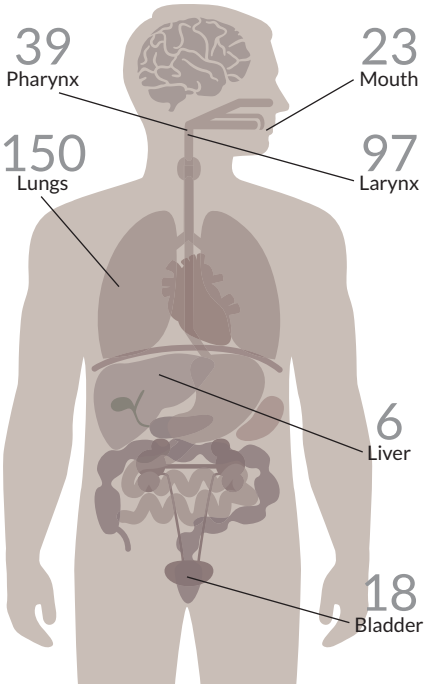
## Patterns of cancer mutations differ in smokers and nonsmokers

**BY RACHEL EHRENBERG**

Different DNA mutation patterns show up in the cancerous tissues of smokers than in those of nonsmokers, a new analysis finds. The study, in the Nov. 4 *Science*, reveals how smoking contributes to different cancers, enhancing several kinds of DNA damage.

"We are doing a sort of molecular archaeology," says Ludmil Alexandrov, a cancer geneticist at Los Alamos National Laboratory in New Mexico who led the analysis. While smoking's link to cancer has been known for decades, "it's always been a bit of a mystery why smoking increases the risk of cancers like bladder or kidney — tissues that aren't exposed to smoke," Alexandrov says.

Mutations in DNA arise naturally in a person's lifetime, but some genetic changes — such as those spurred by smoking — increase the risk of certain cancers. Scientists have identified several patterns of mutations that consistently show up in tissues of some cancers. These patterns, which may appear over and over again in a single stretch of tumor DNA, can serve as a signature of the underlying mechanism that led to the mutations, offering clues to how different cancers strike.




**Smoke signals** Smoking harms tissues in the body to differing degrees. Scientists estimate that smoking a pack of cigarettes a day for a year results in 150 mutations on average in each lung cell. Other cell types rack up fewer changes. SOURCE: L.B. ALEXANDROV *ET AL*/*SCIENCE* 2016

"When someone has a cancer, we only see what is now — we don't know what happened 20 years ago when that cancer was only one cell," says cancer biologist Gerd Pfeifer of the Van Andel Research Institute in Grand Rapids, Mich. "These signatures give us a really good clue of what might have happened," Pfeifer says.

Alexandrov and an international team of researchers found several differences in the number of altered DNA signatures in tumors of smokers compared with those from nonsmokers with the same type of cancer. The research adds dismal specifics to what's already known about smoking: It is really bad for you.

"Tobacco smoking leaves permanent mutations; it erodes the genetic material of most cells in your body," says Alexandrov. "Even if you are just a social smoker who occasionally has one or two or five cigarettes, there is still a cumulative effect."

Alexandrov and colleagues compiled data on DNA extracted from more than 5,000 human samples representing 17 cancers for which smoking is a known risk factor. About half of the samples were from smokers. The team then searched the DNA for various patterns of damage, or "mutational signatures."

One suite of mutations, called signature 4, was consistently found in tissues exposed to tobacco smoke. While this signature also appeared in nonsmokers' tumors, it occurred far less often. Smokers with lung squamous cancer, lung adenocarcinoma and larynx cancers had an especially high number of signature 4 mutations. Signature 4 signals damage to guanine (the structural component of DNA known as "G"). This signature has also been found in the DNA of cells in a lab dish that were exposed to a chemical found in burnt products, including polluted air and the tar in cigarette smoke.

Signature 4 mutations also showed up in cancers of the oral cavity, pharynx and esophagus but much less often. The researchers aren't sure why these tissues, which are also directly exposed to smoke, don't have as heavy a mutational load. Those tissues may metabolize smoke differently, the researchers speculate.

Another suite of mutations, known as signature 5, also differed between smokers and nonsmokers. This signature typically shows up in all cancers and across all tissue types. The cause of signature 5 remains unknown, but scientists do know that the number of signature 5 mutations is "clocklike," increasing with age. The new analysis revealed that the signature 5 "clock" ticks faster in smokers. And the more heavily a person smoked, the more signature 5 mutations were found.

In patients with lung adenocarcinoma, far more mutations associated with two other signatures, 2 and 13, had accumulated in smokers than in nonsmokers. There are hints that these mutations result from overactive DNA-editing machinery. But because these signatures are found in many kinds of cancers, it isn't clear why smoking ups the mutation load. Inflammation from smoke might be activating the cellular machinery that underlies the mutations.

When the researchers took into account the quantity smoked, they discovered that the number of mutations for some cancers was linked to the "pack years" smoked (a pack of cigarettes a day for one year). Breaking these data down allowed the team to calculate the average number of mutations caused by smoking in each cell by tissue type: A pack a day for one year leads to 150 mutations on average in each lung cell, 97 in each larynx cell, 39 in pharynx cells, 23 in oral cavity cells, 18 in bladder cells and six in liver cells. ■

EVELEEN/SHUTTERSTOCK

ATOM & COSMOS

# X-ray mystery shrouds Pluto

## Additional data needed to confirm high-energy photons

**BY CHRISTOPHER CROCKETT**

X-rays appear to be trickling away from Pluto, even though the dwarf planet has no obvious way of making the high-energy photons, a new study reports.

Given what researchers have learned about Pluto since the New Horizons spacecraft flew by in 2015 (*SN: 8/8/15, p. 6*), the discovery is surprising. For many planets and comets, X-rays are generated when the solar wind, a stream of charged particles from the sun, runs into neutral gas atoms in the atmosphere of these bodies or their magnetic fields. But the environment around Pluto isn't conducive to producing X-rays: It has no measurable magnetic field, its atmosphere is very thin and it's losing that atmosphere at rates much lower than expected.

"We naïvely thought Pluto might be losing its atmosphere at the same rate as [some] comets," says planetary astronomer Carey Lisse of Johns Hopkins University Applied Physics Laboratory in Laurel, Md. "We knew comets make X-rays, so we hoped that Pluto did, too." Instead, interactions between the solar wind and a tenuous tail of methane hundreds of times longer than Pluto's width might be the culprit, Lisse and colleagues say online October 25 at arXiv.org.

Lisse's team used the Chandra X-ray telescope, once in 2014 and three times in 2015, to look for X-rays. Chandra detected just seven photons streaming from Pluto in about two days' worth of observing time. The signal is weak, but it's about six or seven more photons than expected based on New Horizons' measurements of Pluto's atmosphere and the solar wind.

"It's a very puzzling finding," says astrophysicist Konrad Dennerl of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany. "I'm not fully convinced. It's a very low signal."

Lisse and collaborators note that the signal appears to follow Pluto across the sky. They detected X-ray photons on four separate occasions. The energy of the photons doesn't appear to match that of the spurious X-ray noise that peppers the telescope, so the signal appears genuine. Still, Lisse and Dennerl are teaming up to get some Pluto time with another X-ray observatory, the European Space Agency's XMM-Newton satellite.

An unexpected trickle of X-rays surrounds Pluto, possibly from a tail of gas dragging behind the dwarf planet.

X-rays aren't just a quirky detail about Pluto. If other bodies in the Kuiper belt, the ring of icy debris just past Neptune's orbit, have atmospheres, then X-ray observations could help detect them. ■

ATOM & COSMOS

# Muon surplus may reveal new physics

## Scientists try to explain particle excess caused by cosmic rays

**BY EMILY CONOVER**

Muons, electrons' heftier cousins, rain down through the Earth's atmosphere in numbers higher than expected. The discrepancy could point to a gap in physicists' understanding of the nitty-gritty physics of particle interactions. Or perhaps something else is going on, such as the creation of a new state of matter.

When cosmic rays — spacefaring protons or atomic nuclei — smash into the atmosphere at ultrahigh energies, they launch a cascade of many other types of particles, including muons. New observations from the Pierre Auger Observatory in Argentina detected about 30 percent more muons than simulations predict, scientists report in the Nov. 4 *Physical Review Letters*.

By comparing simulated particle showers with real data from the observatory, and allowing for possible miscalibration of detectors, the scientists concluded that the predicted numbers of muons don't match up with reality. Hints of this muon excess have been popping up since the 1990s, says physicist Thomas Gaisser of the University of Delaware. But the new measurement does "a better job, which confirms the excess compared to what's predicted by the models."

The ultrahigh energy cosmic rays that the researchers analyzed allowed them to probe physics at energies 10 times those reached at the world's most powerful particle accelerator, potentially allowing scientists to detect new phenomena. But "it's premature to say that this is something really interesting," says Spencer Klein of the Lawrence Berkeley National Laboratory in California. He suggests that the discrepancy could simply be due to an incomplete grasp of how protons and neutrons behave inside a nucleus when nuclei collide. The complexities of that behavior could result in particles that eventually decay into more muons than expected, thus explaining the glut.

Auger physicist Glennys Farrar of New York University points out that scientists have unsuccessfully tried to explain the muon surplus using standard physics for years. She says the finding could indicate a new state of matter that appears at high energies. In such a state, large numbers of gluons, which transmit the strong nuclear force, may behave collectively, like photons in sync in a laser. If enough energy is pumped in by cosmic rays, the gluons might gang up into hypothetical particles called glueballs, which could decay into particles that produce more muons. ■

NASA, JHUAPL

HUMANS & SOCIETY

# Monkey flakes resemble hominid tools

## Unlike human ancestors, capuchins don't use sharp rocks to cut

**BY BRUCE BOWER**

A group of South American monkeys has rocked archaeologists' assumptions about the origins of stone-tool making.

Wild bearded capuchins in Brazil use handheld stones to whack rocks poking out of cliffs and outcrops, although researchers don't know why. In the process, the monkeys unintentionally break off sharp-edged stones that resemble stone tools made by ancient members of the human evolutionary family, say archaeologist Tomos Proffitt of the University of Oxford and his colleagues. It's the first observation of this hominid-like rock-fracturing ability in a nonhuman primate.

The new finding indicates that early hominids needed no special mental ability, no fully opposable thumbs and not even any idea of what they were doing to get started as toolmakers, the researchers report in the Nov. 3 *Nature*. All it may have taken was a penchant for skillfully pounding rocks.

Archaeologists have traditionally thought that ancient stone tools appeared as hominid brains enlarged and hand grips became more humanlike.

"Without the intention of making a stone tool, and with the right rock types, capuchins produce objects that are shaped like stone tools," says Oxford primatologist and archaeologist Susana Carvalho, who did not participate in the new study. She suspects the earliest known stone tools were made either by relatively small-brained hominids or, perhaps in some cases, nonhuman primates. "This is not a wild idea anymore."

The oldest known hominid stone artifacts — a set of pounding rocks and sharp-edged stone flakes — date to 3.3 million years ago in East Africa (*SN: 6/13/15, p. 6)*. Those tools display more elaborate modifications than observed on sharp-edged capuchin creations, Proffitt says. But researchers suspect simpler hominid tools go back 4 million years or more. Those implements might have looked more like what the South American monkeys make, he speculates.

A capuchin monkey in Brazil uses a stone to hammer an embedded rock. Sharp-edged debris from such rock pounding raises questions about how hominid toolmaking evolved.

Three capuchins tracked during an episode of rock pounding did not use fractured pieces of sharp stone to cut, scrape or dig up anything. Observations of nearly 100 rounds of rock pounding show that the monkeys sometimes recycled stone flakes as rock-pounding tools. They also often licked or sniffed powdered stone produced as they pounded rocks. Perhaps capuchins want to ingest the trace nutrient silicon, which assists in bone growth, or find lichens for some medicinal purpose, Proffitt speculates.

GENES & CELLS

# Immune proteins aid viral enemy

## Attacks on B cells may explain some chronic infections

**BY LAUREL HAMERS**

Crucial immune system proteins that make it hard for viruses to replicate might also help the attackers avoid detection, three new studies suggest. When faced with certain viruses, the proteins can set off a cascade of cell-to-cell messages that destroys antibody-producing immune cells. With virus fighters depleted, it's easier for the invaders to persist.

The finding begins to explain how certain chronic viral infections dodge the immune system, says David Brooks, an immunologist at the University of Toronto not involved in the research. The new studies, all published October 21 in *Science Immunology*, pin the blame on the same set of proteins: type 1 interferons.

Type 1 interferons protect the body from viral siege, helping to activate certain parts of the immune system. They also make cells less hospitable to viral replication.

But in three studies, scientists tracked mice's immune responses when infected with lymphocytic choriomeningitis virus, or LCMV. In each case, type 1 interferons masterminded the loss of B cells, which produce antibodies specific to the virus being fought. Those antibodies latch on to the virus, flagging it for destruction by immune cells called T cells. With fewer B cells, the virus evades capture for longer.

The proteins' response "is driving the immune system to do something bad to itself," says Dorian McGavern, an immunologist at the National Institute of Neurological Disorders and Stroke in Bethesda, Md., who led one study.

Interferons didn't directly destroy B cells. They worked through intermediaries, which differed depending on factors including the site of infection and how much of the virus the mice received.

T cells were one intermediary. McGavern and colleagues filmed T cells destroying their B cell compatriots under the direction of interferons. When the scientists deleted those T cells, the B cells didn't die off even though the interferons were still hanging around.

Another study found that the interferons send messages via other immune cells, too. Those messages told B cells to morph into cells that rapidly produce antibodies against the virus. But those cells die off within a few days instead of mounting a long-term defense.

MICHAEL HASLAM/PRIMATE ARCHAEOLOGY GROUP



Watch a capuchin monkey smash rocks at **bit.ly/SN_capuchin**

His team studied 111 capuchin-modified stones, including complete and broken pounding stones, stone flakes and stones that had been struck by rock-wielding monkeys.

Capuchin flakes are smaller and contain fewer fractured areas than ancient hominid tools, says archaeologist David Braun of George Washington University in Washington, D.C. But the monkeys' sharp-edged stones display "remarkable similarity" to artifacts from a nearby Brazilian site that some researchers think were made by humans more than 20,000 years ago (*SN: 10/18/14, p. 14*), Braun says. Researchers must now determine whether those artifacts and others at several ancient South American sites were made by humans or monkeys, he says.

Capuchin rock smashers' inadvertently sharpened debris also raises questions about how hominids started making tools in the first place. Techniques for using one stone to pound away pieces of another, creating a rock with smooth faces bordered by razor-sharp edges, "could have been invented independently in different hominid species through [stone-pounding] behaviors we have yet to identify," Proffitt says. ■

That strategy could be helpful for a short-term infection but less successful against a chronic one, says virologist Daniel Pinschewer of the University of Basel in Switzerland, who led that study. Throwing the entire defense arsenal at the virus all at once leaves the immune system shorthanded later on.

But interferons can prolong even short-term viral infections, a third study showed. Scientists injected lower doses of LCMV into mice's footpads. In the lymph nodes, interferons stifled B cells by working through inflammatory monocytes, immune cells that rush to infection sites.

Since all three studies looked at the same virus, it's not yet clear whether the mechanism extends to other viral infections. But Brooks thinks it's likely that other viruses that dampen antibody response, such as HIV and hepatitis C, may also exploit type 1 interferons. ■

LIFE & EVOLUTION

# Warming alters ant turnovers

## In forest test, climate change disrupted nest transfers

**BY SUSAN MILIUS**

Heating small patches of forest shows how climate warming might change the winner-loser dynamics as species struggle over prize territories. Such shifts in control could have wide-ranging effects on ecosystems.

The species are cavity-nesting ants in eastern North America. Normally, communities of these ant species go through frequent turnovers in control of nest sites. But as researchers heated enclosures to mimic increasingly severe climate warming, nest ownership began shifting toward a few persistent winners. Several heat-loving species tended to stay in nests unusually long, instead of being replaced in faster ant upheavals, says Sarah Diamond of Case Western Reserve University in Cleveland.

That's worrisome for the ecosystem as a whole, she and colleagues argue October 26 in *Science Advances*. Ants have an outsized effect on ecosystems. They churn up soil, shape the flow of nutrients and disperse seeds to new homes. Ant species that can't compete in a warmer climate may blink out of the community array, with consequences for other species they affect.

Teasing out the indirect effects of climate change has been difficult. Until now "we've all sort of thrown up our hands and said probably these interactions are quite important, but they're really hard to measure so we're just going to ignore that," Diamond says.

Simulated climate warming altered the dynamics of an ant community living in an enclosure.

JAMES WATERS

Experiments have begun tackling those interactions, and the ant enclosures are among the most ambitious. At each of two experimental sites — in North Carolina and Massachusetts — the researchers set up 15 plots to mimic various warming scenarios. Giant propane tanks fueled boilers that forced warmer air into the enclosures to heat the chambers, from 1.5 to 5.5 degrees Celsius above the surrounding air temperature.

At least 60 species of local ants came and went naturally over five years of regular monitoring.

Warmth gave an edge to heat-tolerant species such as *Temnothorax longispinosus* in the Massachusetts forest. This tiny ant can build colonies inside an acorn and is a known target for attacks by slave-maker ants that invade nests instead of establishing their own. With increased warming, however, *T. longispinosus* and a few other heat-loving ants tended to hold their nests longer.

Those longer stints destabilize the ant community. The usual fast pace of nest turnovers typically gives more species a chance at shelter and better luck in surviving. The analysis showed that the more a plot was heated, the more time the ants needed after some disturbance to return to the equilibrium of their usual affairs.

"A key strength of this study is their regular sampling," says Jason Tylianakis, who holds joint appointments at the University of Canterbury in New Zealand and Imperial College London. Those data provide an unusually detailed picture of subtle community effects, he says.

The study has "documented a new consequence of temperature change on communities," says marine ecologist Sarah Gilman of the Claremont Colleges in California. Other studies have talked about climate change pushing communities to dramatically new but ultimately stable states. But the ant experiment shows that climate change may be undermining the stability of communities that, at least for the moment, still look fairly normal. ■

HUMANS & SOCIETY

# Australia's interior colonized quickly

## Roots of Aboriginal culture may stretch back 49,000 years

**BY BRUCE BOWER**

Australia's early settlers hit the ground running, or at least walking with swift determination. After arriving on the continent's northwest coast by around 50,000 years ago, humans reached Australia's southeastern interior within a thousand years or so, researchers find.

This ancient trip covered more than 2,000 kilometers through terrain that, although stark and dry today, featured enough lakes and rivers at the time of Australia's colonization to support long-distance treks, say archaeologist Giles Hamm of La Trobe University in Melbourne, Australia, and colleagues.

Excavations at Warratyi rock-shelter in the continent's arid southeast have yielded tools and other artifacts. These indicate that it took only a few millennia for Australia's early colonists to forge a distinctive Aboriginal culture that continued to develop over the next 40,000 years, Hamm's team reports online November 2 in *Nature*.

"Archaeological finds at Warratyi are surprisingly old and significant, especially coming from an excavation of only a meter of sediment," Hamm says.

These new discoveries are "remarkable and atypical" for Australia, says archaeologist Peter Hiscock of the University of Sydney. But the finds' ages and significance for understanding Aboriginal culture will be debated, he predicts.

Until now, the oldest human sites in Australia's huge, arid interior dated to no more than 44,000 years ago in the continent's northwest, not far from where the first settlers presumably arrived. Lake Mungo, now a dry lake bed in southeastern Australia that lies outside this arid zone, has yielded artifacts from about 50,000 years ago. Unlike artifacts at Warratyi that represent human activity over a long time span, it's not known if Lake Mungo finds come from a group that made an isolated foray into the region before dying out within a few generations.


Warratyi rock-shelter's artifacts include a sharpened bone point that's 38,000 to 40,000 years old. The point's discoverers say it's the oldest known bone tool from Down Under.

Hamm's group unearthed evidence of an intermittent human presence at Warratyi that lasted from around 49,000 to 10,000 years ago. People were largely absent between around 35,000 and 17,000 years ago, when the climate became substantially colder and drier, Hamm says.

Finds at Warratyi dating to between 49,000 and 46,000 years ago include stone tools and a piece of reddish pigment. Bones from 16 mammal species and one reptile species were unearthed from various layers of sediment. Of particular interest were a partial leg bone from an extinct, rhino-sized marsupial and eggshells from a large, flightless bird. These animals died out not long after humans reached Australia, but it hasn't been clear whether humans contributed to the extinctions via hunting or other actions (*SN: 1/20/07, p. 38*).

Warratyi probably won't resolve that issue. No butchery marks from stone tools appear on the marsupial fossil, although people may still have hunted the creature. Possibly burned areas appear on some eggshell fragments. Recent evidence from other Australian sites indicates that people were cooking this extinct bird's eggs between 54,000 and 43,000 years ago.

Other discoveries at Warratyi indicate that Aboriginal people there made a variety of tools up to 10,000 years before similar types of tools appeared elsewhere in Australia or in Southeast Asia, the scientists say. For instance, a 4-centimeter-long bone point that dates to more than 38,000 years ago is Australia's earliest known bone tool.

Comparably ancient discoveries include resin, which was probably used to glue stone tools to handles of some type. Tool handles probably came into use even earlier than that in Australia, argues Sandra Bowdler, an archaeologist at the University of Western Australia in Crawley. Researchers generally agree that stone cutting implements with ground, beveled edges were once attached to handles in Australia, Bowdler says. A team led by Hiscock recently dated a ground-edge tool from northwest Australia to 49,000 to 44,000 years ago. That means handle use started there before it appeared at Warratyi, Bowdler holds.

Excavations at Warratyi rock-shelter, situated in the middle of this outcrop, suggest people reached southeastern Australia's interior shortly after settlers arrived on the continent.

Tools with sharpened edges along one side appeared at Warratyi between 30,000 and 24,000 years ago. While Hamm's team regards these as Australia's oldest such implements, Bowdler awaits more thorough dating of Warratyi before accepting that conclusion.

To date the artifacts, Hamm's group calculated the time since buried sediment was last exposed to sunlight and did radiocarbon analyses of charcoal from ancient hearths and of eggshells.

Questions remain about the age of the oldest Warratyi discoveries, says geochronologist Richard Roberts of the University of Wollongong in Australia. Two samples of the deepest artifact-bearing sediment were dated to roughly 44,000 to 43,000 years ago, whereas three radiocarbon dates of eggshells from the same sediment ranged in age from 45,000 to 50,000 years or more, in Roberts' view. If the younger age is correct, then Warratyi finds are no older than those previously discovered at Riwi rock-shelter, another site in Australia's arid interior. If older than 50,000 years, says Roberts, "the Warratyi artifacts would be among the oldest on the continent." ■

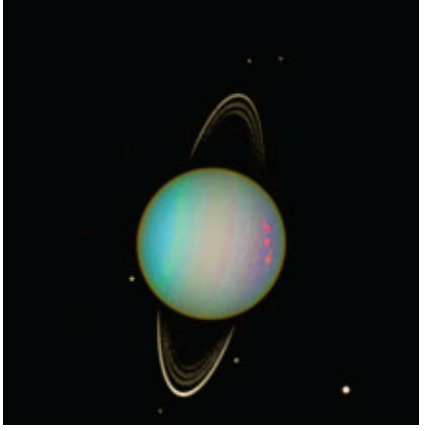
BOTH: G. HAMM

ATOM & COSMOS

## Uranus moon count: 27 and rising

Two more teeny moons might be lurking around Uranus. That's in addition to the 27 we already know about. Fluctuations in the density of two of the planet's dark rings, seen in radio data from the 1986 flyby of the Voyager 2 spacecraft, could be caused by unseen moonlets, Robert Chancia and Matthew Hedman, astronomers at the University of Idaho in Moscow, report online October 9 at arXiv.org.

At probably just 4 to 14 kilometers wide, both moons would be very difficult to detect in Voyager 2 images, the researchers report. New observations with ground-based telescopes might have better luck. — *Christopher Crockett*



A false-color image from the Hubble Space Telescope shows the rings of Uranus. Newly identified clumps in the rings may have been created by two undiscovered moons.

GENES & CELLS

## Genetic variant protects against rash of autoimmune diseases

Tweaking activity of one protein may help protect against 10 autoimmune diseases, a new study suggests. The protein, tyrosine kinase 2 or TYK2, helps regulate how strongly the immune system responds to threats.

Using genetic data from more than 36,000 people with a variety of autoimmune diseases, researchers found that one genetic variant in the gene that codes for the TYK2 protein protects against a wide range of diseases that cause the immune system to attack the body. The variant changes one amino acid in the protein. As a result, the protein's activity is greatly reduced, but not completely eliminated, researchers report November 2 in *Science Translational Medicine*.

The researchers say the variant strikes just the right balance between incapacitating the immune system and protecting against overreactions that lead to multiple sclerosis, Crohn's disease and other autoimmune disorders. New drugs that reduce TYK2's activity would need similar Goldilocks-like precision. But if such a drug could be developed, it could prove useful against a broad range of diseases. — *Tina Hesman Saey*

BODY & BRAIN

## Nose cells fix knee cartilage

Using nasal cartilage cells to repair joints is nothing to sniff at.

It has worked in goats. Now, in the first human trial, researchers at the University of Basel in Switzerland have grown cells called chondrocytes, taken from the noses of 10 patients with damaged knee joints, into cartilage grafts. These repair patches were then surgically implanted into the patients' knee joints.

Two years after surgery, nine patients have seen improvements in knee function, quality of life and pain. (One patient dropped out of the trial because of additional athletic injuries.) MRI scans showed that the grafts looked like normal hyaline cartilage, the hard-to-replicate material that coats the tips of bones, the team reports in the Oct. 22 *Lancet*. Tests in more people are needed to determine whether the technique is ready for prime time. — *Helen Thompson*

GENES & CELLS

# Chimps, bonobos interbred long ago

Like lipstick on a collar, new DNA evidence is pointing to ancient affairs between bonobos and chimpanzees.

Chimps carry a small percentage of bonobo DNA, researchers report in the Oct. 28 *Science*. Analysis of the genetic instruction books, or genomes, of 63 wild-born chimps, two captive chimps and 10 wild-born bonobos led to the finding. The apes came from 10 African countries.

Although chimps (*Pan troglodytes*) and bonobos (*Pan paniscus*) became separate species 1.6 million to 2 million years ago, they are still closely related enough to interbreed occasionally. Finding bonobo genetic variants in chimp DNA suggests at least two past periods of interspecies intimate relations. Between about 550,000 and 200,000 years ago, bonobos mated with the ancestors of eastern and central chimp subspecies. Central chimps and bonobos interbred again about 100,000 to 200,000 years ago, giving modern central chimps more bonobo DNA than their sister subspecies.

Even with the extra dose of interbreeding, individual chimps have inherited less than 1 percent of their genomes from bonobos. That and other evidence suggests that bonobo DNA is an evolutionary disadvantage for chimps, evolutionary geneticist Marc de Manuel of Pompeu Fabra University in Barcelona and colleagues report. Bonobos may also possess some chimp DNA, but most of the gene flow that researchers can detect appears to have been from bonobos into chimps. DNA evidence has shown that humans mixed with now-extinct cousins (*SN: 11/12/16, p. 13*), but this is the first solid evidence of hybridization between humans' closest living relatives. — *Tina Hesman Saey*

Chimpanzees (left) and bonobos (right) interbred in the past. Genetic evidence of that mixing was found in a new study.

CLOCKWISE FROM TOP: NASA, E. KARKOSCHKA/UNIV. OF ARIZONA; PIERRE FIDENCI/WIKIMEDIA COMMONS (CC BY-SA 2.5); KEVIN LANGERGRABER

# SENTINELS OF FOREST HEALTH

## Scientists tap lichens as early sensors of impending problems for plants and animals

**By Amy McDermott**

Ecologist Linda Geiser works her way through thick undergrowth on the steep hills of the Bull Run Watershed just outside of Portland, Ore. Every step in her heavy boots is deliberate. It would be easy to break an ankle here, or worse. A dense sea of ferns and berry bushes hides deep pits and sharp fallen branches.

This treacherous slope is a U.S. Forest Service field site, one of many in the United States, recognizable by its bright orange flagging fluttering from the trees. Geiser has patrolled terrain like this for 30 years. As manager of the Forest Service's air-quality program, she's tasked with monitoring pollution. So she has come here, not to check sophisticated equipment, but to find lichens.

Fringed and fuzzy, or as slick as a coat of paint, lichens are mosaics of fungi partnered with algae or cyanobacteria that speckle tree bark and dangle from the canopy (*SN: 11/7/09, p. 16*). In those precarious perches, lichens absorb their food from fog, wind and rain. With no roots but very absorbent tissue, lichens are exquisitely vulnerable to gases released from burning fossil fuels and other pollutants carried by the wind and rain. That sensitivity makes lichens powerful sentinels of forest health.

"Where there is pollution, there is a predictable effect on lichens," Geiser says. Rare and delicate lichen species that are highly specialized to their habitat are some of the first to die out as air quality falls. Less-sensitive, generalist lichens hang on longer and, in some cases, even survive and

Aptly named "fairy barf" lichen (*Icmadophila ericetorum*) clings to bark in the Great Smoky Mountains of Tennessee.

JASON HOLLINGER/FLICKR (CC BY 2.0)

expand. Both can signal problems to come.

A 2014 study linked an abundance of the nitrogen-loving lichen *Candelaria pacifica* in Yosemite National Park with hot spots of excess nitrogen blown over from the sprawling farmlands of California's Central Valley. Nitrogen becomes a pollutant at very high concentrations. A 2015 study in Washington State tied an area of heavy metal pollution, detected in lichen tissues in the Colville National Forest, to a zinc and lead smelter just across the border with Canada.

Pollution builds up inside lichen tissues in proportion to its concentration in the wider environment. Anything poisoning lichens is also accumulating more broadly in the forest. Lichens and other supersensitive species begin to shift first, but the same contaminants may hit hardier plants and animals next.

That's why Geiser is hiking in the shadow of Mount Hood. She jots down the name and abundance of every lichen species she finds at Bull Run to track changes in the lichen census since the last survey of this plot, 10 years ago. Geiser carries a large, clear bag in her pack and fills it with a seafoam green lichen called *Platismatia glauca*. In a lab at the University of Minnesota, researchers will dissolve the *P. glauca* in acid to measure levels of 24 air pollutants. Other tests measure sulfur, nitrogen and mercury.

The Forest Service has used lichens to track air quality since the 1980s. What began as a few pilot studies has expanded into a national program, with thousands of lichen-monitoring plots across the country. The information collected at those sites is cataloged in a database, used by the Forest Service to track changes in the lichen landscape. Until now, that database has not been publicly available. But in 2017, it will be released — along with an atlas of lichen distributions nationwide — so anyone can track this early warning system.

The timing is good, because while these fungal mélanges have been counted on as air monitors for decades, they have now also begun to show their worth as sentinels of climate change in the Lower 48 states and, increasingly, in the Arctic.

## Environmental watchdogs

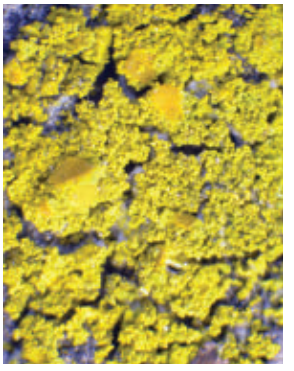
Far from the rain-drenched forests of the Pacific Northwest, on the gray streets of 1860s Paris, a botanist named William Nylander noticed a peculiar pattern. More lichen species grew in the oasis of the Luxembourg Garden than elsewhere in the city. The park was less polluted than the rest of Paris. Nylander inferred a connection: Better air quality meant higher lichen diversity.

Proof that lichens respond to air quality came about a century later. Studies in the 1950s found that lichen diversity fell as sulfur dioxide rose. In 1958, botanist Erik Skye found that airborne sulfur dioxide, emitted from a Swedish oil works, killed lichens surrounding the factory. The sulfur dioxide acidified the lichens' cells, disrupting metabolism and photosynthesis. Other pollutants, like nitrogen dioxide, can also kill some lichen species by overfertilizing them. Without protective structures common in plants, such as a waxy cuticle and pores that can close to keep out unwanted substances, lichens are especially vulnerable to environmental vagaries.

By the 1980s, most large cities in Central Europe monitored lichens to track air quality, says biologist Christoph Scheidegger of the Swiss Federal Institute for Forest, Snow and Landscape Research in Birmensdorf. What's appealing, he says, is the tight relationship between lichen diversity and pollution levels. When the number of sensitive lichen species goes down, it reveals areas where pollution levels are going up.

In the United States, lichens help the Forest Service and National Park Service set pollution targets and identify areas where those targets are being exceeded. Those agencies don't have the authority to set pollution laws. Instead, they make recommendations to state governments and the U.S. Environmental Protection Agency on the amount of pollution an ecosystem can withstand before falling into decline.

To figure out how much pollution is too much, government scientists look to lichens,



In the presence of high levels of excess nitrogen, moderately sensitive wolf lichens (*Letharia vulpina*, top) languish while candleflame lichens (*Candelaria pacifica*, bottom) thrive.

Linda Geiser of the U.S. Forest Service counts and collects lichen species clinging to tree bark in the Bull Run Watershed outside of Portland, Ore.

FROM TOP: JASON HOLLINGER/WIKIMEDIA COMMONS (CC BY 2.0); J-DAR/MUSHROOM OBSERVER (CC BY-SA 3.0); AMY MCDERMOTT

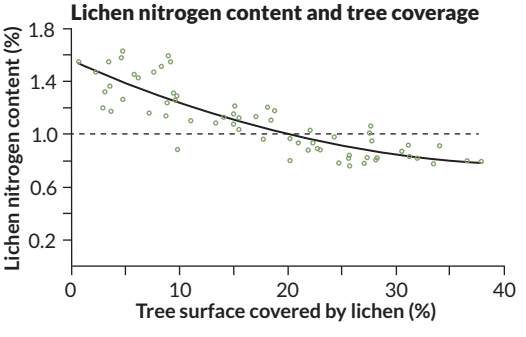
as well as alpine plants, trees, grasses and other parts of the ecosystem, says ecologist Tamara Blett of the National Park Service, which also monitors air quality. Many field studies show that lichens "start to disappear at a lower amount of air pollution than other species," Blett says. Other organisms "aren't affected until the pollution is higher."

That means lichens set the high bar for pollution standards. Protect them, and everything else is safe. Once pollution thresholds are established, U.S. scientists can use lichens to identify hot spots that exceed recommended limits. It works like this: Scientists like Geiser hike into forest field sites to collect lichen tissues and survey the number and abundance of lichen species. In the lab, the tissues are analyzed for concentrations of nitrogen, sulfur and other potential pollutants. From the results, ecologists make a map that reveals "red zones," "orange zones" and "green zones," where pollution thresholds are met or exceeded across the landscape, Blett says.

Sensitive species, such as this oakmoss lichen (*Evernia prunastri*), thrive in clean air (top). The same species droops and is more vulnerable to infection in polluted air (bottom).

Fluffy, green wolf lichen (*Letharia vulpina*) collected in 2011 along a major road in California's Sierra Nevada had nitrogen levels exceeding recommended pollution limits. In Wyoming's Wind River Range, an area plagued by air pollution, nitrogen concentrations were twice as high in lichens growing near natural gas drilling operations as those growing farthest away, researchers reported in 2013; concentrations decreased exponentially with distance from drilling sites.

**Roadside damage** Wolf lichen (*L. vulpina*) near two California roads had high levels of nitrogen and covered less tree trunk area.




## Machines and nature

The lichens are "like teeny living instruments," Blett says. Studying them is an order of magnitude cheaper than installing human-made air-quality monitors. Each lichen plot costs $150 to $500, says Forest Service lichenologist Sarah Jovan, who leads the lichen program with Geiser.

Measuring pollutants directly, using a human-made air-quality monitor, would cost $3,000 to $20,000 a year, Jovan says, depending on the instrument and pollutants measured. "It's an incredible savings," she says.

Plus, Geiser adds, lichens can provide evidence of ecological harm, while chemical and physical methods tell only what's in the air or precipitation. "They don't tell you if that level is harmful to living things."

While lichens have a huge cost advantage, they also have limitations as indicators. In general, Jovan says, the content of lichen tissues today points to pollution over the last six to 12 months. They don't offer the same time frame precision as pricier instruments.

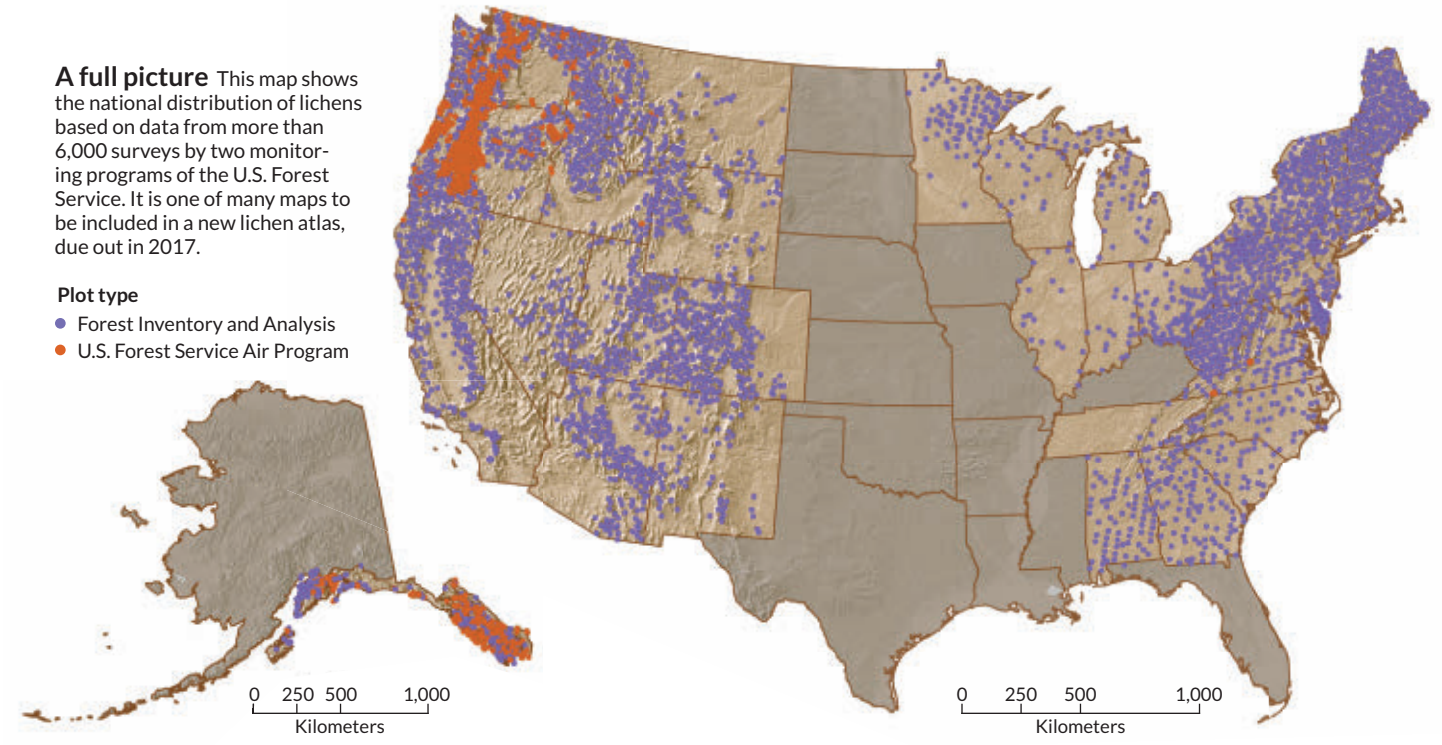
Agencies navigate these pros and cons by using lichens in combination with other monitors. In places where the source of pollution isn't clear, it doesn't make sense to install expensive instruments across the landscape.

Instead, lichen studies are a first step to identify pollution hot spots, Blett and Jovan explain. Then more expensive monitors are installed at heavily polluted sites. "Using the two approaches together creates incredible efficiency," Jovan says, "and cost savings."

When the EPA and the Forest Service set out to track regional environmental health in the early 1990s, they called on lichenologist Bruce McCune, of Oregon State University in Corvallis. The agencies asked McCune to design pilot studies using lichens to assess air pollution. That early work grew into the same lichen census that brought Geiser to Bull Run.

The Forest Service has almost 25 years of lichen data from more than 6,000 sites nationwide. "It's unprecedented to have this scale of information," says Jovan, who created the atlas over

FROM TOP: RICHARD DROKER; S. JOVAN; R. BERMEJO-ORDUNA *ET AL/SCIENCE OF THE TOTAL ENVIRON*, 2014




**A full picture** This map shows the national distribution of lichens based on data from more than 6,000 surveys by two monitoring programs of the U.S. Forest Service. It is one of many maps to be included in a new lichen atlas, due out in 2017.

JOEL THOMPSON

the last decade. "This is the first time all of the data we've ever had has come together." Federal agencies including the Forest Service, the Park Service, U.S. Geological Survey and the Bureau of Land Management are all interested in lichens as environmental sentinels, she says. "Now all of a sudden, everyone and their mom wants to use lichens."

When these data are released publicly in 2017, she says, they will set a baseline for lichen distributions nationwide. In 10 years, or in 50, scientists will be able to track large-scale changes over time.

## Climate ups and downs

Climate change caused by greenhouse gas emissions presents its own kind of air-quality problem. And lichens may help keep an eye out for climate changes, too.

Small differences in temperature and moisture mean big changes in the number and diversity of lichens in the landscape. Lichen diversity in Sweden and Alaska dropped with rising temperature, and lichens were more sensitive to change than vascular plants, according to a study published in 2012.

Earlier work in western Europe found that drought-tolerant lichens become more common in response to warming, while acid-loving species decline. In the Netherlands, *Hyperphyscia adglutinata* increased in abundance substantially from 1995 to 2001. During the same period, *Lecanora conizaeoides* declined by more than 60 percent.

By tracking which species increase or decrease with changing temperature and rainfall, ecologists are learning to read the climate story lichens are telling. The idea, Geiser says, is to use lichens to understand the on-the-ground realities of climate change.

The value of the lichens data trove will only increase with time, McCune says. Today, decades of lichen data offer a national snapshot that "contains priceless information on air quality and a basis for comparison in the future," he says. "Can you imagine 50 years from now," when "we've got thousands of plots in the U.S. with data from way back in 2000 or something like that? It's going to be fantastic to see the difference between 2050 and 2000."

In the meantime, the lichens of the Northwest that Geiser walks among will keep growing and changing in step with the changing planet. They'll breathe in the mountain air and soak up water as it drips down the trees. These and other lichens will stand as a beacon of what's to come. ■

## Explore more

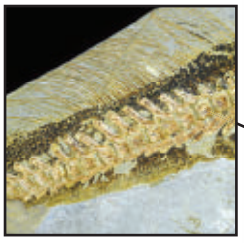
- U.S. Forest Service's National Lichens and Air Quality Database and Clearinghouse: bit.ly/USFSlichens

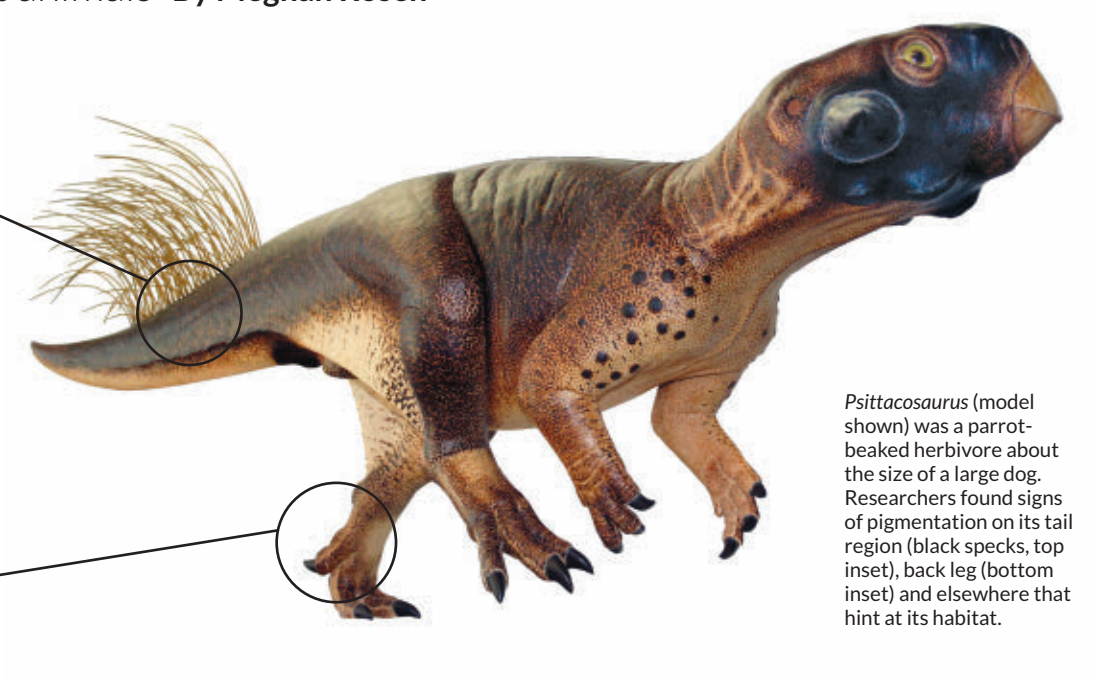
*Amy McDermott is a former* Science News *intern.*
*Her field reporting for this story was supported by a grant from the Council for the Advancement of Science Writing.*

# Color Me Dino

## Fossilized pigment pouches may reveal details about ancient animals

**By Meghan Rosen**





*Psittacosaurus* (model shown) was a parrot-beaked herbivore about the size of a large dog. Researchers found signs of pigmentation on its tail region (black specks, top inset), back leg (bottom inset) and elsewhere that hint at its habitat.

J. VINTHER *ET AL*/*CURRENT BIOL.* 2016

The stories of dinosaurs' lives may be written in fossilized pigments, but scientists are still wrangling over how to read them.

In September, paleontologists deduced a dinosaur's habitat from remnants of melanosomes, pigment structures in the skin. *Psittacosaurus*, a speckled dinosaur about the size of a golden retriever, had a camouflaging pattern that may have helped it hide in forests, Jakob Vinther and colleagues say.

The dinosaur "was very much on the bottom of the food chain," says Vinther, of the University of Bristol in England. "It needed to be inconspicuous."

Identifying ancient pigments can open up a wide new world of dinosaur biology and answer all sorts of lifestyle questions, says zoologist Hannah Rowland of the University of Cambridge. "You might be able to take a fossil ... and infer a dinosaur's life history just from its pigment patterns," she says. "That's the most exciting thing."

Not so fast, says paleontologist Mary Schweitzer of North Carolina State University in Raleigh. Evidence for ancient pigments can be ambiguous. In some cases, microscopic structures that appear to be melanosomes may actually be microbes, she says. "Both hypotheses remain viable until one is shot down with data." Until then, she says, inferring dinosaur lifestyles from alleged ancient pigments is impossible.

Vinther's work, published in the Sept. 26 *Current Biology*, is the latest in a long-simmering debate in the field of paleo color, the study of fossil pigments and what they can reveal about ancient animals. Disputes over his team's findings and what's needed to clearly identify fossilized melanosomes point to current pitfalls of the field.

But the promise is clear: Paleo color could paint a vivid picture of a dinosaur's life, offering clues about behavior, habitat and evolution.

"This is a crucial new piece in the puzzle of how the past looked," Vinther says.

### A field emerges

Scientists have been puzzling over animals of the past for centuries, but eight years ago, paleontology got a wake-up call. That's when Vinther and colleagues proposed that microscopic structures in a roughly 125-million-year-old fossil feather were actually a type of melanosome (*SN: 8/2/08, p. 10*). These pigment pouches rest inside pigment cells and, in this particular fossil feather, might have delivered a blackish hue, like a blackbird's.

Scientists had noticed similar structures inside fossilized

skin and feathers since the early 1980s. But people assumed that these structures were remnants of bacteria — perhaps decomposers that feasted on the dead animals, says paleontologist Martin Sander of the University of Bonn in Germany.

The new, colorful interpretation sparked a flurry of research, and scientists have since spotted what appear to be melanosomes in all kinds of fossilized animals. Paleontology, in fact, is now awash in colors and patterns. Pigment pods may have painted reddish-brown speckles on the face of a Late Jurassic theropod, brushed chestnut stripes on a long-tailed dino from China and made the plumage of a four-winged dinosaur called *Microraptor* iridescent. That shimmery dinosaur "probably had a weak, glossy iridescence all over its body," says evolutionary biologist Matthew Shawkey of Ghent University in Belgium. His team deduced *Microraptor*'s color from the shape of its melanosomes.

In a slab of volcanic rock lies the complete skeleton of *Psittacosaurus*, with black-speckled skin.

Modern melanosomes generally carry a mixture of two melanin pigments: dark brown-black eumelanin and red-yellow pheomelanin. Scientists have linked color in mammals and birds to melanosome shape — a meatball shape for reddish brown hues, for example, and a sausage shape for darker colors.

In iridescent feathers, melanosomes tend to be even thinner, Shawkey says. *Microraptor*'s melanosomes looked like skinny sausages — similar to those seen in the feathers of modern crows and ravens, says Shawkey, who reported the findings with Vinther and colleagues in *Science* in 2012 (*SN Online: 3/9/12*).

Three years later, Vinther laid out the case for inferring color — and ancient histories — from fossilized pigments in a review in *Bioessays*. Not only can the distinctive shapes of melanosomes offer clues, he noted, but chemical tests can help detect the presence of melanin itself. Finding this pigment in fossils, he argued, puts the old bacteria hypothesis to rest.

Schweitzer and colleagues disagreed with Vinther's take in a review published in *Bioessays* later in 2015. Researchers need to be cautious when deducing the hues of extinct animals, the scientists wrote. Any melanosome look-alikes in fossilized feathers or skin could actually be microbes.

After all, microbes are everywhere. "These animals died in an environment that was not sterile and free from microbes," Schweitzer says. "Think about it. If you take a piece of chicken and throw it out in your backyard, how long does it take for microbes to overgrow that chicken?"

The tiny organisms are hardy, too. Both microbes and the sticky biofilms they form are preserved in the fossil record. And, Schweitzer says, microbes and melanosomes overlap completely in shape and size, which makes the two tough to tell apart. What's more, some microbes actually make melanin themselves; detecting the pigment in a fossil is not a rock-solid sign that the ancient animal was black, brown or freckled.

It's not that Schweitzer or *Bioessays* coauthor Johan Lindgren, a geologist at Lund University in Sweden, doubt that melanosomes can leave traces in the fossil record. The issue, Lindgren says, is that not all round structures you find are melanosomes.

Chemical tests could help distinguish the two. Bacteria, for example, leave behind traces that can be identified with pyrolysis gas chromatography-mass spectrometry. But that requires samples to be vaporized. "It can mean destroying much of what you are trying to study," says geochemist Roy Wogelius of the University of Manchester in England. "So it's not always possible."

Vinther's new work isn't likely to settle the debate. In fact, people were arguing both sides in October at a meeting of the Society of Vertebrate Paleontology in Salt Lake City.

Arindam Roy, a Bristol colleague of Vinther's, reported size differences between fossilized melanosomes and bacteria growing on decaying chicken feathers in the lab. Alison Moyer, an N.C. State colleague of Schweitzer's, said that looks weren't enough. Finding keratin, a protein that typically surrounds melanosomes, could serve as evidence for pigments in fossils.

## From color to camouflage

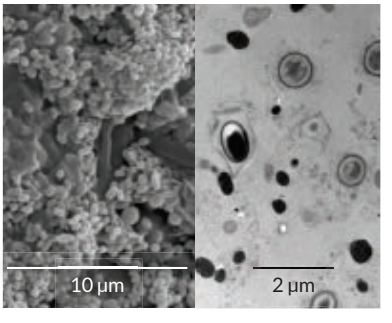
The fossil described in Vinther's new paper is "spectacular," Schweitzer says. "It's got skin all over the place. I can't think of too many dinosaur specimens that are preserved like this."

The dinosaur lies on its back, flattened in a slab of volcanic rock. Skin covers a completely intact skeleton, and dozens of long bristles poke from the tail. *Psittacosaurus*, an herbivore that lived some 120 million years ago, walked on two legs and would have reached about half a meter in height.

"It would have been a supercute animal," Vinther says. "It's got this wide face and looks a little bit like E.T."

Black material speckles the dinosaur's body, tail and face. Vinther believes the material is the ancient remains of pigment. His team examined samples chipped from the fossil and saw what he considers the telltale orbs of melanosomes — mostly impressions in the rock but also some microbodies, the 3-D structures themselves.

Based on the dinosaur's pigment patterns, it would have had a dark back that faded to a lighter belly. That type of coloring,




Degraded snake skin contains a mix of microstructures; bacteria and melanosomes are hard to tell apart in a scanning electron microscope image (left). But in the same tissue, observed under a transmission electron microscope (right), melanosomes appear as black spots while bacteria look translucent.

FROM TOP: J. VINTHER/UNIV. OF BRISTOL, BOB NICHOLLS/PALEOCREATIONS.COM; J. LINDGREN/LUND UNIV.

called countershading, shows up in animals from penguins to fish and may act as a form of camouflage. It lightens parts of the body typically in shadow, and darkens parts typically exposed to light. "If you want to hide, it makes sense to try and obliterate those shadows," Rowland says.

To figure out where *Psittacosaurus* may have lived, Vinther's team crafted two life-size models of the dinosaur. One was painted with the color patterns inferred from the fossil. The other was made a uniform gray. The researchers then photographed the gray model in diffuse light (typical of a forest) and direct light (like that of a prairie or savanna), and predicted the best way to camouflage the model under both scenarios.

Their prediction for diffuse light matched the model painted like *Psittacosaurus*. "It's like what we see in forest-living animals," Vinther says. "This thing was camouflaged."

## Lingering doubts

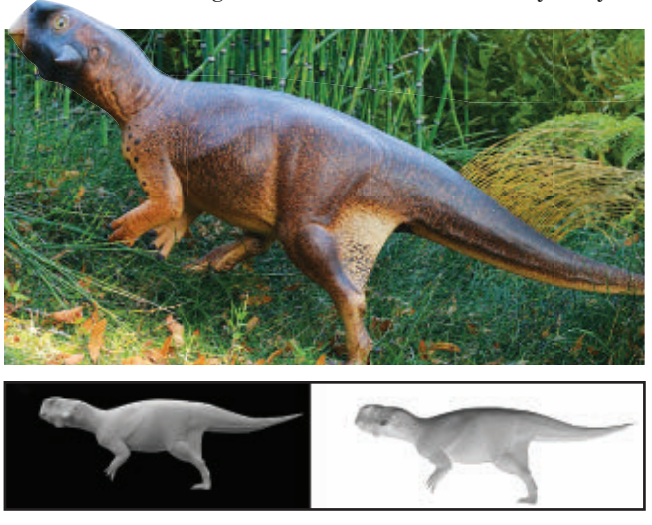
Going from fossil to forest may be more of a leap than a step, other scientists suggest.

*Psittacosaurus*' skin very well may contain ancient pigments, Wogelius says. "I don't think it's a crazy idea." But, he adds, of Vinther's group: "I don't think they've proved what they claim."

Vinther's team, for example, used just four tiny fossil samples to extrapolate the coloring of the whole dinosaur. "I think it's a bit of an overreach," Wogelius says.

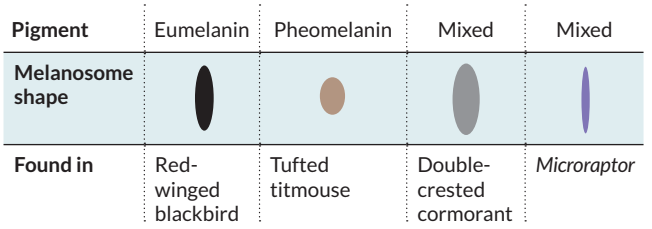
Schweitzer also notes that the specimen was varnished, presumably to protect the bones and soft tissues. It happened before Vinther and colleagues got their hands on the dinosaur and makes it impossible to perform the chemical tests that would bolster the claim for pigments. "Varnish is horribly destructive to fossils," she says. "It totally ruins the specimen for other types of analysis."

Vinther argues that his team has chemically analyzed other fossils and found evidence of melanin — not bacteria. The microbodies in those fossils look just like the ones in *Psittacosaurus*, he says.



Researchers photographed a gray-colored cast under different lighting (diffuse light shown, bottom left.) Then, they inverted the image (bottom right) to create the optimal camouflage pattern. This pattern matched the one inferred from the fossil (*Psittacosaurus* model, top), suggesting the dinosaur lived in a place with indirect light, like a forest.

**Shape of color** Melanosomes of different shapes carrying different pigments have been found in fossilized and living animals. All melanosomes may carry a mix of pigments, and iridescent melanosomes (shown as purple) line up in orderly structures. SOURCE: Q. LI *ET AL/SCIENCE* 2012




Vinther's team also saw evidence of just one kind of microbody, and it had a distinct round shape. If the structures were actually bacteria, he says, you'd expect to see a whole range of shapes and sizes. "Some of them would be shaped like corkscrews, some would have flagella, some would be humongous, some would be tiny."

That's the tricky part with bacteria, counters Lindgren. "In some cases you can have a huge consortium, but in other cases you can have one single type."

Vinther's interpretation has its supporters. "I was skeptical at first," Sander says, "but now there's been such an array of these little bodies that it's pretty clear that at least some of them are not bacteria." Despite some continuing controversy, Sander says many paleontologists now accept that microstructures in fossils may be melanosomes.

Additional research, though, "would help the entire community," he says, "so that there are no longer any lingering doubts."

Along with chemical tests, Schweitzer suggests, researchers could try transmission electron microscopy, a technique that blasts an electron beam through a thinly sliced sample. With TEM, melanosomes appear as black blobs. Bacteria tend to look different — in some cases, more like fried eggs.

Shawkey, for one, is looking to chemistry. In a paper published online November 14 in *Palaeontology*, his team used a technique called Raman spectroscopy to help build a case for feather color in a bird that died some 120 million years ago. In the feathers, the researchers spotted the skinny sausages of iridescent melanosomes and chemical signs of the pigment eumelanin. Shawkey thinks the chemical evidence could help "head off any criticism that we might encounter."

Working through the field's snags, paleontologists might come together to fill in the hues and tints, and potentially the habits and habitats, of ancient animals that until recently had been known primarily by their bones. ■

## Explore more

■ Jakob Vinther *et al.* "3D camouflage in an ornithischian dinosaur." *Current Biology.* September 26, 2016.

J. VINTHER *ET AL/CURRENT BIOL.* 2016

Clockwise from top left: Members of the red team discovered background radiation in a *Stranger Things*–themed challenge; Kaien Yang explained his project in a media interview during the Science and Engineering Project Showcase; Nikolai Ortiz and Eleanor Sigrest wrote a computer code to turn on a light in one of their challenges; Ananya Ganesh and Brendan Crotty waded into the Chesapeake Bay to catch wildlife in large nets.

ALL: L. DOANE

# Designing nutritional games and brains for space

Thirty Broadcom MASTERS finalists from around the United States convened in Washington, D.C., in October. The middle school students participated in team challenges and presented their research to judges and the public during the Broadcom MASTERS Science and Engineering Project Showcase.

Ananya Ganesh, from Georgia, was excited to meet other finalists and check out the competition. "Their projects are just impressive," she said, wearing several electrodes on her face.

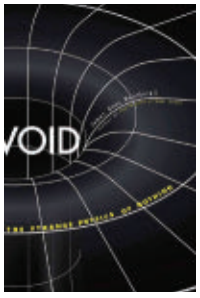
Ganesh has bruxism, a condition which causes her to clench her jaw. She built a device that detects signals coming from a muscle when it contracts and provides biofeedback to the wearer. "As soon as you clench, a light comes on and it alerts someone to stop clenching to help lessen the pain," she said. Ganesh won the 2016 Science Award at the competition.

Kaien Yang, from Virginia, was also inspired to work on a project very personal to him. He studied depression because his grandfather developed mood swings as a result of a shrinkage in his cerebellum. Yang developed an app that can help doctors detect depression based on shrinkage or expansion in certain areas of the brain.

"I'm excited to compete with the other finalists and build lasting friendships that I'll have for the rest of my life," Yang said. "It's fulfilling to engage with all of these like-minded peers." Yang won the 2016 Marconi/Samueli Award for Innovation.

During their week in D.C., finalists also competed in several team challenges. Some teams built a cloud chamber to visualize background radiation, developed an educational game that encourages a healthy diet and designed a hypothetical brain to endure long-distance space exploration.

**View more stories from the competition at student.societyforscience.org/blog/doing-science**




**Void**
*James Owen Weatherall*
YALE UNIV., $26

BOOKSHELF

## Philosopher dives into physics of nothingness

In empty space, quantum particles flit in and out of existence, electromagnetic fields permeate the vacuum, and space itself trembles with gravitational waves. What may seem like nothingness paradoxically teems with activity.

In *Void: The Strange Physics of Nothing*, physicist and philosopher James Owen Weatherall explores how physicists' beliefs about nothingness have changed over several revolutionary periods. The void, Weatherall argues, is physics distilled to its bare essence. If physicists can't agree on the properties of empty space, they won't be able to explain the physics of planets or particles either.

Scientists have argued over nothingness since the early days of physics. Vacant space was unthinkable to Aristotle, and Descartes so abhorred the idea of a vacuum that he posited that an invisible "plenum" suffused the gaps between objects. But Isaac Newton upended this view, arguing that space was just a barren container into which matter is placed.

Since then, physicists have continued to flip-flop on this issue. The discovery in the mid-1800s that light is an electromagnetic wave led scientists to conclude that a vibrating medium, an "ether," filled space. Just as sound waves vibrate the air, physicists thought there must be some medium for light waves to ripple. Albert Einstein tore down that idea with his special theory of relativity. Since the speed of light was the same for all observers, no matter their relative speeds, he reasoned, light could not be traveling through some absolute, stationary medium. But he later predicted, as part of his general theory of relativity, that space itself can ripple with gravitational waves (*SN: 3/5/16, p. 6*) — suggesting that the void is not quite empty.

Under the modern view of quantum physics, various fields pervade all of space, and particles are simply excitations, or waves, in these fields. Even in a vacuum, experiments show, fluctuating fields produce a background of transient particles and antiparticles. Does a space pulsating with gravitational waves and bubbling with particles really qualify as empty? It depends on the scientific definition of "nothing," Weatherall argues, which may not conform to intuition.

Weatherall serves readers a fairly typical buffet of physics theories, dishing up Newtonian mechanics, relativity, quantum mechanics and a small helping of string theory. But he does this through a lens that highlights connections between those theories in a novel way. Weatherall contends, for instance, that differing notions of nothingness between theories of general relativity and quantum mechanics could help explain why scientists are still struggling to unite the two ideas into one theory of quantum gravity.

Exploring the physics of nothing demands quite a bit of wading through the physics of something, and it's not always clear how the threads Weatherall is following will lead back to the void. When he finally makes these connections, though, they often reveal insights that are missed in the typical focus on things of substance. — *Emily Conover*

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SCREENTIME

## New citizen science project turns Alzheimer's research into a game

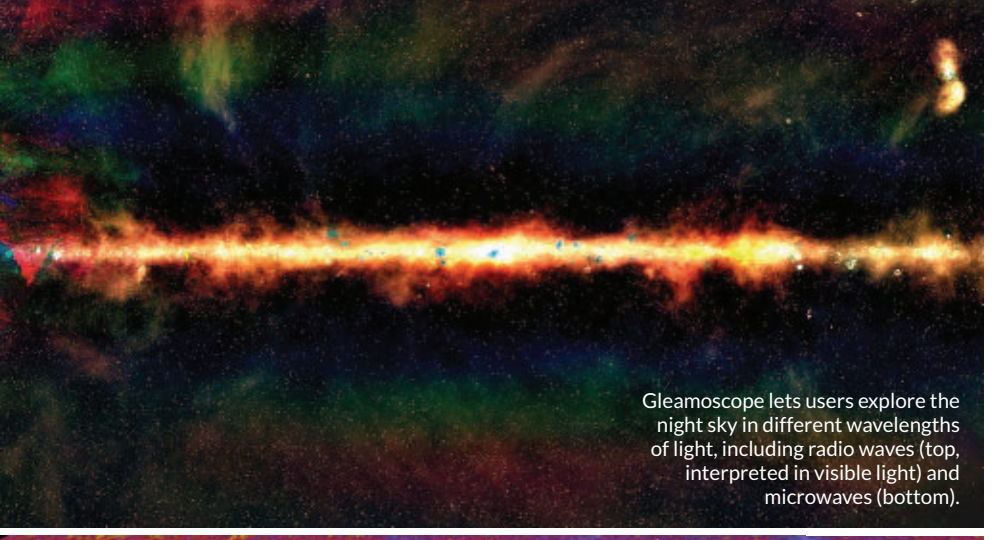
Traffic jams in the brain's blood supply may play a role in Alzheimer's disease. A new online game turns people at home into amateur traffic cops. This policing, which involves spotting hard-to-see sluggishness in tiny capillaries in mice, may ultimately help scientists better understand, and perhaps even treat, Alzheimer's, a devastating disorder that affects over 5 million Americans.

The science behind the game, called Stall Catchers, comes from Cornell University. Chris Schaffer, Nozomi Nishimura and colleagues found that mice designed to exhibit symptoms similar to Alzheimer's have more blocked blood vessels in their brains than regular mice. That difference can deprive the brain of sustenance and may be a key to understanding how Alzheimer's damages the brain, the researchers suspect.

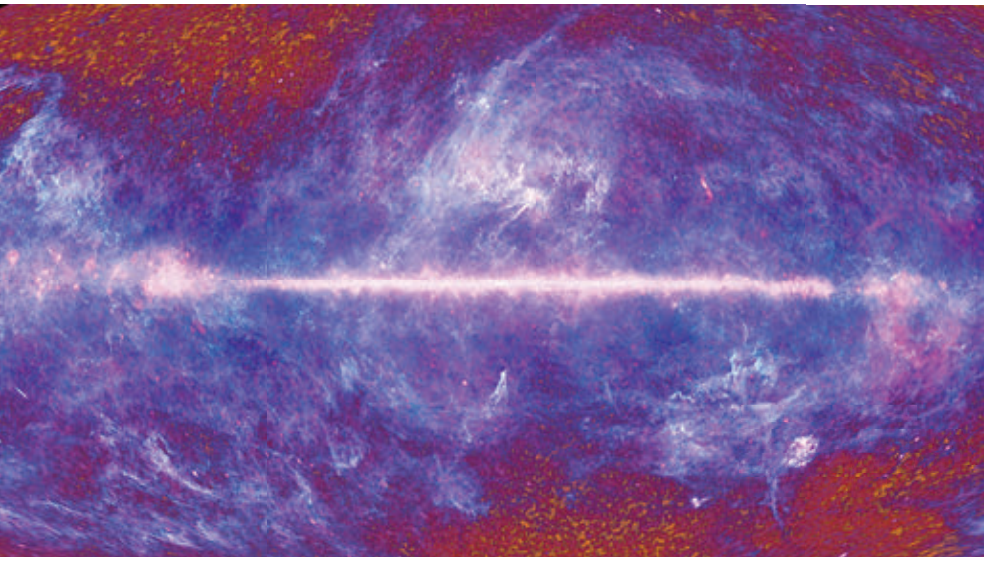
But finding congested capillaries is a slog. Computers haven't been up to snuff, and experts could spend an entire year analyzing the thousands of microscope images needed to amass enough data to explore links between Alzheimer's and blocked vessels. "I thought, if we could change that, it would be tremendous," says Pietro Michelucci, director of the Human Computation Institute in Fairfax, Va. The institute is a nonprofit organization that runs the EyesOnALZ program, which aims to crowdsource Alzheimer's research.

That's where StallCatchers.com comes in. The website asks players to sift through short black-and-white videos of real mouse brains, on the prowl for blocked blood vessels. In the videos, moving blood appears white. But stationary black segments that appear between two white segments signal trouble — a stall. Players rack up points and ascend levels as they classify vessels. With practice, the task gets easier. And people who suffer from performance anxiety shouldn't fret; each video will be scrutinized by multiple users to get the final verdict. With a little help from the crowd, "not only do [researchers] get answers faster, but they can ask more questions," Michelucci says.

So far, nearly 1,000 users have played Stall Catchers, Michelucci says. Those players are beginning to generate data that will let researchers see how good these amateur traffic cops are. With luck, their eyes will help unstall the fight against Alzheimer's. — *Laura Sanders*



Gleamoscope lets users explore the night sky in different wavelengths of light, including radio waves (top, interpreted in visible light) and microwaves (bottom).



FROM TOP: N. HURLEY-WALKER/ICRAR/CURTIN UNIV., THE GLEAM TEAM; LFI AND HFI CONSORTIA/ESA

SCREENTIME

## Interactive map reveals universe's hidden details

There's much more to the universe than meets the eye, and a new web-based app lets you explore just how much our eyes are missing. Gleamoscope (at gleamoscope.icrar.org) presents the night sky across a range of electromagnetic frequencies. Spots of gamma rays pinpoint distant feeding black holes. Tendrils of dust glow with infrared light throughout the Milky Way. A supernova remnant — the site of a star that exploded roughly 11,000 years ago — blasts out X-rays and radio waves.

Many of these phenomena are nearly imperceptible in visible light. So astronomers use equipment, such as specialized cameras and antennas, that can detect other frequencies of electromagnetic radiation. Computers turn the data into images, often assigning colors to certain frequencies to highlight specific details or physical processes.

In Gleamoscope, a slider smoothly transitions the scene from one frequency of light to another, turning the familiar star-filled night sky into a variety of psychedelic landscapes. Pan and magnification controls allow you to scan all around the night sky and zoom in for a closer look. The interactive map combines images from many observatories and includes new data from the Murchison Widefield Array, a network of radio antennas in Australia. Over 300,000 galaxies appear as dots in images of the new radio data, described in an upcoming issue of *Monthly Notices of the Royal Astronomical Society*. The radio map by itself can also be explored on mobile devices in a separate app called GLEAM, available on Google Play.

*— Christopher Crockett*

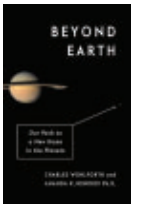
BOOKSHELF


**Birds of Stone**
*Luis M. Chiappe and Meng Qingjin*
This coffee-table book showcases the exquisitely preserved bird fossils that have revamped the understanding of avian history. *Johns Hopkins Univ., $85*

**Other Minds**
*Peter Godfrey-Smith*
A philosopher ponders what can be learned about the evolution of consciousness through studies of the octopus "mind." *Farrar, Straus and Giroux, $27*

**The Wood for the Trees**
*Richard Fortey*
Over the course of a year, a retired paleontologist documents the natural wonders he discovers in a few acres of British woodland. *Alfred A. Knopf, $28.95*


**A History of Medicine in 50 Objects**
*Gill Paul*
From trepanation to the first stethoscope and surgical robots, this book chronicles 12,000 years of medicine. *Firefly Books, $29.95*



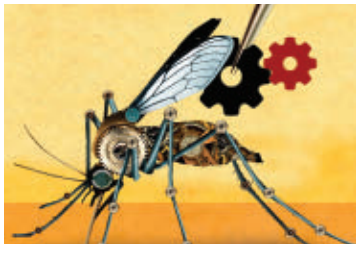

**Beyond Earth**
*Charles Wohlforth and Amanda R. Hendrix*
This book makes the case that Saturn's moon Titan is the perfect site for a future space colony. *Pantheon Books, $27.95*

**Buy Books** Reviews on the *Science News* website include Amazon.com links that generate funds for Society for Science & the Public programs.


OCTOBER 1, 2016

## The prize goes to...

*Science News'* coverage of gravitational waves (*SN: 3/5/16*) recently won an award from Folio, a publishing industry magazine, for best series of articles in the science category. **Tina Hesman Saey**'s feature on gene drives (*SN: 12/12/15, p. 16*) — a hotly debated technology that could wipe out invasive or disease-carrying pests — won for best single article. Read the stories again at bit.ly/SN_cosmicvibrations and bit.ly/SN_genedrives



### Join the conversation

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### Connect with us

### Science's human side

*In "The SN 10: Scientists to Watch" (SN: 10/1/16, p. 16), Science News recognized 10 up-and-coming scientists across a range of scientific fields who will be answering big questions in the decades to come.*

**Barry Maletzky** thought that highlighting 10 young scientists may have been unfair and detrimental to other researchers. "By drawing attention to just 10, I wonder if you are thereby discouraging others who may not make the headlines but whose basic research may lead the way toward important discoveries in the future," **Maletzky** said. He also pointed out that scientific progress is made "through the tedious and often under-publicized work of a number of investigators working barely noticed through the years."

It's true that in science journalism, as with all journalism, what you choose to cover can matter as much as how you choose to cover it, says **Elizabeth Quill**, *Science News*' enterprise editor, who led the SN 10 project. *Science News* editors and writers take this responsibility seriously, which is why *Science News* avoided terms like "top," "best" and other superlatives. Whenever possible, the names of mentors and collaborators were also included in the stories. "We recognize the dangers in calling out specific individuals, but we believe the rewards outweigh the risks," **Quill** says. "The majority of *Science News* focuses on the data and the process. But here we see a different side. We are showing science as a human endeavor. We hope this list inspires all young scientists to follow their passion and their curiosity. But we also hope to do what we do best — inform our readers about new and interesting science."

**Kenneth Abate** was disappointed by "The SN 10: Scientists to Watch" profiles and questioned how *Science News* chose the researchers. "The issue is probably a nice piece of advertising for the individuals to further their careers," **Abate** said. However, it "is of little value to the scientific community nor does it contribute to the knowledge bank of those scientists or would-be scientist readers."

Choosing is never easy, but thankfully *Science News* staff didn't do it alone. Every featured scientist was nominated by a Nobel laureate or recently elected member of the National Academy of Sciences on the basis of the scientist's contributions to the field and promise for future contributions. As they do with any news or feature story, *Science News* editors and writers selected the final list of scientists by looking at who was doing novel, interesting and important work. As readers point out, the list could have easily been much, much longer.

### Cool it

*The next big thing in high-tech clothing may be a plastic material similar to kitchen cling wrap that vents body heat, **Meghan Rosen** reported in "New fabric could make cool clothes" (SN: 10/1/16, p. 9).*

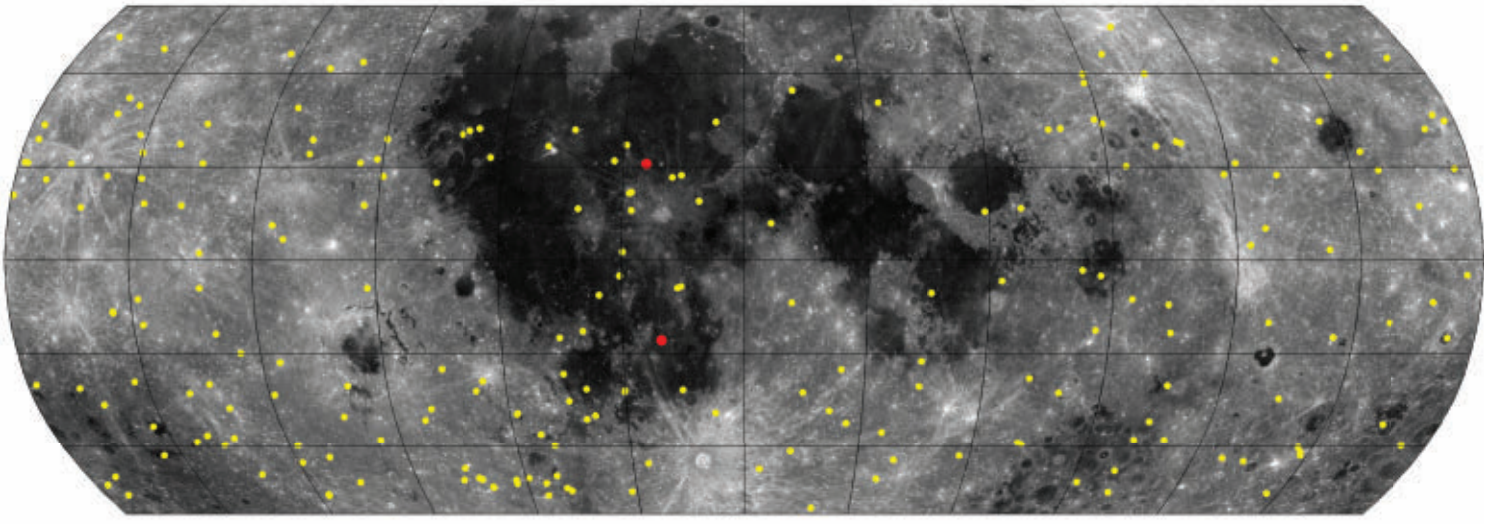
Online reader **Karl Chwe** pointed out one potential drawback to the new material: "It is just a thin plastic film with tiny holes, and the holes aren't big enough to allow water vapor to escape easily, so it doesn't allow evaporative cooling," he wrote. **Chwe** suggested that it might be better to wear fewer clothes.

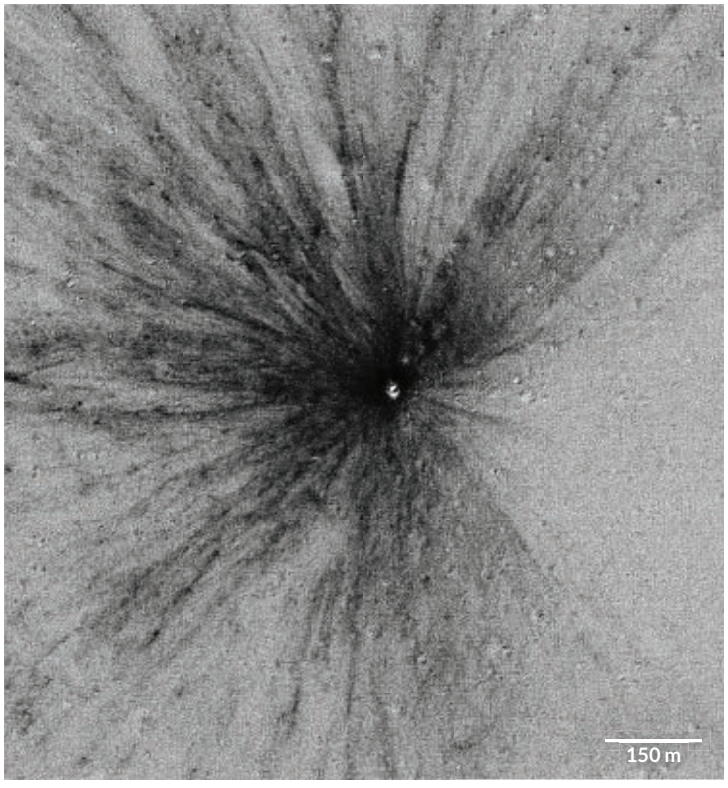
Actually, the nanopores *are* permeable to water vapor, the authors reported. "In this regard, the new fabric is comparable to cotton," **Rosen** says. "Without the nanopores, the fabric would be a literal sweat suit; it's completely nonpermeable." But even with pores, the fabric doesn't quite feel like normal clothes just yet. Weaving the fibers into a textile could help. Still, when it comes to evaporative cooling, **Rosen** says, wearing fewer clothes might be the simplest solution of all.

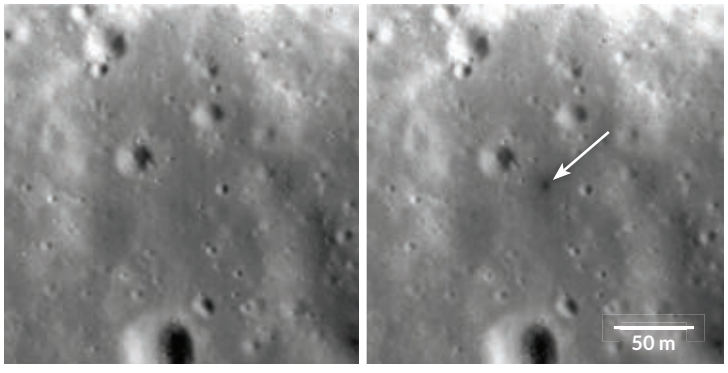
### Correction

"A gut check gets personal" (*SN: 10/1/16, p. 19*) profiles Lawrence David, a computational biologist who studies the human gut microbiome at Duke University. David's wife is a psychiatrist, not a psychologist as was incorrectly stated in the article.

MICHAEL MORGENSTERN






## Surprising number of craters, splotches mark the moon

The moon is one tough satellite. With no atmosphere, it endures a barrage of incoming asteroids and comets that pit its surface with a constellation of craters. A new map (above) reveals 222 recent impact craters (in yellow), 33 percent more than simulations predicted. Scientists spotted the features by analyzing about 14,000 pairs of before-and-after images captured by the Lunar Reconnaissance Orbiter from 2009 to 2015. (Red dots note new craters whose impacts were observed from Earth.)

The craters — up to 43 meters in diameter — were probably formed by small meteoroids crashing into the crust. Using the image pairs, the researchers created ratio images, which highlight how the impacts alter the reflectance of the moon's surface. That perspective illuminated the starburst debris patterns around the craters (left).

The scientists also found about 47,000 "splotches," faint marks several to tens of meters across (bottom left, before and after). Most result from secondary debris being jettisoned by impacts and spattering the surface, the researchers propose in the Oct. 13 *Nature*.

Those splotches would "churn" the upper two centimeters of lunar soil in about 81,000 years, more than 100 times faster than previous predictions that didn't include the smudges, researchers say. That revelation could improve interpretations of remote-sensing data and help engineers design equipment to better withstand the occasional speckling of soil, says study coauthor Mark Robinson, a planetary geologist at Arizona State University in Tempe. "All of the images we're taking ... and the discoveries we're making are feeding forward into future human exploration of the moon," he says. — *Emily DeMarco*

GSFC/NASA, ARIZONA STATE UNIV.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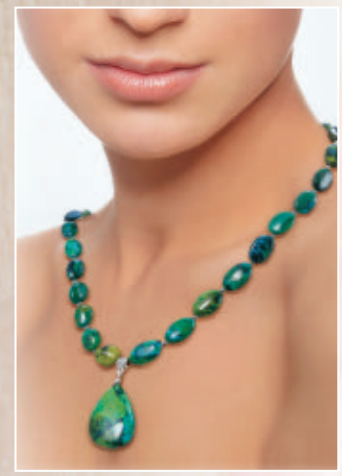

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