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Postcards From the Red Planet

Longevity Genes

When Mom's for Dinner

Brontosaurus Is Back

BETTER Weather Warnings

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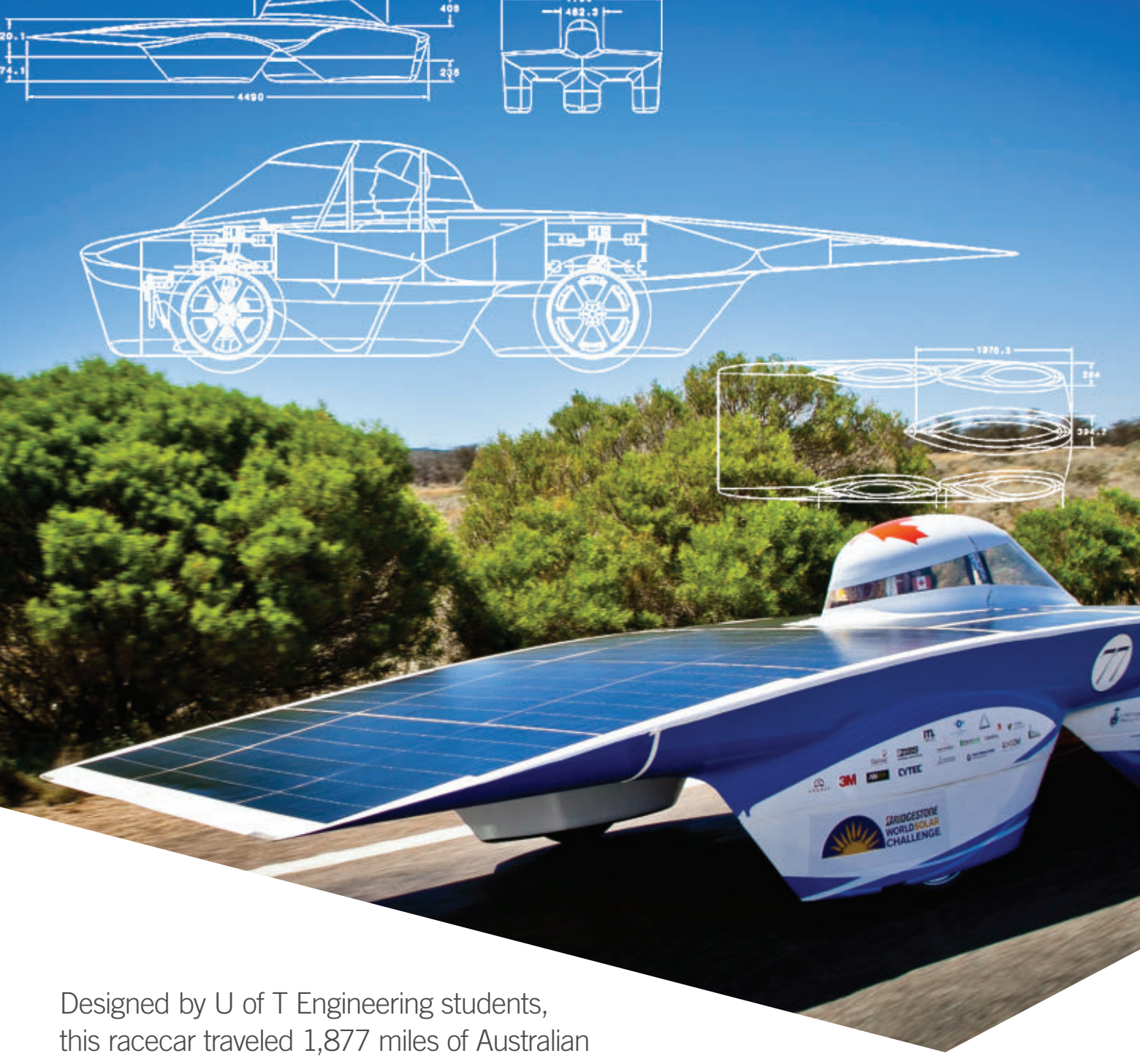

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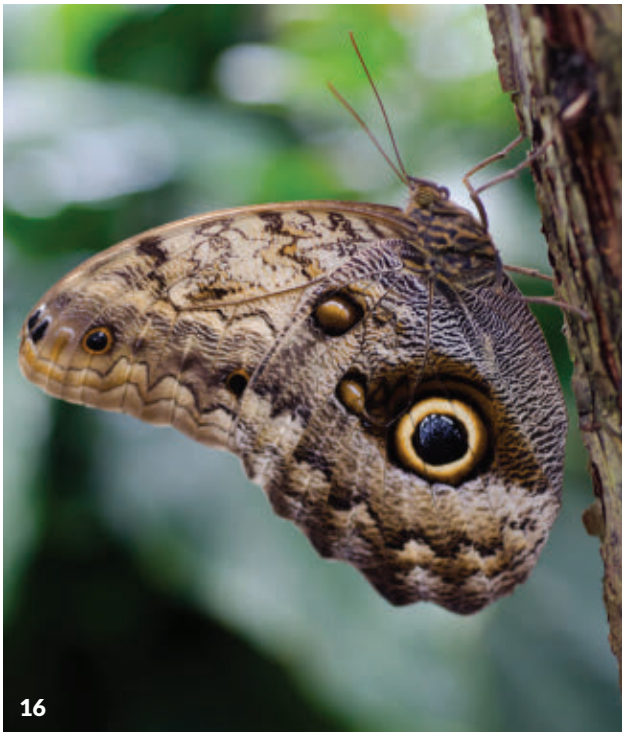
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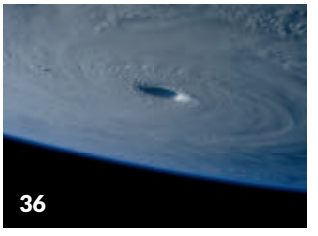
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COVER A storm looms over New York City in 2012. Better warnings for the Big Apple and elsewhere are in the forecast. *Lisa Bettany*

CLOCKWISE FROM TOP LEFT: JPL-CALTECH/NASA, MSSS; S. CRISTOFORETTI/ESA, NASA; LOKI PHOTOGRAPHY/ALAMY

Driving Curiosity to discovery

Clara Ma, who in 2009 won an essay contest to name NASA's new Mars rover, named it Curiosity. "Curiosity," the young student wrote, "is an everlasting flame that burns in everyone's mind. It makes me get out of bed in the morning and wonder what surprises life will throw at me.... When I was younger, I wondered, 'Why is the sky blue?', 'Why do the stars twinkle?', 'Why am I me?', and I still do."

Prone to bouts of wonder myself, I like Ma's choice. Curiosity is the most advanced robot to roll on the Red Planet, and the fourth NASA rover on Mars. One other NASA rover, Opportunity, is still wheeling around up there. With 17 cameras and an onboard lab, Curiosity has explored a nearly 10-kilometer stretch of Martian landscape. As contributing correspondent Alexandra Witze describes on Page 24, the rover has spent the last 33 months evaluating Mars' ability to have supported life in the ancient past. Curiosity has discovered unexplained methane gas, the presence of organic molecules in the soil and (more) evidence that lakes and rivers once covered the planet's now barren surface.

Curiosity's findings have been covered in these pages and elsewhere, but Witze pulls them all together in a travel diary to highlight the rover's key moments. (Visit our website at bit.ly/SN_MartianDiaries for an interactive version of the journey). As Witze says, "Curiosity has done about as much in under three years as the Opportunity rover has in 10 years. It's kind of like the Cadillac to Opportunity's Ford Fiesta."

Examples of discovery driven by curiosity, lowercase, also fill this issue. A new report documents how a mother spider gives of herself completely to feed her brood (Page 4). Another explains the origin of the bend in the chain of volcanic seamounts punctuated by the Hawaiian Islands (Page 15). And genes involved in fighting inflammation, called *SIGLEC*s, have been linked to life span (Page 6), adding a new clue about why some creatures live longer than others.

Obviously, there's more to explore, on Mars and closer to home. Predicting the weather is a big one (see "The Future of Forecasting" on Page 20). As Ma concludes in her essay, "We have discovered so much about the world, but still so little." —*Eva Emerson, Editor in Chief*

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Excerpt from the May 1, 1965, issue of *Science News Letter*

50 YEARS AGO

Moon surface safe?

Both the unmanned Surveyor spacecraft and the two-man Lunar Excursion Module (LEM) will be able to land safely on the moon without breaking through the crust or sinking down out of sight in a layer of dust, some scientists now believe.... Another and very different picture of the moon [suggests] the moon has a layer of ice some 300 feet deep, bottled up beneath a surface of sediment topped by dust.

UPDATE: No lunar spacecraft cracked the moon's crust or was swallowed by its dust. Some of NASA's Surveyor crafts and manned Apollo missions landed safely in the 1960s and 1970s, though lunar soot did make visibility difficult during touchdown. Going to the moon revealed that it probably doesn't have a layer of ice 90 meters down, but it has some ice in craters and at its poles. Current unmanned probes are working to figure out how much. NASA astronauts probably will not get another crack at moonwalking; they are setting their sights on Mars (*SN: 8/23/14, p. 22*).

It's not a metaphor. Yellow spiderlings eventually suck the life out of the mother they're swarming over.

IT'S ALIVE

When mom serves herself as dinner

SAY WHAT?

Supernova sweeping *\SOO-per-NOH-vah SWEEP-eeng\ n.*

A process in which exploding stars push gas out of a galaxy.

Supernovas might be the maid service of the universe. These explosions of the cores of massive stars work hand in hand with supermassive black holes to sweep out gas and shut down galaxies' star-forming factories, new research suggests. A celestial cleaning partnership might help astronomers understand why some massive galaxies stopped forming stars billions of years ago.

The black hole at the core of a galaxy can launch fountains of charged particles, which can stir up gas throughout the galaxy and temporarily interrupt star formation. But unless something intervenes, the gas will eventually cool and start forming stars again.

One mega-outburst from the black hole, though, could heat the gas surrounding the galaxy enough to let supernovas take over and mop up the mess, researchers say March 10 at arXiv.org. — *Christopher Crockett*

Jets erupt from a supermassive black hole, such as the one in Centaurus A (shown in a composite image).

FROM TOP: JORGE ALMEIDA/FLICKR (CC BY-NC-ND 2.0); WFI/ESO (OPTICAL); A. WEISS *ET AL*/APEX/MPIFR AND ESO (SUBMILLIMETER); R. KRAFT *ET AL*/CXC/CFA AND NASA (X-RAY)

See more photos of the mom-eating spider at **bit.ly/SN_matriphagy**

In a less squeamish universe, Mother's Day cards would have a spider on them. She's extreme in her generosity and sacrifice: tireless regurgitation, liquefying guts and the personal touch in family dinners.

Female *Stegodyphus lineatus* spiders spin loosely woven webs "like a ping-pong net," says Mor Salomon of the Israel Cohen Institute for Biological Control in Yehud-Monosson, Israel. She finds the webs in shrubbery along dry river beds in the Negev Desert. Protected inside a spider-size cave spun at one end of the web, a female creates what looks like a tiny silk hockey puck filled with 70 to 80 yellowish eggs.

When spiderlings hatch, they're trapped in the puck. Mom pierces the protective silk to free them — and then she stops eating for the rest of her life. For the next two weeks or so, she feeds the dozens of young by regurgitating a transparent liquid. This slurry mixes what's left of her last meals plus some of her own guts.

Mom regurgitates her guts, and plump spiderlings gather for the treat.

The mother's midgut had already started breaking down while she guarded the eggs, Salomon and her colleagues report in the April *Journal of Arachnology*. And by the time the pale youngsters hatch, liquefied gut suitable for baby mouthparts is building up in her abdomen.

As liquid wells out on mom's face, spiderlings jostle for position, swarming over her head like a face mask of caramel-colored beads. This will be her sole brood of hatchlings, and she regurgitates 41 percent of her body mass to feed her spiderlings.

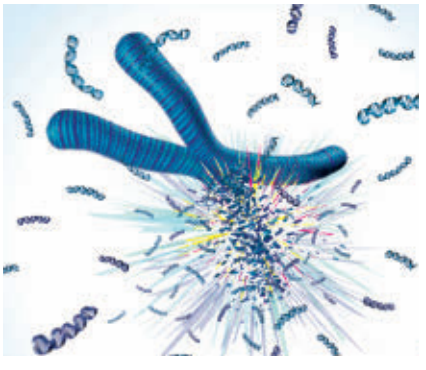
But her young take even more, possibly at her invitation. "She makes no attempt to escape," Salomon says. Spiderlings pierce her abdomen with their mouthparts and over the course of several hours drain her innards.

At the beginning of the feeding, Salomon says, "if you touch a leg, she will pull it back. She's definitely alive." By the end, of course, she's not. And she has contributed all but 4 percent of her body mass to offspring feeding. The liquefaction process that makes this possible proceeds in an orderly way, dissolving organs as they become expendable. One organ that remains till the end is mom's heart. — *Susan Milius*

HOW BIZARRE

The upside of a demolished chromosome

A shattered chromosome cured a woman of a rare genetic disease. The woman had been diagnosed as a child with WHIM syndrome, an immune disease caused by a mutation in a gene called *CXCR4*.



Like other WHIM syndrome patients, the woman had a large number of warts and was frequently hospitalized with infections. But at about age 38, her symptoms mysteriously disappeared. Researchers at the National Institutes of Health in Bethesda, Md., examined the woman's DNA and found that some of her blood cells were missing the mutant copy of *CXCR4* and 163 other genes. In one of her blood-forming stem cells, the chromosome carrying the mutant gene had shattered (illustrated above) and reassembled Humpty-Dumpty style, leaving out some genes, the researchers report in the Feb. 12 *Cell*.

Usually when chromosomes shatter, a rare process called chromothripsis (*SN: 6/29/13, p. 4*), it's a catastrophe that can lead to cancer. This is the first known case of chromothripsis helping someone, and a rare case of a spontaneous cure of an inherited disease. — *Tina Hesman Saey*

FROM TOP: M. SALOMON; © EMBL/P. RIEDINGER

SCIENCE STATS

Stinkin' rich

Sewage may be a gold mine. Researchers have found that sewage entering municipal wastewater treatment plants teems with 58 valuable elements such as gold and copper.

To dig up the soiled loot, researchers analyzed treated sewage samples from 94 sites around the country. Extracting the goods, however, would be a dirty job.

$500 million

approximate value of elements in a metric ton of treated sewage sludge

$13 million

approximate value of a year's worth of sewage from 1 million people

SOURCE: P. WESTERHOFF *ET AL/ENVIRONMENTAL* SCIENCE & TECHNOLOGY 2015

GENES & CELLS

Species longevity linked to 'Siglecs'

Life span lengthens with more inflammation-fighting genes

BY TINA HESMAN SAEY

Stocking up on genes that help control inflammation leads to longer life spans for humans and other species, a new study suggests.

Genes encoding some inflammation-dampening molecules are more numerous in longer-lived species such as humans than in short-lived animals such as mice, researchers report April 7 in *eLife*. The genes produce proteins known as CD33-related Siglecs.

These Siglecs are proteins that recognize different versions of sialic acid, sugars that stud cells in the body. By distinguishing between forms of sialic acid, the proteins help the immune system decide which cells are normal residents of the body and which are intruders. In addition, the proteins soothe inflammation in the aftermath of such assaults as injury, allergies or infection. The new findings suggest that Siglecs also help the body deal with reactive oxygen molecules, which can damage DNA and other cellular components and promote aging.

Siglec numbers probably don't explain why individual people live longer than others but may be a powerful force in a species' longevity, says Caleb Finch, a neurobiologist and evolutionary biologist at the University of Southern California in Los Angeles.

The new study, led by Ajit Varki and Pascal Gagneux of the University of California, San Diego, reinforces previous studies suggesting that immunity and inflammation are tied to aging and its associated diseases, Finch says.

Varki, Gagneux and colleagues compared the number of Siglec genes in 17 species of mammals. Longer-lived species had more of the genes. Mice, which live up to four years, have five of the genes. Humans have 10 and have a maximum life span of 120 years. Dogs fall in the middle, with six Siglecs and a life span that tops out at 24 years. The link between life span and Siglec gene numbers held even after researchers adjusted for body mass — another characteristic associated with longevity.

Exceptions may be found, Varki says. "Like anything in evolution, there are no rules. This is just a trend."

When the researchers genetically engineered mice to lack one of the Siglecs, encoded by a gene called *Siglec-E*, those mice died younger than mice that had all five intact genes. Males especially suffered; only 48 percent of the mutant male mice were left at 100 weeks old, compared with 70 percent of normal males. Median life span for female mutant mice was 17 percent shorter than for normal females.

Why the mutant mice died younger isn't clear. They didn't have obvious signs of disease, although some tissues had more inflammation than normal. The mutant mice did show signs that they were aging faster than normal. They lost a step in their mental abilities and appeared grayer and frailer than their normal counterparts.

That early frailty probably stems from increased vulnerability to reactive oxygen species, also known as oxidants, the researchers say. Reactive oxygen species are side products of metabolism that can harm important molecules in cells, such as DNA, proteins and lipids. Varki's team found that mice lacking Siglec-E accumulated more oxidant damage to DNA and protein in their livers than normal mice did. The finding suggests that Siglecs protect against oxidative damage, but exactly how they do it isn't known.

If that hypothesis is correct, adding another Siglec gene to mice should make the rodents live longer. The researchers hope to conduct those experiments, but won't know the results for years.

The study may give insight into why humans are so prone to inflammation-related diseases, says Laura Dugan, a neuroscientist at Vanderbilt University in Nashville who studies inflammation and brain aging.

"We live longer, but don't age well near the end," she says. The study provides preliminary but intriguing data that Siglecs play a role in keeping inflammation and oxidative damage — and thus aging — at bay. At some point, she speculates, accumulated exposure to things that tip the balance toward inflammation may overwhelm the Siglecs' ability to keep up, leading to the infirmities of old age.

Siglecs alone can't account for humans' extremely long lives, Varki says. African elephants also have 10 Siglecs, but don't live past 65. Varki hypothesizes that Siglecs can prolong life into the 60s, but some other mechanism must carry people into old age and past the century mark. ■

Longevity by the numbers How long a species lives depends upon the number of "Siglec" genes it carries, a new study suggests. Siglec genes encode proteins that may protect against aging by fighting inflammation and oxidants. SOURCE: F. SCHWARZ *ET AL*/*ELIFE* 2015

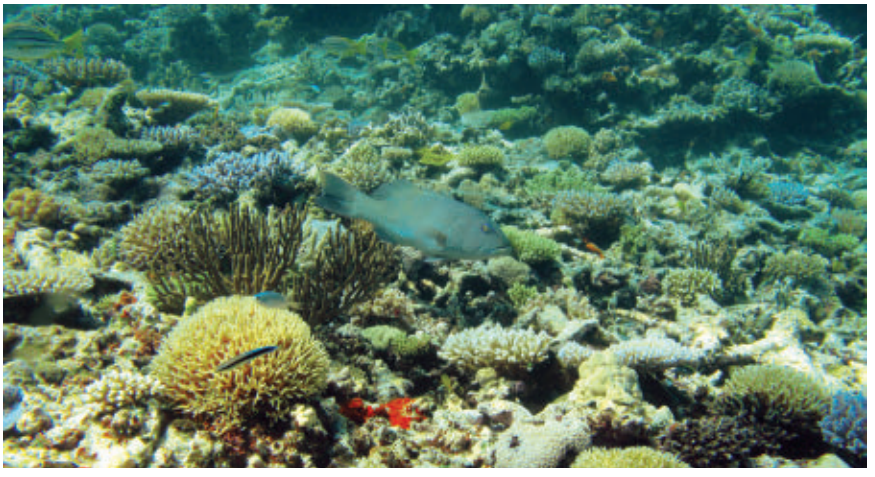
House mouse (*Mus musculus*)
Maximum life span (years): **4**
Number of Siglec genes: **5**

Domestic dog (*Canis familiaris*)
Maximum life span (years): **24**
Number of Siglec genes: **6**

African elephant (*Loxodonta africana*)
Maximum life span (years): **65**
Number of Siglec genes: **10**

Human (*Homo sapiens*)
Maximum life span (years): **120**
Number of Siglec genes: **10**

FROM LEFT: DAVID ILLIG/FLICKR (CC BY-NC-SA 2.0); DEDI SHARABI/FLICKR (CC BY-NC 2.0); NICKANDMEL2006/WIKIMEDIA COMMONS (CC BY-SA 2.0); MOODBOARD/FLICKR (CC BY 2.0)



A common coral trout (center) stalking a small-fish dinner is one of several prized *Plectropomus* species responding well to Australia's system of no-take reserves within Great Barrier Reef Marine Park.

AIMS LTMP

EARTH & ENVIRONMENT

No-fishing scheme in Great Barrier Reef succeeds with valuable fishes

Coral trout thrive but protection helps less with other species

BY SUSAN MILIUS

An ambitious, hotly debated system of no-take reserves inside the Great Barrier Reef Marine Park has boosted the population of its most commercially valuable fishes, says the first 10-year progress report.

Coral trout (certain species of the genus *Plectropomus*) are now more common and bigger on average in protected spots than in comparable places still being fished, researchers report online March 26 in *Current Biology*. The no-take zones also seemed to give these fish populations more resilience, with ample coral trout that had grown large enough to survive when severe tropical cyclone Hamish hit in 2009.

Creating the no-take zones in the Great Barrier Reef "was a politically risky move," says study coauthor Hugh Sweatman of the Australian Institute of Marine Science in Townsville. "There has been considerable interest in how this is playing out." The Australian government expanded the portion of the park where fishing is banned from about 5 percent to about a third in July 2004.

Conservationists have embraced the concept of such no-take zones, and the number of marine protected areas is growing. In March, the U.K. government announced plans to create a large marine protected area around the Pitcairn Islands. Yet an analysis of 87 marine protected areas around the world published in *Nature* in 2014 found that poaching, regulatory loopholes or design flaws such as skimpy sizes of the protected areas often undermine the efforts.

Sweatman and his colleagues scrutinized underwater census data on matters such as fish length and abundance from four monitoring programs going back as far as 1983. The researchers found that no-take zones may be nurturing the coral trout, but there's not much effect on other fishes or their neighbors in unprotected areas.

> Creating no-take zones in the Great Barrier Reef "was a politically risky move."
>
> **HUGH SWEATMAN**

That finding makes sense for the Great Barrier Reef where commercial and recreational fishing mostly targets a few species, says marine ecologist Trevor Willis of the University of Portsmouth in England. These marine protected areas work differently from ones off coasts crowded with people catching anything they can for food. There, no-take zones should have dramatic effects on many species — because many species get fished.

On the Australian coast with fewer people and less subsistence fishing, the targeted fish populations respond strongly when the fishing stops. Consequences for those fishes' prey or competitors can be too small to pick out of the noise of natural variability, explaining why researchers found little change among other species.

What the monitoring data do suggest, Sweatman and his colleagues argue, is that no-take zones don't seem to harm their neighbors. Critics have raised concerns that banning fishing in so much of the park might intensify damage in places still fished. Yet that doesn't seem to be happening, the researchers say.

That's a surprise in some respects, says Stuart Kininmonth of Stockholm University, a coauthor of the 2014 paper in *Nature*. Recreational fishing has grown in popularity, and high-tech gear has become more affordable, he says.

One question that the new monitoring paper doesn't address is whether coral trout spawned in protected areas spill over the boundaries to enhance legal fishing, notes Peter Sale of the University of Windsor in Canada. In 2012, researchers announced that they had traced coral trout larvae from Great Barrier Reef protection to fishing areas. "Elegant," Sale says. The 2012 study "was the first-ever demonstration, with a fishery species, that no-take marine reserves worked as theory said they would." But whether those larvae grow up to have an impact on neighborhood fishing stocks remains to be seen.

Even with a decent report card for the first 10 years of stepped-up protection in the Great Barrier Reef, no-take zones face some tough challenges. The park's 2014 report identified climate change as a top threat to reefs, Sweatman says. "Clearly marine reserves do not protect against climate change, which is a global phenomenon and needs a global solution." ■

HUMANS & SOCIETY

‘Little Foot’ lived in same era as Lucy

New dating pushes back age of earliest South Africa hominids

BY BRUCE BOWER

Lucy’s species, an East African hominid line called *Australopithecus afarensis*, had a South African counterpart, a new study finds.

A nearly complete fossil skeleton from South Africa’s Sterkfontein Caves dates to 3.67 million years ago, making it roughly 1 million years older than any other South African hominid, say geochemist Darryl Granger of Purdue University in West Lafayette, Ind., and his colleagues. Dubbed Little Foot, the skeleton represents *Australopithecus prometheus,* a species originally proposed for fossils at a nearby site in 1948, the scientists contend in the April 2 *Nature*.

Previous estimates of Little Foot’s age ranged from 3 million to 2 million years ago. The new date, if correct, would make Little Foot contemporary with Lucy’s species, which lived in East Africa from about 4 million to 3 million years ago.

“Little Foot’s new date is a reminder that there could well have been many species of *Australopithecus* extending over a much wider area of Africa than just the small number of fossil sites in East Africa and South Africa,” says study coauthor Ronald Clarke of the University of the Witwatersrand in Johannesburg.

Clarke has worked since 1997 to free much of Little Foot’s skeleton from rock that had encased it (*SN: 8/10/13, p. 29*). Gradual sinking of cave sediments created gaps later filled by calcite deposits as water flowed down the walls or along the floor of the cave. That made it difficult to know whether Little Foot lay in rock from its own time or later.

Granger and colleagues measured the decay of radioactive forms of aluminum and beryllium in 11 samples from quartz surrounding Little Foot’s skeleton. Such decay occurs at known rates shortly after sediment is buried. Nine of the 11 samples displayed comparable levels of decay, the researchers say, indicating that the rock was deposited on a single occasion. Calculations based on decay rates of each substance produced the new age estimate.

Little Foot, a South African fossil skeleton that includes this skull, may have lived 3.67 million years ago. If the new age is confirmed, it would make Little Foot the oldest known hominid in that part of Africa.

Granger’s group used the same technique to date stone artifacts found elsewhere in Sterkfontein Caves to 2.18 million years ago.

While the sediment dates appear solid, Little Foot may not be as old as the new report concludes, says geoarchaeologist Andy Herries of La Trobe University in Melbourne, Australia. “Few, if any,” fossil deposits in South Africa date to as early

LIFE & EVOLUTION

‘Neandertal’ ant grows fancy food

Discovery provides new look at coevolution of symbiosis

BY SUSAN MILIUS

A living relict of an ancient species of farmer ants has startled biologists by cultivating a fancy, modern food crop that arose more than 30 million years after the ants did. The discovery provides a new look at how symbiotic species evolve.

“It’s like a lost tribe of Neandertals growing a GMO crop,” says Ted Schultz of the Smithsonian Institution in Washington, D.C.

Ant colonies that grow their own specialty fungus for food can die when coaxed to farm unfamiliar strains, lab tests show. Yet *Apterostigma megacephala* — the oldest known species of farmer ant — has somehow switched to grow a kind of fungus that has been around for less than 8 million years, Schultz and his colleagues report in May’s *The American Naturalist*. Scientists thought this fungus could survive only in the farms of leaf-cutting ants.

Over 240 ant species, all native to the Western Hemisphere, grow some kind of fungus for food. Biologists divide these species into five groups, from simple family farmers to industrial-scale producers, each with its companion cluster of crop fungi. Young queens carry a bit of mom’s fungal strain in their mouths when they fly out to start their own farms. When an ant species switches its specialty food, it’s usually a small change to a fungus in the same cluster as the original fungus.

Not so with *A. megacephala* ants, which Schultz describes as the “oddball of all oddballs.” Until 2009, the species was known only from four museum specimens. Its unusual mix of physical traits meant its ancestors took their own evolutionary path some 39 million years ago. Schultz and colleagues searched for living colonies of the ants in Peru and Brazil for 10 years before researchers found some, along a service road in a regional zoo.

There, small colonies of about 20 workers tend a baseball-sized, spongy mass of fungus riddled with passageways where farmhands and nursemaids scurry to their tasks. The ants collect fresh insect droppings, flower parts and other small tidbits to feed the fungus but otherwise don’t process this debris.

So Schultz’s team was stunned when DNA analysis showed that the fungus (*Leucoagaricus gongylophorus*) was actually a relatively young species, also farmed by the highly evolved leaf-cutting

JASON HEATON

as 3.67 million years ago, says Herries, who has conducted dating studies at Sterkfontein and nearby caves. Rushing water or other natural events may have moved sediment dated by Granger's team from an older to a younger part of the cave where Little Foot lay, Herries cautions.

"Little Foot is certainly somewhere between 3.7 million and 2.2 million years old," he says.

Even if Little Foot lived 3.67 million years ago, "it's interesting but hardly shocking that australopithecines might be that old in South Africa," comments paleoanthropologist William Jungers of Stony Brook University in New York. Several *Australopithecus* species evolved in East Africa around that time, suggesting that other variants could have emerged elsewhere in Africa, he says.

Clarke argues that Little Foot's distinctively shaped molar teeth, flat face and other traits justify assigning it to *A. prometheus*. But others classify hundreds of *Australopithecus* fossils recovered at Sterkfontein Caves, including those of Little Foot, as *Australopithecus africanus*. Sterkfontein's *A. africanus* fossils are generally regarded as between 2.6 million and 2 million years old. ■

species of farming ants. These ants snip greenery to make special fodder for their crop, which is so dependent on the ants that it can't live without them. Yet somehow this pampered, domesticated fungus species also grows in the rough circumstances of the old-style farmer nests.

"Understanding better what governs such switches might let us understand how pairings evolve and how they change over time," says Michael Thomas-Poulsen of the University of Copenhagen.

Evolutionary biologist Duur Aanen of Wageningen University in the Netherlands is testing the idea that gut microbes are factors in permitting (or preventing) a big crop switch. Among termites that farm fungi, gut microbes and the fungi seem to divide the labor of breaking down plant material, a sign that microbial compatibility — not just farming method — matters in farmer-crop partnerships. ■

Z. YANG ET AL/PHYSICAL REVIEW LETTERS 2015

MATTER & ENERGY

A new spin on guiding sound

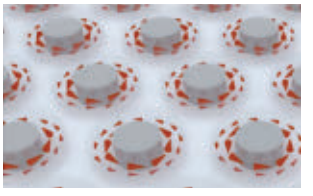
Acoustic device could cloak submarines, divert loud noises

BY ANDREW GRANT

An array of miniature turntables could offer a powerful new way to control the flow of sound.

The proposed device, reported in the March 20 *Physical Review Letters,* would channel sound waves in a protected one-way thoroughfare along its edge. The structure is an acoustic version of a hotly researched class of materials called topological insulators. As the name suggests, these materials are primarily insulators, yet they efficiently transport electrons along their periphery.

The study "shows that this rather exotic physical property can emerge in something as familiar as sound propagation," says Steven Cummer, an electrical engineer at Duke University.



A proposed acoustic topological insulator relies on a network of counterclockwise spinning metal cylinders, each of which churns surrounding air and manipulates incoming sound waves.

For now, the design requires many moving parts and manipulates only a narrow swath of sound frequencies. But a similar structure could eventually allow engineers to redirect loud noises out of a room or perhaps to cloak submarines from sonar.

Topological insulators have exotic split personalities (*SN: 5/22/10, p. 22*). They both insulate, blocking the movement of electrons, and conduct, moving electrons but only in special thoroughfares along the materials' edge. All electrons with a particular spin move in the same direction; as they cruise along this one-way road, they scale bumps and leap potholes because the material's properties don't allow the particles to bounce or scatter backward — they can only move forward.

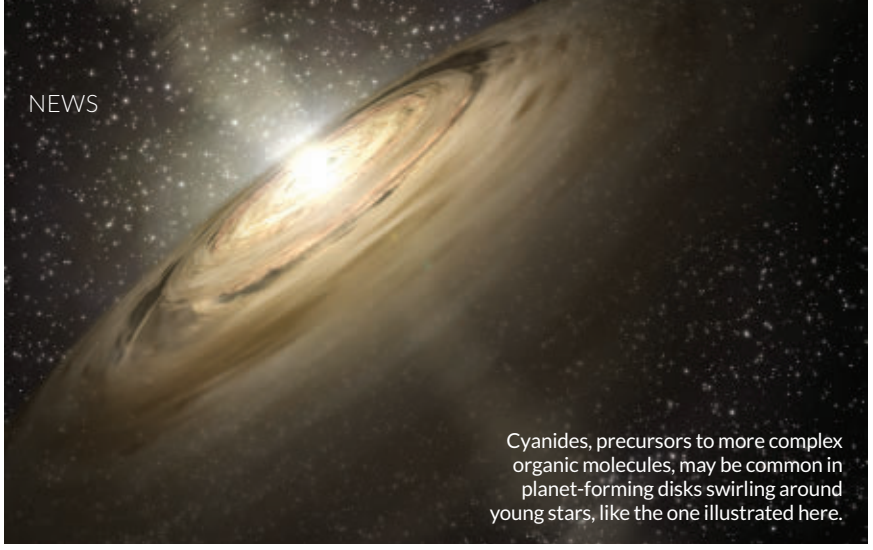
Recently, scientists have expanded the scope of topological insulators by creating materials that steer light instead of electrons (*SN: 5/18/13, p. 8*). Physicist Baile Zhang and colleagues at Nanyang Technological University in Singapore went further and designed an analogous device for manipulating sound. Their proposed structure is a lattice of metal rods, each encased in a cylindrical shell. The rods are sized and spaced to interfere with sound waves and confine the waves to the material's edge.

Zhang's team proposes spinning the metal rods like turntables to create swirling pockets of air within each shell. The counterclockwise motion of the air should force sound waves into a counterclockwise path along the edge of the device. Zhang suggests using small motors like those used to turn the rotors of toy helicopters to spin the metal rods.

Computer simulations confirm that a network of hundreds of centimeter-wide spinning rods would confine audible sound waves to a narrow one-way path along the material's boundary. The simulated sound waves remained on course even after encountering imperfections and sharp turns. "Sound is forced to propagate along the boundary, even if you do rather tortuous things" like making it jagged or bumpy, Cummer says.

The device manipulates only a narrow range of frequencies, Cummer notes. And physicist Eugene Mele of the University of Pennsylvania, who coauthored a pivotal paper on topological insulators in 2005, is skeptical about the practicality of so many spinning cylinders. "It's a bit of a Rube Goldberg contraption," he says.

Zhang hopes to demonstrate a device within months. An eventual prototype may not duplicate the design exactly but could still find uses. Cummer envisions topological acoustic paneling on a wall to capture sound from a noisy generator. Zhang says that a similar structure could cloak submarines by preventing sonar pulses from bouncing back. But University of Texas at Austin engineer Andrea Alù says it's hard to steer sound around a curved, free-floating object. ■



Cyanides, precursors to more complex organic molecules, may be common in planet-forming disks swirling around young stars, like the one illustrated here.

ATOM & COSMOS

Cyanides signal complex chemistry

Biomolecule precursors found in disk around young star

BY CHRISTOPHER CROCKETT

Cyanide shows up in apple seeds, toxicology reports and now a planetary nursery encircling a young star. Compounds found in a planet-forming disk suggest that the brew of organic compounds in asteroids and comets around our sun might also be common in other solar systems.

A vapor of hydrogen cyanide, methyl cyanide and cyanoacetylene swirls around the star MWC 480, about 460 light-years away in the constellation Auriga. The molecules, possible precursors to substances needed for life, appear in abundances similar to those found in local comets, report astrophysicist Karin Öberg of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and colleagues in the April 9 *Nature*.

"One of the existential questions is how unique our solar system is," says Öberg. Now that we know planets are common around other stars, the next step "is to figure out how unique our chemistry is."

Öberg and colleagues used the Atacama Large Millimeter/submillimeter Array in Chile to detect radio waves emitted by the cyanide molecules. Öberg's team mapped cyanide abundances around MWC 480 at distances from the young star that are about 30 to 100 times farther than Earth is from the sun. The team figured this was a region where comets probably form.

"People used to say that disks inherited their chemical composition from the interstellar medium and ... that's the end of the story," says Joan Najita, an astrophysicist at the National Optical Astronomy Observatory in Tucson. "These data show that the story is more complex and interesting than people used to think."

To date, researchers have been able to see only relatively small molecules in young disks. The presence of substances such as methyl cyanide shows that disks are breeding grounds for more complex organic molecules. That means that these ingredients can be present when comets, asteroids and planets are forming.

Cyanide might not be the first chemical that pops to mind when thinking about environments conducive to life. But the molecules needed to originate life are not necessarily the best ones to sustain it, Öberg notes. Lab experiments indicate that conditions producing methyl cyanide also lead to simple sugars. And cyanide is a chemical precursor to amino acids (the building blocks of proteins), which are also found in meteorites.

Meteorite data show that amino acids were floating around the sun as asteroids and planets were taking shape. But those data provide just a glimpse of the early solar system's inventory of complex organics. "How abundant would those have been? Where were they synthesized?" Najita asks. Öberg's observations help put our own solar system in context.

Öberg plans to investigate other young stars to see how common the complex cyanides are. ■

EARTH & ENVIRONMENT

North met South sooner than later

Crystals from Panama suggest continents linked up early

BY THOMAS SUMNER

North and South America may have hooked up 10 million years earlier than thought.

Many scientists think that the seaway separating the two continents closed about 3 million years ago, sparking mass animal migrations and an ice age in the Northern Hemisphere. After analyzing crystals excavated from an ancient South American streambed, researchers report in the April 10 *Science* that this continental connection must have taken place before 13 million years ago. Although not all experts are convinced, the researchers argue that the unearthed crystals originated in Panama and flowed down a river that straddled both continents.

"The only origin for these crystal fragments we found in Colombia is in Panama," says study coauthor Camilo Montes, a geologist at the Universidad de los Andes in Bogotá, Colombia. "There had to have been a river flowing over a land connection 13 million years ago."

While interesting, the finding isn't conclusive proof of an early connection between the two continents, says hydrologist Robert Stallard of the U.S. Geological Survey's National Research Program in Boulder, Colo. The crystals could have originated from somewhere other than Panama, he says. "There are plenty of opportunities to get these crystals into Colombia without closing the seaway."

When the Pangaea supercontinent broke apart about 200 million years ago, the Americas went their separate ways and then slowly drifted back together. Around 20 million years ago, only a small strip of water called the Central American Seaway connecting the Pacific and Atlantic oceans separated the two continents. A heap of volcanic rock sitting on the Caribbean tectonic plate

JPL-CALTECH/NASA

then slammed into northwestern South America and rose up above the sea surface, closing off the seaway.

Scientists initially dated the seaway's closure based on its wide-scale impacts on animal populations and global climate. Animals such as mammals scurried across the newly formed land bridge, and freshwater fish swam down its waterways about 3 million years ago. Around the same time, the lost passageway between the Pacific and Atlantic probably rerouted Earth's ocean currents, intensifying the Gulf Stream and triggering a glaciation period in the Northern Hemisphere.

While digging around northern Colombian streambeds and drainage basins, Montes and colleagues uncovered ancient rock shards called zircon crystals embedded inside much younger rock. Zircon crystals, which form when molten rock solidifies, are relatively easy to date thanks to radioactive uranium atoms that become entombed in the crystal structure. While the surrounding rock was laid down about 11 million to 13 million years ago, the zircons were as much as 65 million years old.

The zircon ages serve as a fingerprint of where the crystals came from, Montes says. In this case he traced the zircons back to Panama. He proposes that the zircons were eroded by water and wind, making their way down an ancient river system from Panama to their final resting places in South America.

Stallard, however, points out that volcanic rock to the east of modern-day Colombia may share this age fingerprint and could have supplied the zircons without the need for a closed seaway.

A much older land bridge would mean scientists have to rethink the impacts of the Central American Seaway's closure, Montes says. For instance, the mass migration between North and South America may have been postponed by thick jungle that many animals would be unable to traverse. Around 3 million years ago, as the region's climate cooled (for reasons unrelated to the seaway closure), the jungle could have thinned, allowing more animals to pass through, Montes says.

But even if a river did run from Panama to South America 13 million years ago, that doesn't mean that the Americas were completely connected, says geologist Anthony Coates of the Smithsonian Tropical Research Institute in Panama City.

"Even if they're absolutely right with everything having to do with the zircons, showing that something closed at one point in the extreme southern end doesn't necessarily apply to the rest of the seaway," he says. "There were other gaps all the way up to Mexico." ■

M. TAGLIORETTI AND F. SCAGLIA

LIFE & EVOLUTION

Fossil reveals power of terror bird's beak

With a swift chop of its beak, the terror bird could have whomped its prey, a new fossil find confirms. Terror birds were one of South America's top predators from about 50 million to 1.8 million years ago. Researchers have discovered a nearly compete skeleton of a new species of terror bird in a cliff face close to Chapadmalal, Argentina. The researchers call the bird *Llallawavis scagliai* —Scaglia's magnificent bird — for naturalist Galileo Juan Scaglia, the grandfather of one of the researchers. They describe the fossil in the March *Journal of Vertebrate Paleontology*. The skeleton includes a tiny bone that strengthened the link between the bird's beak and skull. It's the first time scientists have found this bone in a terror bird fossil, providing direct evidence that the beak would have been sturdy enough to be used as a hatchet while hunting. *L. scagliai*, roughly 1.2 meters tall and weighing about 18 kilograms, roamed South America around 3.5 million years ago. Its existence shows that more than one terror bird species bullied smaller creatures at the time. The finding also suggests that mammals moving in from North America around 5 million years ago didn't force terror birds to go extinct. What caused them to die off is still an open question. — *Ashley Yeager*

BODY & BRAIN

Rats navigate mazes, even when blind

Prosthetic compass wired into brain can substitute for sight

BY ASHLEY YEAGER

With a compass prosthesis wired into their brains, blind rats can learn to navigate complex mazes to find food. What's more, they can do it nearly as well as rats that still have their sight, researchers from Japan report in the April 20 *Current Biology*.

Success using the prosthesis demonstrates the flexibility of the brain to comprehend a completely new sense, they say. The result may lead to improved therapies for human blindness and to the enhancement of human senses beyond the standard five.

"These rats are learning and really learning fast," says neurophysiologist Peter König of Osnabrück University in Germany. He adds that it's pretty cool that the animals can learn to use geomagnetic signals in a meaningful way.

Study coauthor Yuji Ikegaya of the University of Tokyo says the rats may not perceive the meaning of direction as humans do. But, he says, the results suggest that the animals can develop an internal map from a sense that isn't inherent.

In previous studies, scientists manipulated ferrets' senses so the animals could interpret visual cues with brain pathways originally wired for sound. Researchers have also developed a brain prosthesis that helps rats detect infrared light, which is usually invisible.

In the new study, Ikegaya and Hiroaki Norimoto, also of the University of Tokyo, tested whether their prosthetic brain compass could help blind rats regain their ability to recognize the position of their bodies within mazes. Food was the incentive. To prevent the rats from using their sense of smell, the scientists scrubbed the odor of the food pellets all over the walls of the mazes.

The scientists then put the rats through 20 trial runs per day in a T-shaped maze. Relying on their vision, normal rats learned within a week where food was hidden and how to consistently get back to it. The normal rats had similar success in a five-armed maze. Blind rats did not have such success in either maze unless they had been given a prosthetic brain compass.

> Scientists might be able to give humans super-sensing abilities.

The prosthesis is made of a digital compass, microchip and tiny electrodes. Ikegaya and Norimoto first implanted the electrodes into the brain region responsible for vision. When the digital compass sensed a blind rat's head pointed north, the microchip transferred data to the right electrode and it pulsed. When the rat's head pointed south, the left electrode pulsed. With this stimulation, the blind rats learned to navigate a maze and find food in roughly the same number of trials as rats with intact vision. Even with the compass turned off, trained blind rats could still orient themselves and find the food in the maze.

Blind rats that had the electrodes implanted in the region of the brain responsible for touch performed equally well.

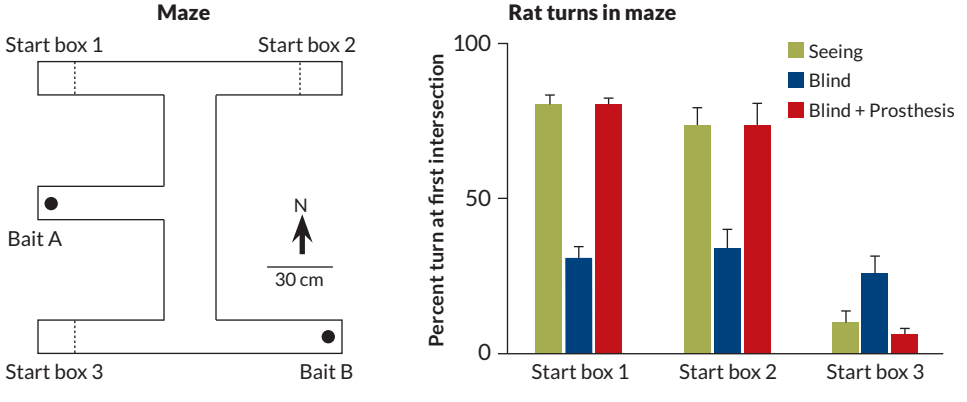
König says the result supports the idea that senses are not innate. The brain learns how to handle the senses, and it can do it with information beyond sight, sound, taste, touch and smell.

This adaptability of the brain sparked the idea of substituting and enhancing the senses, König says. He notes that the new prosthesis directly augments the rats' senses, an advance that may offer a look at how the brain changes at the cellular level when given new sensory information.

Ikegaya says the results could be used in an immediate and practical way to advance the development of the canes that blind people use when walking. One idea is to incorporate the compass into the cane. When the person pushes a button on the top of the cane, it could signal the direction of north through vibrations. "This is very simple," Ikegaya says, "but it would greatly help the blind to walk."

He notes that scientists might also be able to use the information to give humans super-sensing abilities. "Sensing ultraviolet light may be important for reducing skin cancer," Ikegaya says. "Sensing ultrasonic and radio waves may enable a next-generation form of human-to-human communication." ■

Sense of direction In one maze (left), rats were placed at three different start locations and had 90 seconds to find food. Blind rats (blue, right) made roughly the same number of turns from all three starting points, suggesting they used the same strategy to forage each time. Rats with intact vision (green) and blind ones with the prosthesis (red) turned more often from start boxes one and two. That suggests the prosthesis allowed the blind rats to use spatial navigation similar to the way seeing rats do to find food.



H. NORIMOTO AND Y. IKEGAYA/*CURRENT BIOLOGY* 2015

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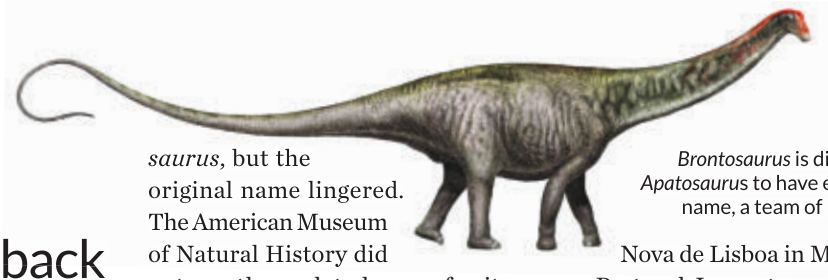


Brontosaurus is different enough from *Apatosaurus* to have earned its own genus name, a team of paleontologists says.

LIFE & EVOLUTION

Brontosaurus gets its name back

New analysis splits iconic dino from *Apatosaurus* genus

BY KATE BAGGALEY

After spending over a century dismissed as a mislabeled *Apatosaurus, Brontosaurus* may be getting its identity back.

The long-necked dinosaur deserves a genus distinct from that of *Apatosaurus*, European paleontologists report April 7 in *PeerJ*. Two other misclassified dinosaurs should also migrate to the *Brontosaurus* genus, the researchers determined after reviewing the members of the Diplodocidae family of dinosaurs.

The original *Brontosaurus excelsus* was named in 1879. But in 1903, paleontologist Elmer S. Riggs decided that the dinosaur was so similar to species in the *Apatosaurus* genus that it belonged there as well.

Brontosaurus was renamed *Apatosaurus*, but the original name lingered. The American Museum of Natural History did not use the updated name for its *Brontosaurus* skeleton. "People were exposed to these long-necked dinosaurs labeled as *Brontosaurus*," says paleontologist Matthew Mossbrucker of the Morrison Natural History Museum in Colorado. "*Brontosaurus* never really went away, especially in popular culture."

A few paleontologists have campaigned for the name's restoration since the 1990s, says Mossbrucker. "I certainly agree ... that *Brontosaurus excelsus* deserves to be recognized as its own genus."

The paleontologists compared bones in 81 skeletons of diplodocids (a family that includes the *Diplodocus* genus) and related dinosaurs, tallying similarities between individual specimens.

"We can see which specimens group together and have particular characteristics that help identify them as a species," says study coauthor Emanuel Tschopp, a paleontologist at the Universidade Nova de Lisboa in Monte de Caparica, Portugal. In most cases, the original designations about species held true, he said.

But the original *Brontosaurus* specimen was distinct enough to deserve its own genus separate from *Apatosaurus*. Though many of the differences between the two dinos were subtle, *Apatosaurus* had the wider, stronger neck of the two.

"*Apatosaurus* is in general more robust than *Brontosaurus*, even though both of them are very massively built," says Tschopp.

Whether the reidentified *Brontosaurus* is widely embraced is up to the paleontological community. "The move is now in the court of public opinion — if people use the names in the senses the authors propose, their perspective will have credibility," says Daphne Fautin of the International Commission on Zoological Nomenclature, which produces guidelines for assigning scientific names to animals. ■

LIFE & EVOLUTION

Personality match speeds up breeding

Mice mates with similar anxiety levels produce offspring sooner

BY SUSAN MILIUS

Who knows whether opposites attract among mice? But similars do best when it comes to making a fast start on a family.

Among mound-building mice (*Mus spicilegus*), the more alike mates' personalities were, the more likely the mice were to start having babies soon after being caged together, says Heiko Rödel of the University of Paris. Rödel and colleagues scored the animals' similarities based on tests of anxiety, the researchers explain in the May issue of *Animal Behaviour*.

"Ours is the first study in mammals on personality matching and reproductive parameters," Rödel says.

How couples' quirks mesh, or don't, as they reproduce could be an underappreciated factor in how a population fares and maintains variety in personalities.

For nonhuman animals, Rödel describes "personality" as a basic tendency — such as shy or bold, aggressive or cringing — that an individual shows again and again in different situations. These consistent tendencies have turned up in creatures from pea aphids to zebra finches. And tests have found that personality traits are to some degree inherited.

In bird species, couples with matching personalities tend to have offspring that are better in some way, such as weight, than mismatched couples do, Rödel says.

With mound-building mice, he and his colleagues looked at a different kind of evolutionary advantage: how readily the animals started breeding. They live only for a single breeding season, so a speedy start could help them have as many offspring as possible — and even allow their offspring to have offspring.

Mice tested for anxiety reacted similarly over time, sticking to elevated walkways protected by high walls, or venturing along exposed ones. When paired randomly, couples with similar personalities were at least twice as likely to have offspring as mismatched couples within three months. Pairs intermediate in similarity ranked in between.

Rödel says perhaps there's less chronic stress in raising a family with a like-minded mate. And maybe couples with similar inclinations coordinate better for more efficient child care.

The study may also help explain why there is such variety in personalities. A baby bonus for closely matched couples could "help to maintain personality variation in the long run," says Sasha Dall of the University of Exeter in England, who has studied variety in animal personality. The lab mice had no say in picking partners, and biologists don't know if personality matters when mice flirt in the wild. ■

DAVIDE BONADONNA/MILAN, ITALY

Plate loss gave chain of Pacific islands, seamounts a kink

Shift in mantle flow repositioned hot magma plume responsible for Hawaiian archipelago

BY THOMAS SUMNER

The disappearance of a tectonic plate into Earth's interior may be responsible for the distinctive bend in the chain of underwater mountains and islands that includes the Hawaiian archipelago.

A reconstruction of the mantle flowing under the Pacific Ocean about 50 million years ago suggests that the submergence of the Izanagi Plate near East Asia reversed the flow's direction. This mantle U-turn could have immobilized the mantle-dwelling plume of magma that built the mountain ranges, the researchers report online March 24 in *Geophysical Research Letters*. The abrupt stop probably caused the roughly 120-degree kink in the Hawaiian-Emperor seamount chain as Earth's crust moved westward over the plume, they conclude.

Scientists had previously thought a sudden shift in the Pacific Plate's movements over the magma-spewing hot spot produced the bend where the Emperor undersea mountain range connects to the Hawaiian one. In a related paper published online March 27 in *Geology*, researchers calculate that the plate didn't significantly alter course around the time the seamount chain got bent.

The two findings together suggest that the bend's initial origin story was off the mark, says geodynamicist Lijun Liu of the University of Illinois at Urbana-Champaign. "These two papers might actually resolve this longstanding debate," he says. "These are two powerful, independent pieces of evidence that the Hawaiian-Emperor bend is an indication of a deep mantle process, rather than a surface plate motion."

The Hawaiian hot spot is a tube-shaped plume in the mantle that carries magma from near Earth's core to the surface. Over more than 80 million years, molten rock from the hot spot built up a chain of islands and underwater seamounts stretching more than 5,800 kilometers across the Pacific Ocean. The seamount chain grew southward at first before abruptly turning east around 50 million years ago.

> "These are two powerful, independent pieces of evidence that the Hawaiian-Emperor bend is an indication of a deep mantle process, rather than a surface plate motion."
>
> LIJUN LIU

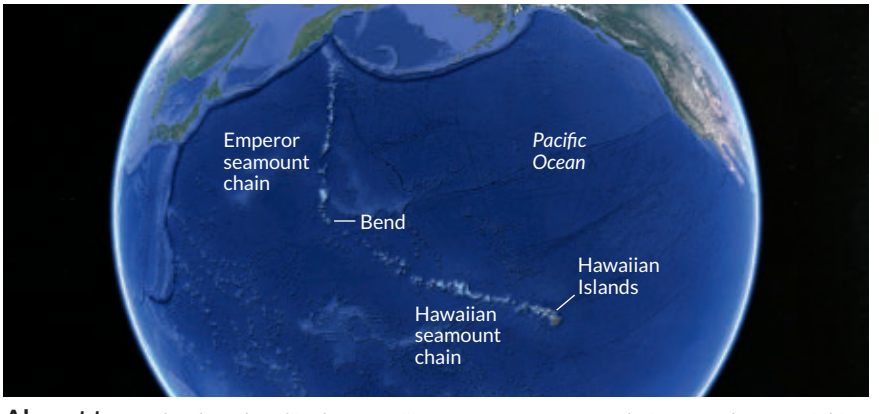
About 10 million years before the seamount chain took a turn, a tectonic plate off the coast of East Asia met its doom. The Izanagi Plate completely slipped under another plate and into the mantle. Geodynamicist Maria Seton of the University of Sydney and colleagues wondered how the plate's plunge impacted the movement of mantle beneath the Earth's surface. Before the plate's demise, the sinking rocky slab had acted like a wall in the mantle layer, obstructing the mantle flow.

By simulating the interactions between the mantle and the sinking plate, the researchers deduced that removal of the mantle-blocking Izanagi Plate triggered a 7-million-year reorganization of mantle movements beneath the Pacific. Mantle flows did an about-face in the simulation, switching from a southward flow at a rate of 0.5 to 1.7 centimeters per year to a slower northward to northwestward flow of 0.1 to 1.1 centimeters per year.

Because the Hawaiian hot spot sits within the mantle, the reversed mantle flow halted the hot spot's southward drift but wasn't strong enough to push it northwestward. The hot spot remained stationary as the Pacific Plate drifted westward over it. As a result, the Hawaiian seamount chain expanded to the east.

In the study published in *Geology*, geoscientist Nicky Wright of the University of Sydney and colleagues including Seton used geological data to retrace the Pacific Plate's movements going back tens of millions of years. While the Izanagi Plate's disappearance ultimately caused the Pacific Plate to shift more westward, this process was too slow to account for the sharp Hawaiian-Emperor bend, the analysis showed.

"For the longest time scientists assumed that this prominent bend formed because the Pacific Plate changed direction," says geophysicist Dietmar Müller of the University of Sydney, who coauthored both studies. "We now can demonstrate that the mantle, not the plate, changed its direction of motion." ■



GOOGLE EARTH PRO

Abrupt turn The sharp bend in the Hawaiian-Emperor seamount chain formed after a sinking tectonic plate redirected the mantle flowing underneath the Pacific Ocean, new research suggests.

LIFE & EVOLUTION

Butterfly spots can mimic eyes to scare birds

Test revives old idea about wing marks' role in evolution

BY SUSAN MILIUS

Big spots on butterfly wings actually can mimic the eyes of predators, a new study finds, reviving a partly discredited textbook truth with fresh evidence.

In lab tests, images of butterflies with big spots on their wings spooked hungry little songbirds about as much as images of real, predatory owls did, says Johanna Mappes of the University of Jyväskylä in Finland. Yet butterfly images were only about half as likely to startle or scare away the birds when researchers removed the eyespots or reversed their colors, Mappes and colleagues report in the May 7 *Proceedings of the Royal Society B*.

The experiment shows that conspicuous contrast by itself doesn't give these wing spots their shock value, Mappes says. If the effect is instead due to a resemblance to predators' eyes — an old and now disputed idea — that advantage could have nudged along the evolution of more realistic eyespots on wings.

The new study "is by far the most convincing evidence that eyespots can work by mimicking eyes," says Martin Stevens of the University of Exeter in England.

These big round spots with concentric rings stare out of fish flanks, caterpillar rumps and plenty of other flesh in the animal world. Flashing the spots in the face of an attacking predator can cause an instant of consternation sometimes just long enough for prey to dodge away.

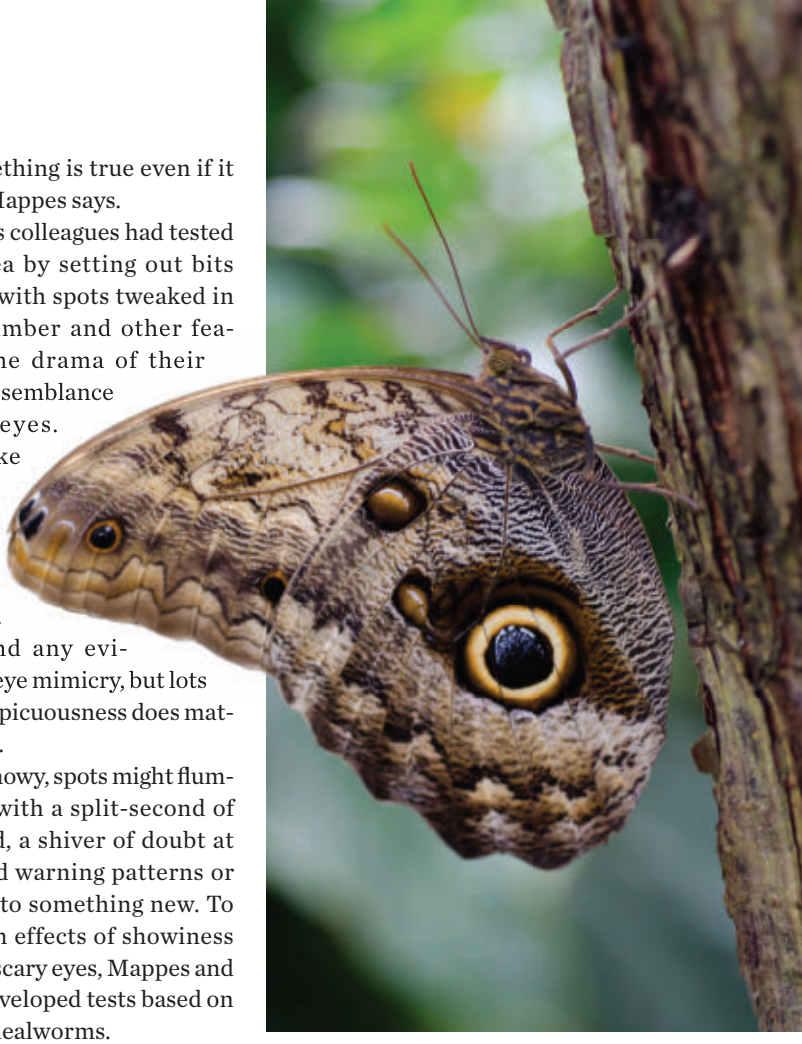
The idea that eyespots evolved as mimics of vertebrate predator eyes dominated discussions of spot evolution for at least a century before biologists began serious tests of the concept, Mappes says. Then, starting in 2005, came a string of critiques by Stevens. "He had a very good point that we should not assume something is true even if it looks as if it is," Mappes says.

Stevens and his colleagues had tested the mimicry idea by setting out bits of paper as prey with spots tweaked in shape, color, number and other features to vary the drama of their looks and their resemblance to vertebrate eyes. The more eyelike features didn't prove important in scaring birds away in his experiments. "We never found any evidence in favor of eye mimicry, but lots to show that conspicuousness does matter," Stevens says.

Just by being showy, spots might flummox a predator with a split-second of sensory overload, a shiver of doubt at similarity to bold warning patterns or merely aversion to something new. To try to distinguish effects of showiness from mimicking scary eyes, Mappes and her colleagues developed tests based on computers and mealworms.

At a research station in Finland, the researchers conscripted 97 wild birds called great tits (*Parus major*) for temporary stints in a small cage with a mostly covered computer screen as the floor. A short length of plastic pipe rose from the floor. A bird perching on the rim would peer down inside the pipe at a real mealworm lying on a clear window with a view of the computer screen below. Just as the bird reached for the snack, the computer would flash an image of either an owl or a butterfly behind the mealworm as suddenly as an attacked butterfly spreads its startling wings. The butterfly images Mappes used came from an owl butterfly (*Caligo martia*) with eyespots that have an unusually vivid resemblance to a real owl's eyes, she says. This setup allowed for sudden, more realistic deployment of eyespots than in many previous experiments.

The sudden sight of the owl face with its eyes wide open or the natural eyespots sent some of the birds darting to the edge of the cage. Birds that saw fake-looking or spotless wings were less likely to flee.



The owl butterfly *Caligo martia*, sporting eyelike spots on its wings, stars in a new wave of rigorous testing of the longtime belief that the spots evolved as mimics of scary predator eyes.

LOKI PHOTOGRAPHY/ALAMY

Stevens applauds Mappes' study but adds a note of caution. "Something like 10 studies recently have tested the eye-mimicry theory, with most either finding evidence for conspicuousness instead, or producing ambiguous results," he says. Documented mimicry effects, like those in Mappes' paper, are unusual, so "it would be premature to conclude that all eyespots mimic eyes."

Ullasa Kodandaramaiah of the Indian Institute of Science Education and Research, Thiruvananthapuram suggests a middle ground. "Instead of asking whether eyespots are effective due to eye-mimicry or conspicuousness, it might be more fruitful to accept that both are important," he says. Future research could move on to tracing the patterns of when scary eyes matter and when big and bold is startling enough. ■

HUMANS & SOCIETY

Early arrival for hominids in Greece

New data place human ancestors there by 206,000 years ago

BY BRUCE BOWER

Greece has long been known as a bastion of research into the birth of democracy. Now, the country appears poised to become a key player in the study of European Neandertals and ancient human groups.

New geologic evidence from a Greek archaeological site indicates that hand axes and other stone artifacts previously unearthed from one soil layer date to about 206,000 years ago. Stone implements from a higher sediment layer at the site, called Kokkinopilos, date to about 172,000 years ago, a time when Neandertals inhabited Europe, geoarchaeologist Vangelis Tourloukis of the University of Tübingen in Germany reported March 27.

Kokkinopilos contains the oldest archaeological material in Greece that comes from sediment dated with measurements of radioactive elements, Tourloukis said.

He and project collaborators Panagiotis Karkanas of the American School of Classical Studies in Athens and Jakob Wallinga of Wageningen University in the Netherlands also describe new findings at the site in May's *Journal of Archaeological Science*.

New dates for Kokkinopilos begin to illuminate when hominids inhabited a region that has been little studied, remarked archaeologist Alison Brooks of George Washington University in Washington, D.C.

A handful of other proposed Stone Age sites in Greece with similar geologic settings can now be dated using the same approach, Tourloukis said. That raises the possibility of dating finds that may shed light on when *Homo sapiens* first reached Europe, presumably sometime between 100,000 and 40,000 years ago.

"Southeast Europe, including Greece, was a likely route of human dispersal from Africa to Europe," said Katerina Harvati, a paleoanthropologist at the University of Tübingen who was not involved in the research. Harvati directs ongoing excavations at several hominid sites in Greece.

Until now, tentative dates for a handful of Stone Age sites in Greece ranged from 130,000 to 40,000 years ago. Several of these sites have yielded Neandertal fossils. One site contains stone tools typically considered to be products of *H. sapiens*. Stone artifacts have also been found in two or more soil layers at two sites of uncertain age near Kokkinopilos, Tourloukis said.

Since the initial recovery of stone tools at Kokkinopilos in 1962, scientists have debated the age of the artifacts. At issue was whether water from an ancient lake adjacent to the site seeped into the soil and caused it to shift. Mixing of soil layers would greatly complicate efforts to estimate ages of recovered artifacts.

Surveys and soil analyses uncovered no evidence that sediment layers or artifacts at Kokkinopilos had shifted over time, Tourloukis said. The scientists measured the decay of radioactive elements in samples from three soil layers at Kokkinopilos. That data enabled them to estimate the time since those layers were buried and unexposed to sunlight. A soil layer above the two artifact-bearing deposits, which has not yielded stone tool finds, dates to about 156,000 years ago. ■

CHIP CLARK/SMITHSONIAN INSTITUTION

MEETING NOTES

Kennewick Man's bones reveal an ancient taste for seafood

Kennewick Man (skeleton shown at left) almost exclusively ate seafood despite access to land animals. Proportions of certain forms of carbon and nitrogen in the bones of the 9,000-year-old skeleton denote a diet dominated by seafood, Henry Schwarcz of McMaster University in Hamilton, Canada, reported March 28. Kennewick Man, found in Washington state in 1996, may have belonged to a Pacific Northwest population that continued to shun land prey long after his demise, Schwarcz said. In 2014, Schwarcz reported that the bones of people who lived along the British Columbia coast over much of the last 6,000 years displayed chemical signs of diets heavy on fish, mollusks and marine mammals. — *Bruce Bower*

Footprints offer clues about daily hominid life

Male hominids living in East Africa 1.5 million years ago hung out in groups by a lake that also attracted many animals. The evidence: lots of footprints. Researchers led by Brian Richmond of the American Museum of Natural History in New York City excavated 1.5-million-year-old hominid footprints near Kenya's Lake Turkana in 2007 (*SN: 3/28/09, p. 14*). Last year, the team found 20 more comparably ancient footprint sites in the same area. Most impressions belonged to antelopes, pigs, hippos and waterbirds. But sets of footprints from groups of hominids, probably of the genus *Homo*, turned up surprisingly frequently, Richmond said March 27. Unlike the other animals, the hominids traveled east to west and west to east, perhaps skirting the edge of what was once a big lake. The hominid prints appear to be those of tall males. Adult males must have been involved in some sort of cooperative activity, Richmond suggested. — *Bruce Bower*

EARTH & ENVIRONMENT

Canadian glaciers endangered

The Great White North may lose its glaciers faster than previously thought. A detailed physics simulation of how glaciers melt in a warming world shows that by 2100 Western Canada's glaciers (such as Athabasca Glacier, shown) will shed about 70 percent of their ice relative to their 2005 volumes, researchers report online April 6 in *Nature Geoscience*. That melting would raise global sea levels by roughly 4 millimeters and reshape the region's landscape. Western Canadian glaciers cover 26,700 square kilometers, an area larger than Vermont. Each glacier melts differently than its siblings depending on its shape and location. Most previous projections ignored or greatly simplified the ice-melt physics that makes each glacier's fate unique. Glaciologist Garry Clarke of the University of British Columbia in Vancouver and colleagues instead created a highly detailed 3-D simulation of how different glaciers melt. The simulation predicts over 25 percent more ice loss than previous studies, with peak melting occurring between 2020 and 2040. Mountain glaciers fared the worst, losing 90 percent of their 2005 volumes by 2100. The researchers say that with tweaking, their work will provide more accurate ice loss predictions for glaciers elsewhere in the world. — *Thomas Sumner*

ATOM & COSMOS

A new quirk for quarks

Like atoms, subatomic particles can link up to form "molecules." A long-studied subatomic particle called Lambda (1405) is actually a molecule of two tightly knit particles, researchers report in the April 3 *Physical Review Letters*. The study reveals a novel arrangement of matter made of quarks, the basic constituents of Lambda (1405) and every atomic nucleus in the universe. Quark-containing particles are divided into two groups: mesons, which have two quarks, and baryons, with three. Many physicists considered Lambda (1405) to be a baryon, like protons and neutrons. But some researchers proposed that Lambda (1405) could be one part meson and one part baryon, with a total of five quarks. Physicists at the University of Adelaide in Australia ran a supercomputer simulation using quark interaction equations to show that Lambda (1405) consists of a meson called an antikaon coupled to a proton or neutron. It's the first example of a meson-baryon molecule. The study is the latest to suggest new combinations of quark-based matter. Recent experiments have hinted at the existence of subatomic molecules composed of two mesons (*SN: 5/17/14, p. 12*). — *Andrew Grant*

Watching a young star erupt

Dramatic changes around a young massive star are giving astronomers a rare real-time look at how these stellar behemoths develop. Images taken 18 years apart show an eruption of gas streaming away from the star's poles, researchers report in the April 3 *Science*. Radio telescope images taken in 1996 showed a growing bubble of gas forming around the star, about 4,200 light-years away in the constellation Cygnus. The same gas is now spewing out in opposite directions, data obtained in 2014 show. The star belched out a wave of gas that subsequently ran into a doughnut of dust surrounding the star, suggest Carlos Carrasco-González, an astrophysicist at the National Autonomous University of Mexico in Morelia, and colleagues. The wall of dust slowed down some of the gas while the rest burst out above and below the disk. The outburst could become far-reaching jets of gas like those seen around less massive young stars (*SN: 10/5/13, p. 12*). Researchers expect jets to erupt from massive stars as well, but generally find only amorphous blobs of gas oozing in all directions. These before-and-after images can help astronomers understand how stellar winds, gas and their environment interact to build a new massive star. — *Christopher Crockett*

BODY & BRAIN

Improved test for Down syndrome

A prenatal test that examines a baby's DNA in the mother's blood is much more accurate for detecting Down syndrome than standard screening methods are. In a study of 15,841 pregnant women, babies identified by the DNA test as having an extra copy of chromosome 21 had an 80.9 percent chance of actually having Down syndrome. Only 3.4 percent of babies that tested positive with standard screening methods had Down syndrome, an international team of researchers report online April 1 in the *New England Journal of Medicine*. In the United States, one in 691 babies is born with Down syndrome. Standard screening methods include ultrasound and maternal blood tests. If these methods indicate a problem, doctors may perform more invasive tests, such as amniocentesis. More accurate screening methods could reduce the need for further testing. In the study, the fetal DNA tests — in use since 2011 — identified nine false-positive cases of Down syndrome among 15,803 babies, a rate of 0.06 percent. Standard screening methods found 854 false-positive cases, a rate of 5.4 percent. — *Tina Hesman Saey*

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FEATURE

The FUTURE of FORECASTING

Technology promises faster weather predictions on a smaller scale

By Thomas Sumner

In late January, a massive snowstorm drifted toward New York City. Meteorologists warned that a historic blizzard could soon cripple the Big Apple, potentially burying the city under 60 centimeters of snow overnight. Governor Andrew Cuomo took drastic action, declaring a state of emergency for several counties and shutting down the city that never sleeps. For the first time in its 110-year history, the New York City Subway closed for snow.

As the hours wore on, however, the overhyped snowfall never materialized. The storm hit hard to the east but just grazed the city with a manageable 25 centimeters of fresh powder. When Cuomo took grief for overreacting, many meteorologists sympathized. A meteorological misjudgment of just a few minutes or miles can mislead officials, trigger poor decisions and bring on public jeers. But underestimating a storm's impact may put people in peril. The answer is to make weather forecasts more precise, both in time and space.

Unfortunately, that's exceedingly difficult. Despite years of improvements in predictions, weather gurus may never be able to deliver accurate daily forecasts further ahead than they can now. So they're switching gears. Instead of pushing predictions further into the future, they are harnessing technology to move weather forecasting into the hyperlocal.

By incorporating clever computing, statistical wizardry and even smartphones, future forecasts may offer personalized predictions for areas as narrow as 10 Manhattan city blocks over timescales of just a few minutes. The work could one day provide earlier warnings for potentially deadly storms and even resolve personal conundrums such as whether to grab an umbrella for a run to the coffee shop or to wait a few minutes because the rain will soon let up.

"We're entering a promising era for small-scale forecasting," says meteorologist Lans Rothfusz of the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory in Norman, Okla. "The sky's the limit, no pun intended."

Atmospheric chaos

Weather is so complex that to predict it with any precision, forecasters need robust information about what the weather is doing right now. A worldwide battalion of planes, ships, weather stations, balloons, satellites and radar networks streams details of nearly every facet of the atmosphere to meteorologists. "In the meteorology business, we'll take all the data we can get," Rothfusz says.

Measurements such as atmospheric pressure, temperature, wind speed and humidity feed into data assimilation software that compiles a 3-D reconstruction of the atmosphere. Where no measurements exist, the software uses nearby data to intelligently fill in the gaps. Once the reconstruction is complete, the computer essentially presses fast-forward. Numerical calculations simulate the future behavior of the atmosphere to predict weather conditions hours or days in advance. For instance, a rising pocket of moist, warm air might be expected to condense into a storm cloud and be blown from an area with high

KELLY DELAY/FLICKR (CC BY-NC 2.0)

atmospheric pressure to a low-pressure region.

The goal is to provide a useful, or "skilled," prediction. A forecast is said to have skill if its prediction is more accurate than the historical average for that area on that date. Even using cutting-edge supercomputers and a global network of weather stations, meteorologists can provide a skilled forecast only three to 10 days into the future. After that, the computer typically becomes a worse predictor than the historical average.

Only the edge of January's snowstorm hit New York City, as seen in this satellite image (right) taken as the storm moved out. While forecasters correctly predicted snowfall for the Big Apple, they severely overestimated the total amount.

Many meteorologists believe this limitation won't be significantly improved on anytime soon. The problem, they say, stems from proverbial seabirds (or butterflies, depending on the story's telling). In 1961, mathematician and meteorologist Edward Lorenz discovered that small changes in the initial conditions of a weather system, when played out over a long enough period of time, can yield wildly different outcomes. In a presentation two years later, Lorenz quoted a fellow meteorologist who had remarked that if this chaos theory were true, then "one flap of a seagull's wings would be enough to alter the course of the weather forever."

More than five decades later, those flappy birds still cause headaches for weather forecasters. The further ahead meteorologists look into the future, the more their predictions become cluttered by small uncertainties that compound over time, such as imprecise measurements, small-scale atmospheric phenomena and faraway events.

So for now, the most likely place to make improvements is in fine-tuning short-term predictions, before chaos has a chance to kick in. This line of research, called precision forecasting, aims to provide speedier and more detailed visions of the near future. But first researchers need enough computer muscle to pull it off.

Crunching the numbers

Even if forecasters had omnipotent knowledge of meteorological conditions and mathematical equations that perfectly mimicked the atmosphere's behavior, it would do no good if the computers that crunch the numbers weren't up to snuff.

"Scientists are generally not limited by their imaginations, but by the computing power that's available," says computer scientist Mark Govett of NOAA's Earth System Research Laboratory.

For a forecast system to work in the real world, it needs to be fast. The computer should be able to work through the data assimilation and weather simulations in only one one-hundredth of the time the forecast looks ahead. If a meteorologist wants to forecast the weather an hour ahead, for example, the computations should be finished in less than 36 seconds. This time limitation means meteorologists often have to simplify their simulations, trading accuracy for speed. "If it takes two days to forecast tomorrow's weather, that's no use to anyone," says computational engineer Si Liu of the Texas Advanced Computing Center in Austin.

Supercomputers such as Yellowstone (shown) at the National Center for Atmospheric Research help scientists understand and predict weather.

To optimize computation times, meteorologists split the weather simulations into smaller chunks. Since January, NOAA's Global Forecast System has been breaking down the entire planet's weather into a mesh of 13-kilometer-wide sections. NOAA's Rapid Refresh model recently began using an even tighter grid, each cell just 3 kilometers wide, around North America. Govett says researchers plan to extend that resolution globally, breaking Earth's surface into roughly 53 million individual pieces, each topped with 100 or more slices of atmosphere stacked roughly 12 kilometers up into the sky. In total, that's more than 5.3 billion individual subsimulations that the system needs to handle.

That scale poses a major challenge, Liu said in January at the American Meteorological Society meeting in Phoenix. Weather simulations analyze each grid point separately, but changes in one section can affect its neighbors as well. This means that while different computer processors can each handle their own section, they have to quickly communicate information back and forth with other processors. Crowdsourced computing, which has proven useful for other big data challenges such as the extraterrestrial-hunting SETI@home project, is impractical for weather forecasting because too much time is lost transmitting between individual computers.

Instead, computer scientists now increasingly rely on chips called graphic processing units, or GPUs, that are specifically built for parallel processing. Traditional processors, CPUs, run their calculations in a set order as quickly as possible. GPUs, on the other hand, execute calculations out of sequence to save time. The result is that GPUs can power through computationally taxing weather calculations in as little as one 20th of the time it takes their CPU counterparts. This efficiency allows forecasters to incorporate more grid points into their simulations and churn out

FROM TOP: ANTHONY QUINTANO/FLICKR (CC BY 2.0); JEFF SCHMALTZ/GSFC/NASA; CARLYE CALVIN/UCAR

higher-resolution weather forecasts in the same amount of time.

For their next speed boost, computer scientists are looking to video games. GPUs have improved astronomically during recent years thanks to their popularity in gaming consoles and high-end computers, Govett says. "We're looking around at what other people are using and asking, 'Hey, can we use that?' "

The upgrade in computational power will be the backbone of precision forecasting, Govett predicts. In January, the National Weather Service announced that it will acquire two new GPU-based supercomputers and put them into operation by October. These new machines will be 10 times as fast as their predecessors, each capable of powering through 2,500 trillion operations each second.

"The excuse that we don't have the computer power will be gone," says atmospheric scientist Clifford Mass of the University of Washington in Seattle. "A renaissance in U.S. weather forecasting is possible, but now we need to improve other areas of our numerical weather predictions."

Android apps such as PressureNet and WeatherSignal (shown) collect hundreds of thousands of atmospheric pressure measurements from smartphone users around the world.

There's an app for that

Weather models are only as good as the data put in, and large swaths of the United States lack reliable weather monitoring. An imperfect picture of current conditions makes small-scale forecasts impossible. Mass was searching for something to help fill in these weather data gaps. He needed a data deluge, and he found the answer in his pocket.

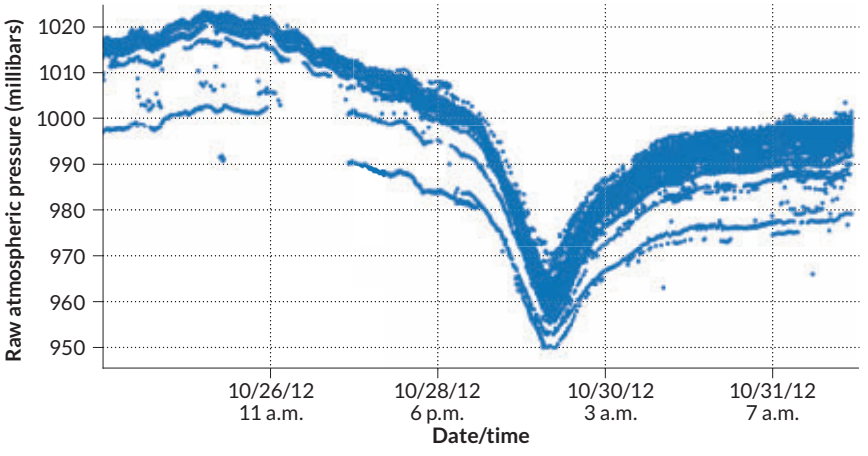
Mass realized that today's smartphones are weather-sensing gizmos. Although typically designed for health and other monitoring uses, some of the latest smartphones contain electronic sensors that track atmospheric pressure, temperature, humidity and even ultraviolet light. Just one problem, though: Unlike weather stations, smartphones move around. Of all the sensors, only the barometer, which measures air pressure, isn't affected by the constant movement from pocket to palm. Still, that's good news for meteorologists, Mass says, because "pressure is the most valuable surface observation you can get."

Air pressure differences drive the winds that carry cool, water-laden clouds across the sky. A sudden drop in pressure can signal that a brewing storm lurks nearby. Smartphones measure these pressure changes using a special chip that contains a miniature vacuum chamber covered by a thin metal skin. As the difference in air pressure between the two sides of the metal layer changes, the metal will bow, changing the flow of electric current passing through it.

Here's where crowdsourcing makes a difference. Thanks to apps such as PressureNet and WeatherSignal, Mass now receives around 110,000 pressure readings each hour from Android smartphones across the country. That's only a tiny fraction of the data out there, says PressureNet's Jacob Sheehy. "There are probably 500 million or more Android devices with barometers in the world right now," he says. "That's a lot more than any other weather network has of anything by, well, about 500 million."

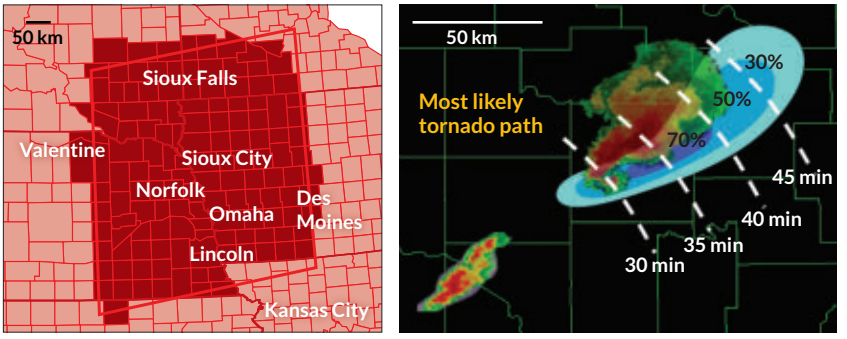
Sheehy recalls being "speechless for a few minutes" in October 2012 as thousands of incoming smartphone pressure readings plummeted in sequence along the East Coast as Hurricane Sandy rolled overhead. "It was the first time that I saw this whole idea was going to work," he says. "Despite not having been designed for it, smartphones can provide surprisingly good weather measurements."

While monitoring hurricanes showcases the network's potential, ultimately the biggest boon will be for tracking more focused storms such as the rotating thunderstorms called supercells that spawn tornadoes. This atmospheric churning is too small to be spotted by long-range weather monitoring techniques such as radar until the storm has already developed.



Under pressure As Hurricane Sandy passed over New York City on October 29, 2012, smartphones across the city, via PressureNet, reported falling atmospheric pressure. The data support the idea that smartphones could one day help scientists track and predict smaller-scale weather events.

CLOCKWISE FROM TOP: UKIX21/SHUTTERSTOCK, PRESSURENET, WEATHERSIGNAL; PRESSURENET



Tornado alert Under the current system (left), tornado watches (red) blanket huge areas with a single threat assessment. With Warn-on-Forecast (right), much smaller areas would get risk assessments (blue) and precise estimates of when a tornado would most likely hit.

In a paper published in the *Bulletin of the American Meteorological Society* in September, Mass proposed that a dense network of smartphone barometers could spot the localized twisting of air that marks the early stages of a tornado-spawning supercell. With those data, forecasters could predict supercell formation. Mass is talking with Google about getting access to the colossal number of pressure readings already gathered by its Google Maps app, which Mass says would give him all the data he'd need to start tracking supercell formation in rural America.

"I've had a few simulations that look favorable," he says, "but I don't know yet what having a hundred million or more readings would do."

Tracking twisters

Foretelling the formation of swirling supercells and their tornado offspring will probably be one of the most important benefits of precision forecasting. Twisters often strike with little warning, flinging cars and razing buildings. In one devastating example, during just four days in April 2011, U.S. tornadoes killed 321 people and caused more than $10 billion in damage.

Today's forecasters issue tornado warnings on average 14 minutes before a twister touches down. While this is enough time for a typical family to take shelter, crowded facilities such as hospitals, assisted-living centers and schools often require more warning to get everyone to safety. To buy people more time, researchers at NOAA's National Severe Storms Laboratory are developing a system called Warn-on-Forecast. It collects up-to-the-minute weather data and uses supercomputers to run gridded air circulation simulations every hour, each time looking only a few hours ahead. The ultimate goal, the researchers say, is to provide tornado warnings an hour or more in advance.

"You could potentially release warnings of tornadoes and other severe storms before the storms even develop," says atmospheric scientist Paul Markowski of Penn State.

However, tornado formation is finicky, says NOAA's Rothfusz, who works on the project. Measurements of the atmosphere always have some degree of uncertainty, and the difference between a tornado forming or not can often be lost in the margin of error. So instead of running a weather simulation once to see the future, the Warn-on-Forecast researchers run an ensemble forecast of simulations, each with a slightly tweaked starting state. If, for example, 25 out of 50 simulations form a tornado, the estimated tornado risk is 50 percent.

While the current system produces a single alert for enormous areas that often encompass entire states, Warn-on-Forecast will calculate fine-scale risk assessments for county-sized zones using a grid of cells, each 250 meters wide.

Since the researchers envisioned Warn-on-Forecast in a 2011 paper in the *Bulletin of the American Meteorological Society*, they have seen significantly improved warning times for tornadoes in tests, Rothfusz says. The NOAA researchers have been testing the system using historical events, such as the massive April 27, 2011, outbreak that spawned 122 twisters across the southeastern United States. In those simulations, the team has foreseen supercell formation as much as one to two hours in advance. "There was a lot of skepticism initially, but as we got into it ... we started to see some tremendous benefit," Rothfusz says. "This looks feasible."

As Warn-on-Forecast draws closer to implementation, a growing concern is how the public will use those extra 40-plus minutes between warning and tornado, says Kim Klockow, a University Corporation for Atmospheric Research meteorologist and behavioral scientist in Silver Spring, Md. In a 2009 survey, when respondents were asked what they would do with the longer lead times offered by Warn-on-Forecast, their answers deviated from the typical approach of sheltering immediately. Instead, respondents said they would try to flee the area.

Bad idea, Klockow says. Cars offer no protection from even weak tornadoes. No matter how advanced the warning, sheltering in a sturdy building remains the safest option, she says. Researchers will need to figure out how best to communicate the risk projections to the public.

As technology transforms how meteorologists predict the weather, both the extreme and the everyday, citizens and city officials should get a better handle on when storms will strike and where snow will fall.

"Over the last few years, we've seen incremental improvements in the precision of weather forecasting," Mass says. "But that's not what we want. We're looking for a forecasting revolution, and it seems like one might not be too far off." ■

Explore more

- C.F. Mass and L.E. Madaus. "Surface pressure observations from smartphones: a potential revolution for high-resolution weather prediction?" *Bulletin of the American Meteorological Society*. September 2014.

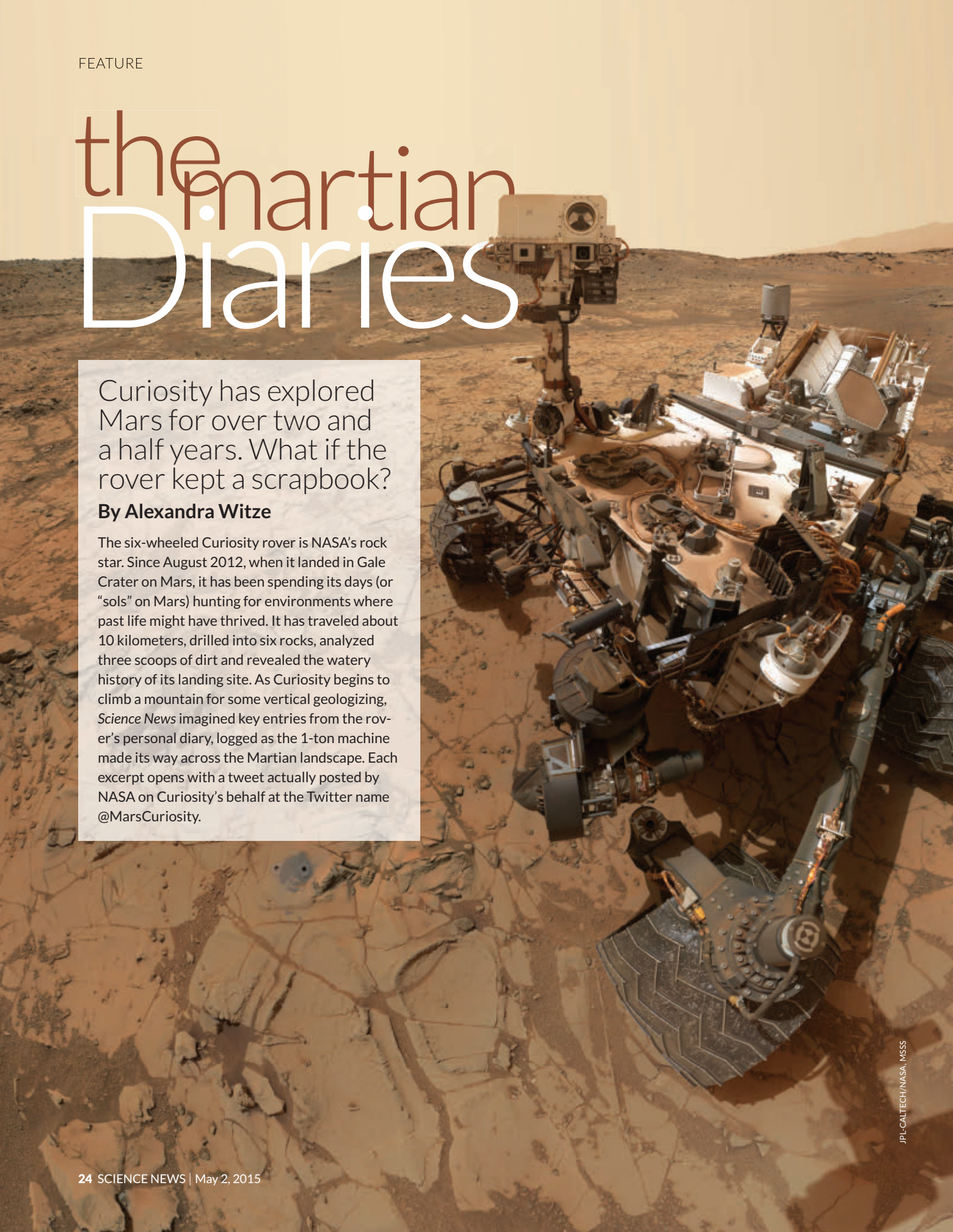
FROM LEFT: STORM PREDICTION CENTER/NWS/NOAA; NOAA NATIONAL SEVERE STORMS LABORATORY

the martian Diaries

Curiosity has explored Mars for over two and a half years. What if the rover kept a scrapbook?

By Alexandra Witze

The six-wheeled Curiosity rover is NASA's rock star. Since August 2012, when it landed in Gale Crater on Mars, it has been spending its days (or "sols" on Mars) hunting for environments where past life might have thrived. It has traveled about 10 kilometers, drilled into six rocks, analyzed three scoops of dirt and revealed the watery history of its landing site. As Curiosity begins to climb a mountain for some vertical geologizing, *Science News* imagined key entries from the rover's personal diary, logged as the 1-ton machine made its way across the Martian landscape. Each excerpt opens with a tweet actually posted by NASA on Curiosity's behalf at the Twitter name @MarsCuriosity.



JPL-CALTECH/NASA, MSSS

AUGUST 5, 2012

I'm safely on the surface of Mars. GALE CRATER I AM IN YOU!!!

Bradbury Landing

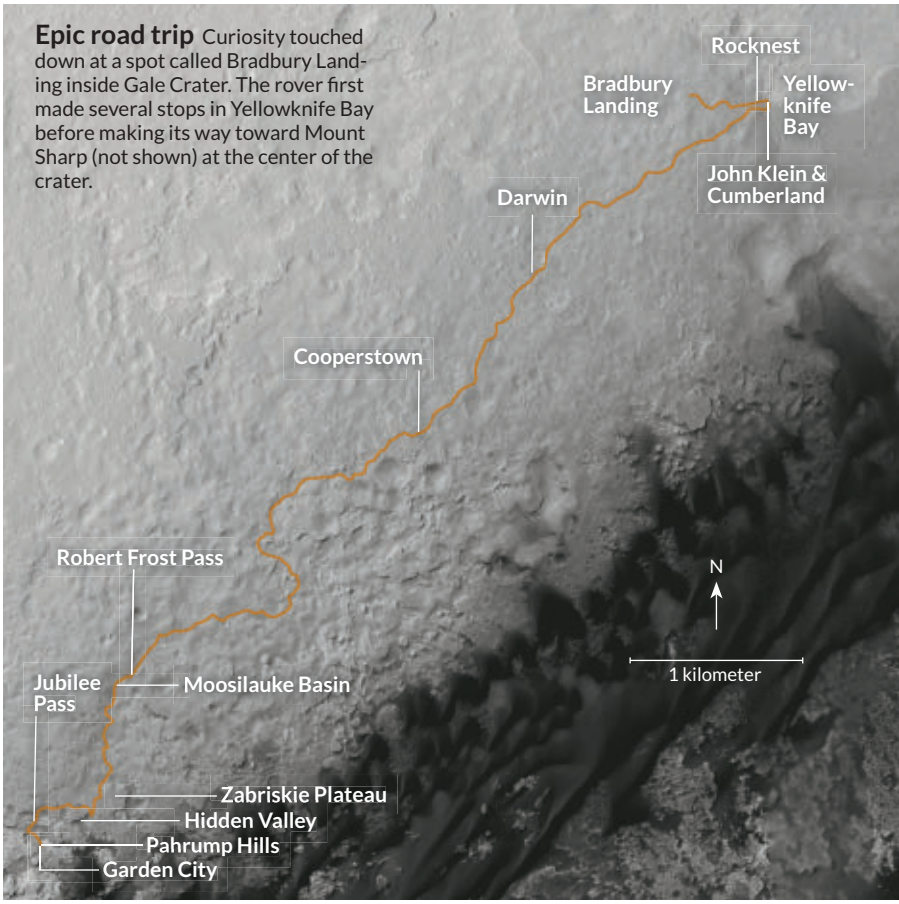
Everyone was worried about those seven minutes that I hurtled through the thin Martian atmosphere, with a rocket-powered "sky crane" slowing my descent. I have to admit it was pretty scary, dangling beneath four fiery engines. But I landed intact at my destination, a spot within Gale Crater named after science fiction writer Ray Bradbury. My job here is to compile my own Martian chronicles, from the stories hidden in the rocks and the dirt. But first, a nap.

AUGUST 22, 2012 | SOL 16

1st drive complete! This is how I roll: forward 3 meters, 90° turn, then back. Electric slide, anyone?

Bradbury Landing

I've got a 10-kilometer road trip in front of me. My ultimate goal is a peak called Mount Sharp, which is so tall and rough that my engineers couldn't land me there. Instead, I've got to drive myself to its base. First, though, I'm going to check out some interesting geology off to the east. True, it's in the opposite direction of Mount Sharp. But it's more about the journey than the destination, right?



Epic road trip Curiosity touched down at a spot called Bradbury Landing inside Gale Crater. The rover first made several stops in Yellowknife Bay before making its way toward Mount Sharp (not shown) at the center of the crater.

OCTOBER 7, 2012 | SOL 61

Today's wake up song: "Digging in the Dirt" by Peter Gabriel. Because no song says "Digging in the Regolith." <sigh>

Rocknest

Pay dirt! I've used my robotic arm to take my first scoop of Martian soil, from a dune called Rocknest. I dump it into my onboard laboratory called the Sample Analysis at Mars to run some Red Planet science. SAM heats up the dirt and measures water coming out. I found small amounts of water, about 1.5 to 3 percent, bound within the minerals that make up Martian soil. If astronauts ever decide to join me here, they might be able to extract some of that water to drink or to make rocket fuel to help them get home again.

NOVEMBER 16, 2012 | SOL 100

I'm taking radiation readings to help future human explorers.

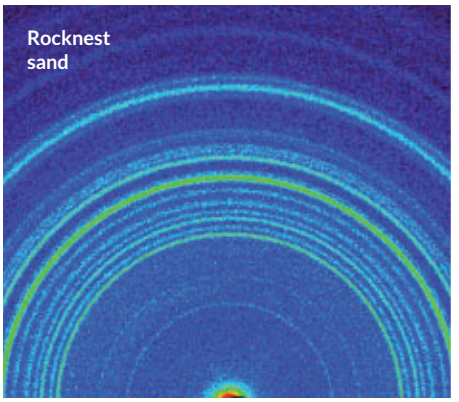
Yellowknife Bay

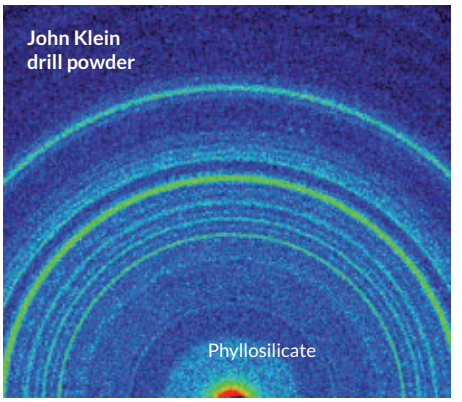
On Earth, a strong magnetic field and a thick atmosphere help protect life from radiation blazing from the sun and the rest of the universe. No such luck on Mars. My radiation counter has clocked enough doses to calculate that astronauts flying from Earth to Mars and back, with a 500-day stay here, would get zapped with enough radiation to increase their chances of developing fatal cancer by about 5 percent. Radiation doesn't bother me, but I'd be sad if visiting me made people sick.

Curiosity collected a scoop of dirt from the Rocknest dune (left) and dumped it into its Sample Analysis at Mars chemical laboratory (right) for analysis.

CLOCKWISE FROM TOP LEFT: JPL-CALTECH/NASA, UNIV. OF ARIZONA. ADAPTED BY E. OTWELL; JPL; JPL-CALTECH/NASA, MSSS

Follow Curiosity's Twitter feed at **twitter.com/marscuriosity**





The first hole drilled (left) to sample the surface of Mars revealed traces of claylike minerals called phyllosilicates (far right) in the rock that did not appear in the Rocknest sand.

FEBRUARY 9, 2013 | SOL 182
The real deal! First drilling on Mars to collect a sample for SCIENCE is a success.

John Klein

Forget dirt: I'm the first to drill into a Mars rock! My grinding instrument has hollowed out a hole about 6.4 centimeters deep within a rock called John Klein. I've dumped the powdered rock into my laboratory instruments, which tell me that at least 20 percent of it is made of clay minerals. Clay forms when water interacts with sediment, so water must have once flowed here. It would have been tasty water too, neither acid nor alkaline. (My friend the Opportunity rover, strolling the other side of the planet, has found similar evidence that water once flowed at her landing site in Meridiani Planum.)

MAY 30, 2013 | SOL 289
Rollin' on the River: Call me Proud Curi. Rounded rocks I found help confirm stream on ancient Mars.

Yellowknife Bay

I've looked at enough rocks by now to confirm my early hunch: I've been exploring an ancient streambed. Three flat rocks I've photographed all contain rounded pebbles, like those at the bottom of rivers on Earth. From what I can tell, the ancient Martian stream had water about waist-deep flowing at walking speed. Not my idea of fun, but could've been a nice place for humans to visit on a hot day.

SEPTEMBER 23, 2013 | SOL 402
Mars' relationship with water? It's complicated. My team is piecing together the long-term history.

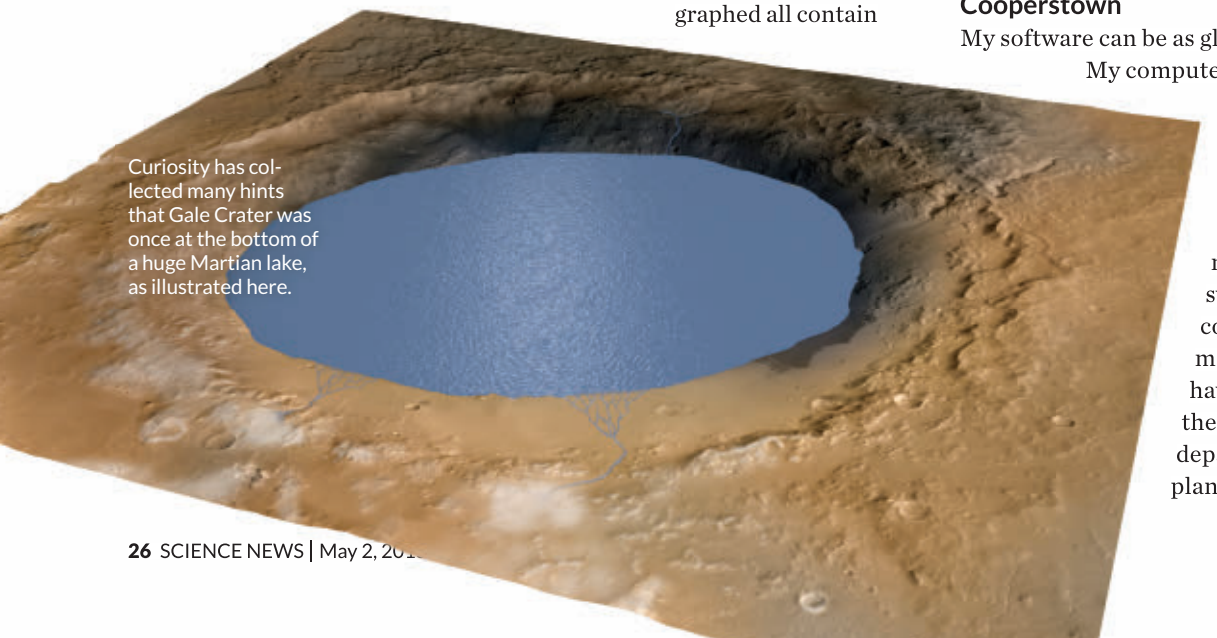
Darwin

I've finally started my long trek toward Mount Sharp, stopping to do some cool science along the way. Here at an outcrop called Darwin, I've been studying another pebbly rock. Its mineral veins, laid down in long-ago water, are different from those I found near my first drill site. That suggests Gale Crater has a complex watery history. Rivers appeared, then dried up, then others took their place. Glad I'm here to bear witness.

NOVEMBER 8, 2013 | SOL 447
So, that happened. Had a warm reset yestersol. I'm healthy. Spending the weekend awaiting new instructions.

Cooperstown

My software can be as glitchy as Windows 8. My computer unexpectedly reset itself, just as I was sending data to another spacecraft to be beamed to Earth. Earlier this year, engineers temporarily switched to my backup computer because of a memory problem I was having. It's all part of the risk of having your IT department on another planet.



Curiosity has collected many hints that Gale Crater was once at the bottom of a huge Martian lake, as illustrated here.

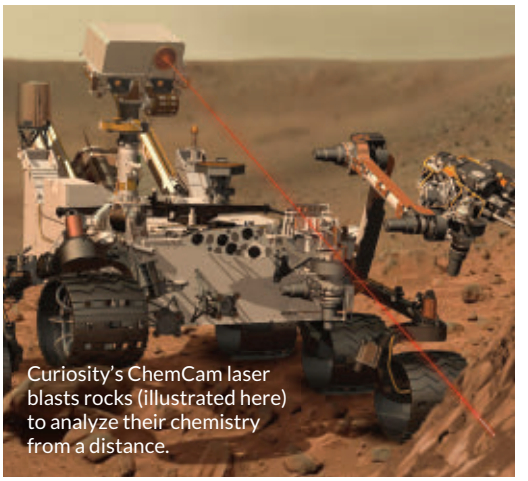
CLOCKWISE FROM TOP LEFT: JPL-CALTECH/NASA, MSSS; JPL-CALTECH/NASA, AMES; JPL-CALTECH/NASA, ESA, DLR, FU BERLIN, MSSS

DECEMBER 5, 2013 | SOL 473

#PewPew #PewPewPew I've fired my ChemCam laser 100,000+ times on Mars for SCIENCE!

Cooperstown

I don't just drill rocks — I blast them as well. My ChemCam laser zaps the surface with more than a million watts of power, turning rock or soil into glowing, electrically charged gas. I analyze the light to read its chemical elements. Call me a perfectionist. I usually blast each spot 30 times with the laser to repeat the measurements and make sure I'm correct. ChemCam has worked so well that NASA plans to launch an upgraded version on another Mars rover in 2020, which is being built based on my design. A mini-me.



Curiosity's ChemCam laser blasts rocks (illustrated here) to analyze their chemistry from a distance.

DECEMBER 9, 2013 | SOL 477

Land O'Lake: I found evidence for an ancient freshwater lake on Mars.

Beyond Cooperstown

At a meeting on Earth, my scientists are reporting a bunch of results from my Yellowknife Bay studies. By comparing John Klein to other rocks, they found that not only did freshwater flow in streams across the surface, it probably also ponded up as a huge lake. I'm glad I don't have to try swimming across something like that.

Another rock I drilled, called Cumberland, turns out to date between 3.86 billion and 4.56 billion years old. This is about the range scientists were expecting, but it's the first time anyone has managed to measure the exposure age of a rock on the surface of another planet. Another first for me. I did it by measuring how much potassium was in the rock compared with argon, which it radioactively decays to over time.

Water running downhill (black arrows) pooled at various times in a lake (illustrated in blue) along Curiosity's path.

DECEMBER 20, 2013 | SOL 488

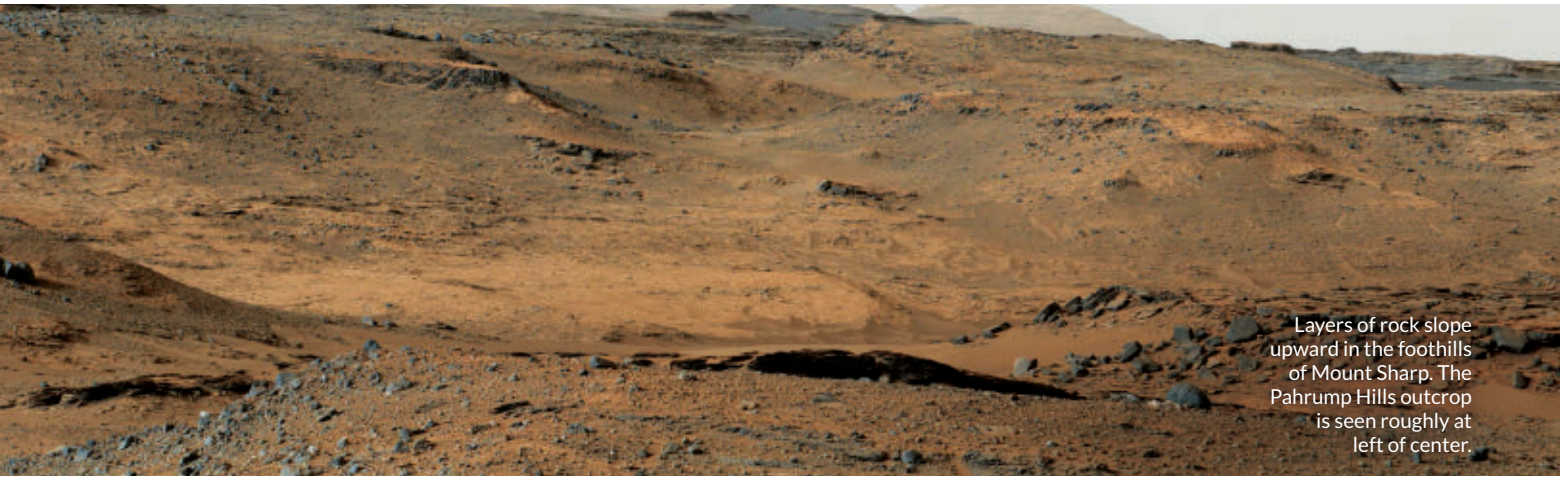
Taking stock this holiday season. I'm planning smoother paths for the new year.

On the road to Mount Sharp

These shoes are killing me! My wheels are made of aluminum, and my engineers made them thin so I wouldn't weigh too much to launch. But maybe, at just 0.75 millimeters thick, they are not quite tough enough: Sharp rocks have been punching holes in them. And there's no AAA on Mars to bring me a spare. Back at the Jet Propulsion Laboratory in California, my engineers are working with a replica of me to fix the problem. They drive the test rover over different kinds of rocks and soil to identify the types of terrain that would be gentlest on my torn-up wheels. I hope they figure it out soon.

The rectangular holes in the rover's wheels are by design, but the irregular tears are unexpected punctures.

FROM TOP: JPL-CALTECH/NASA; JPL-CALTECH//NASA, MSSS; JPL-CALTECH/NASA, MSSS



Layers of rock slope upward in the foothills of Mount Sharp. The Pahrump Hills outcrop is seen roughly at left of center.

10
kilometers
Approximate distance Curiosity traveled on Mars through mid-April 2015

JUNE 17, 2014 | SOL 662
Two paths diverged on a Red Planet, and I, I took the south one, and that has made all the difference.

Robert Frost Pass

Figuring out where to travel is a negotiation between my engineers and me. They plot the general direction they want me to go, then make short-term decisions, based on my feedback, about the best way to get there. For now, we have decided to take a southwestern, sandy path to avoid the hard terrain that was beating up my wheels. Sometimes, they let me drive. I have an autonomous navigation mode where I take several sets of stereo images, and my software figures out if there are any hazards like big rocks in front of me. In auto-nav, I can move around all on my own. Zoom, zoom!

JUNE 24, 2014 | SOL 669
How do I take #selfies? I take many frames & my team stitches them together.

Moosilauke Basin

I may not have an iPhone, but I can snap plenty of good shots. One of my cameras is attached to a mast on my back, and I use it to survey my surroundings. Another camera is on my robotic arm so that I can move it up close to what I want to photograph. It's kind of like my very own selfie stick: I can extend my arm and snap many different shots of myself, which mission controllers combine to create a single selfie.

The high metal content of this iron meteorite, called Lebanon, makes it appear darker and shinier than most other Martian rocks.

JULY 15, 2014 | SOL 689
Heavy Metal! I found an iron meteorite on Mars.

Zabriskie Plateau

It's been a long, hard slog to Mount Sharp, but at least I'm finding some interesting rocks along the way. One, called Lebanon (my picture of it is below left), is an impressive 2 meters long, shiny and black. I found it on my way here. On Earth, iron meteorites are not as common as stony ones, but Mars seems to have a lot of the iron kind. That may be because iron-rich meteorites are tough enough to withstand the powerful sun, strong winds and other forces on Mars that break other rocks apart.

AUGUST 6, 2014 | SOL 711
Smooth roving ahead. I'm navigating a softer trek of sandy valleys on the way to Mount Sharp.

Hidden Valley

As I make my way forward, sand is both a blessing and a curse. It doesn't shred my wheels like the sharp rocks do, but when the sand is too soft I come close to getting stuck. I thought this sand-filled valley would be a safe passage, but I was wrong. I'm going to turn around to find another route.

SEPTEMBER 11, 2014 | SOL 746
Made it! After 2 years of driving over some pretty rough terrain, I'm at the base of Mount Sharp.

Jubilee Pass

I am so happy to be here. Mount Sharp is impressive. I can see layers of rock rising in undulating swales ahead. My scientists think these layers were laid down as sediments at the bottom of an ancient lake. From what I've seen, that's a reasonable guess.

FROM TOP: JPL-CALTECH/NASA, MSSS; JPL-CALTECH/NASA, LANL, CNES, IRAP, LPGNANTES, CNRS, IAS, MSSS

For an expanded look at Curiosity's travels, visit **bit.ly/SN_MartianDiaries**

DECEMBER 16, 2014 | SOL 839

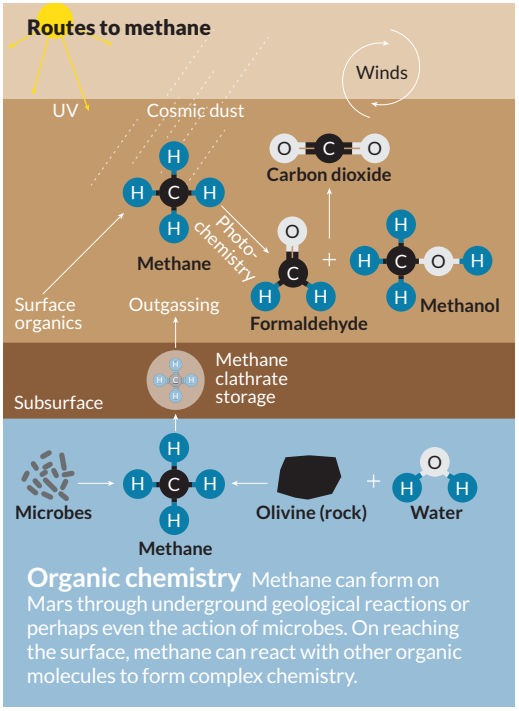
Certified organics! I detected organics for the first time on the surface of Mars.

A change in the air: I detected a 10x spike of methane in Mars' atmosphere.

Pahrump Hills

It's a big week for my scientists back on Earth, who are announcing new results. One involves organic molecules — not the pricey kind from Whole Foods, but molecules that contain carbon. Back in Yellowknife Bay I found very simple organic molecules, but now I've spotted more complex ones. And I'm becoming more confident that the organics are actually from Mars and not something that I carried here from Earth. In other words, I arrived nice and clean.

I've also smelled methane for the first time. Other spacecraft have caught whiffs of methane before, but it has been hard to pin down where the gas might be coming from and what might create it. Methane on Earth comes from cow burps and other nasty things. But geological processes, like chemical reactions, can also produce methane. I've been sniffing for methane as I trundle along Gale Crater. On four occasions I measured spikes of methane that were about 10 times higher than background levels. That suggests something on Mars is generating fresh methane. No idea what, though. I certainly haven't spotted any cows.



MARCH 24, 2015 | SOL 935

YES! I found NO3! Biologically useful nitrogen, that is. Another sign ancient Mars = habitable.

Garden City

I've toasted more sediments and found nitric oxide in them. That's one nitrogen atom plus one oxygen atom, possibly produced by breakdown of nitrate (one nitrogen plus three oxygens), which can be used by living organisms. My discovery doesn't mean life was here, of course (sniff!); nitric oxide could have come from lightning or meteorite impacts striking nitrate in Mars' atmosphere. But it's one more clue that chemical compounds used by life on Earth are also here on Mars.

SPRING/SUMMER 2015

And off into the foothills of Mount Sharp I go. I've had a few memory glitches and my robotic arm sometimes gets creaky, but it's nothing this old rover can't handle. I'd like to think I have plenty of geologizing ahead of me. After all, there's a whole lot more Mars to explore. ■

Curiosity has navigated treacherous sand dunes (foreground) and tough terrain on its way to Mount Sharp, shown in the distance.

FROM TOP: NASA/JPL-CALTECH/SAM-GSFC/UNIV. OF MICHIGAN. ADAPTED BY E. OTWELL; NASA/JPL-CALTECH/MSSS. EDIT BY JASON MAJOR

Infested
Brooke Borel
UNIV. OF CHICAGO, $26

BOOKSHELF

Tales of the bedbug, one of the world's most reviled insects

Bedbugs sure get around. From housing projects, hostels and cheap hotels (and some that aren't so cheap), the bloodthirsty insects hitchhike in the darkest recesses of weary travelers' luggage and backpacks. They've made the rounds in a metaphorical sense too, appearing in poetry, prose, plays and, perhaps unsurprisingly, quite a few blues songs.

The cultural significance and the biology of the insect are the focus of *Infested*, by science writer Brooke Borel, who has suffered infestations both at home and while traveling. Lured by body heat and exhaled carbon dioxide, bedbugs (*Cimex lectularius*) pierce the skin of slumbering victims. The bugs' hypodermic mouthparts have diameters barely exceeding the width of a human red blood cell.

Although bedbugs don't transmit disease, Borel writes, these vampiric pests aren't harmless: Proteins in their saliva can cause rashes and other allergic reactions, and the filth they leave behind can trigger asthma. Extreme bedbug infestations have caused anemia and either produced or exacerbated nervous breakdowns. It's little wonder that the bloodsuckers are the fastest growing moneymaker for exterminators.

In researching this captivating book, Borel spoke with pest control specialists and scientists, some of whom regularly allow the pests they're raising for research to feed on their own arms and legs (*SN: 9/7/13, p. 32*). Borel traveled to Eastern Europe, where she collected bedbugs from a bat-infested attic. Similar finds elsewhere, plus genetic analyses of bedbugs worldwide, suggest that bedbugs first became acquainted with humans more than 200,000 years ago, presumably when our ancestors frequented caves where a similar species of insect fed on bats.

Bedbugs were well known to the ancients, Borel writes. They were mentioned by the Greek playwright Aristophanes in the fifth century B.C. A third century B.C. papyrus reveals that Egyptians had spells to repel the bugs. The insect came to the Americas with European colonists.

Our long shared history with bedbugs seems destined to continue. For a few decades, DDT and other pesticides kept bedbugs largely under control. Alas, bedbugs have evolved resistance to many pesticides and have staged a comeback in many parts of the United States and other countries.

Sleep tight. — *Sid Perkins*

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

SCREENTIME

Spot the northern lights with Aurorasaurus

The Twitterverse can help you catch a glimpse of the shimmering northern lights (shown above in Greenland). The Aurorasaurus project uses crowdsourcing to assemble a real-time map of aurora sightings around the Northern Hemisphere. Aurora-related tweets and reports made by citizen scientists feed in to the project through its smartphone apps and website.

Aurorasaurus got its first major test in March, when the sun spat out a massive flare of charged particles toward Earth. Collisions between these particles and the nitrogen and oxygen in the upper atmosphere produced blue-green auroras seen from as far south as Colorado. Aurorasaurus volunteers submitted more than 160 sightings of the northern lights and verified more than 250 tweets as genuine sightings. Thanks to these reports, Aurorasaurus sent 361 notifications to users alerting them of a nearby visible aurora and helping them check "see the northern lights" off their bucket lists. — *Thomas Sumner*

Track emerging auroras at **aurorasaurus.org**

TO DO

Robot Revolution

OPENS MAY 21, 2015
A hands-on exhibit showcases the abilities of robots. Visitors envision a future of robotic companions and can build their own bot.
MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO

Nature's Fury: The Science of Natural Disasters

THROUGH AUGUST 9, 2015
The exhibit explores the causes and consequences of extreme phenomena including tornadoes, earthquakes and volcanoes.
AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY

Plants of the Society Islands

THROUGH MAY 22, 2015
Prints made from 18th century engravings depict plants that were collected on an expedition to the South Pacific led by the great explorer James Cook.
NATIONAL TROPICAL BOTANICAL GARDEN, KALAHEO, HAWAII

FROM LEFT: MADS PIHL/VISIT GREENLAND/FLICKR (CC BY 2.0); COURTESY OF THE NATIONAL TROPICAL BOTANICAL GARDEN

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xNo


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✓Yes


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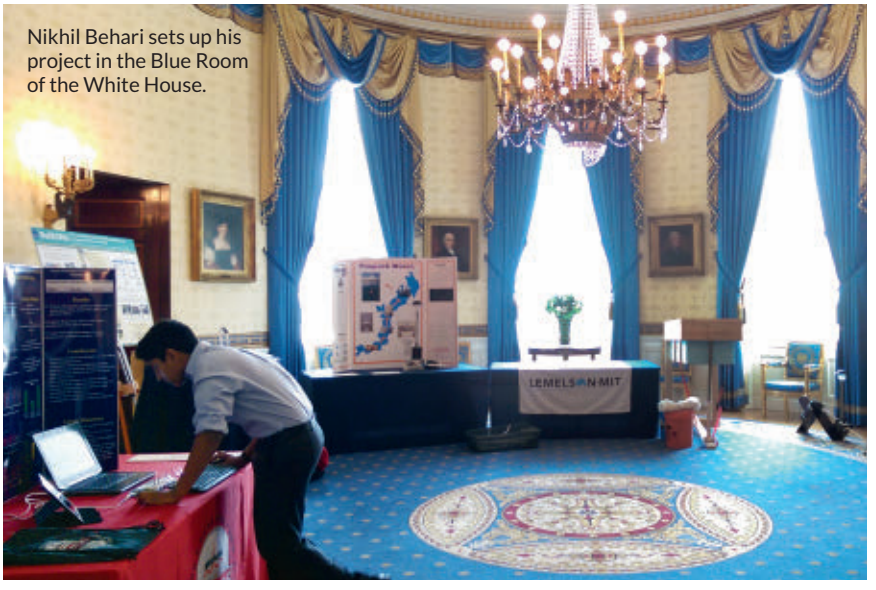
FAIR REPORT

White House hosts student science fair



Nikhil Behari sets up his project in the Blue Room of the White House.

WASHINGTON — When it came to getting into the White House Science Fair, Holly Jackson had it all sewed up. Nikhil Behari, too, had just the right touch. And as for meeting President Barack Obama in person, it sent chills running up and down Harry Paul's spine.

"No pun intended," says Paul, who along with Jackson and Behari, was among the more than 100 students invited to exhibit at the fifth White House Science Fair, held March 23. Paul, 18, presented a novel spinal implant to treat scoliosis. For Paul, the research was personal: He was born with the sideways curve of the spine that marks the condition.

"The notion that you take your own experiences and are able to apply it — what a powerful story that is," Obama told Paul while touring the fair.

The fair highlighted science and engineering projects led by students of all ages. The youngest: a team of 6-year-old girls from Tulsa, Okla. The Girl Scout Daisies created a page-turning device out of Lego bricks. Obama granted them a special award: a group hug.

As in years past, many of the invited students had previously participated in science competitions run by Society for Science & the Public. The nonprofit organization also publishes *Science News* and *Science News for Students*. At the Intel International Science and Engineering Fair in 2014, Paul won a Best of Category award in Engineering: Materials and Bioengineering and the Innovation Exploration Award. Jackson took the top award at the 2014 Broadcom MASTERS competition.

Jackson, 14, of San Jose, Calif., explored the science of sewing for her project. She tested 120 different combinations of fabric, thread and stitch to find the strongest.

"It was combining my passion for sewing with my passion for science," Jackson says.

Behari, 14, was among the dozen students to present his research to the president. Previously, Behari won a second place award in technology at the 2014 Broadcom MASTERS national finals. Using a special keyboard, Behari, of Sewickley, Pa., discovered a way to authenticate user identity by analyzing the way a person types.

"It really motivates me. It pushes me to continue working on the project and on other projects," Behari says of his opportunity to explain his work to Obama.

Among those visiting the fair was television's Bill Nye the Science Guy. In an interview, Nye called Behari's project a fair highlight: "It's freaking brilliant, I have to say."

For Natalie Ng, 19, of Cupertino, Calif., her experiences in the Intel Science Talent Search, Intel ISEF and now the White House Science Fair come with an obligation. "It is my responsibility to share my love for science and try to be an inspiration to other people to go into STEM fields," says Ng, who is in her first year at Stanford University.

Kelly Charley, 16, of Teec Nos Pos, Ariz., was a finalist in the Intel ISEF 2014 for her solar hot water heater. She designed the passive device to heat the traditional Navajo homes known as hogans. Practice made for progress before the device's White House debut.

"It brought in a lot of different views. I was able to look at my project, reassess and amp it up for this year's project," Charley says of her Intel ISEF experience.

At the fair, Obama announced more than $240 million in commitments from the private sector to support students in science, technology, engineering and mathematics.

"These young scientists and engineers teach us something beyond the specific topics that they are exploring. They teach us how to question assumptions, to wonder why something is the way it is and how we can make it better. And they remind us that there is always something more to learn and to try, and to discover and to imagine. And that it's never too early or too late to create or discover something new," Obama says.

— *Andrew Bridges*

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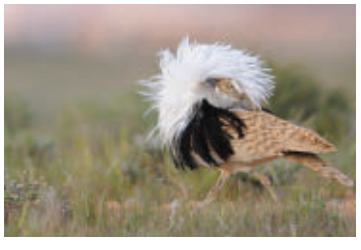
MARCH 21, 2015

SOCIAL MEDIA

Love amongst the birds

Male bustards fluff up their feathers and run in hopes of catching a female's eye (*SN: 3/7/15, p. 4*). Readers on Twitter appreciated this attention-getting display.



"This guy totally stole my move."
@Prof_E_Johnson

"It's working. This lady right here is super impressed."
@delight_monger

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Space-based particle hunting

Physicist Sam Ting spent years lobbying to put a cosmic ray detector aboard the International Space Station. Now he's using the Alpha Magnetic Spectrometer to collect particles that may shed light on the nature of dark matter, as ***Andrew Grant*** *reported in "Eyes on the invisible prize" (*SN: 3/21/15, p. 22*).*

"The Alpha Magnetic Spectrometer experiment can only capture particles that reach it," wrote **Irwin Tyler**. If cosmic rays collide with particles on their way to Earth or stray from their original travel path, he writes, "then there can be no accurate census of the kind Sam Ting is looking for. Should any sky survey find clustering of these particles, it would merely be an artifact created by these variations. Moreover, both counts and clustering would likely look very different if measured from a different position in our galaxy."

Grant agrees that cosmic rays whizzing past the International Space Station aren't necessarily representative of particle populations elsewhere in the galaxy. "The magnetic fields of Earth and the solar system warp the particles' trajectories. And little clumps of dark matter near Earth could theoretically send extra particles our way. Even so, cosmic rays remain a key tool for understanding the universe, and AMS is the best detector ever put in space to study them," he says.

Wheat over water

Wheat came to the British Isles long before farming did. Scientists pulled wheat DNA from the soil of a site near the Isle of Wight. The site predates England's agricultural lifestyle by about 2,000 years, wrote ***Bruce Bower*** *in "Wheat reached England before farming" (*SN: 3/21/15, p. 17*).*

Reader **Mark S.** wanted to know how ancient hunter-gatherers schlepped the wheat all the way to England. "Wheat is bulky. How would people, before the invention of the wheel, have transported it back then?"

Detecting lots of wheat DNA in the soil doesn't necessarily mean large quantities of wheat were present, says study coauthor **Robin Allaby** of the University of Warwick in England. It's more likely that hunter-gatherers only transported small quantities at a time, and that wheat wasn't a big part of their diet. "As for the means of travel, we feel that it is most likely boat contact," he adds. The site where the DNA was found was once a boat-building workshop. The nearest farmers, located along the west coast of France, were also skilled boaters.

Living in the urban jungle

*In "When animals invade human spaces" (*SN: 3/21/15, p. 28*),* ***Nathan Seppa*** *reviewed a book about the unexpected ways that animals adapt to city life.*

Readers had plenty of stories about close encounters with wild animals. **Mike Van Horn** listed the menagerie of mammals that have passed through his neighborhood, including deer, coyotes, mountain lions and river otters. "We've also had migrations of large black and yellow spiders. Beautiful but a bit intimidating," he wrote, adding that "talk of humans invading animals' spaces fails to recognize that we also are animals. We are all invading each other's spaces. It is a shifting balance."

Commenter **RedCentipede** pointed out that hunting may play a role in that shifting balance: "Here in eastern Massachusetts, deer are now so common in suburbia that they're a serious traffic menace, causing a couple of thousand crashes every year. Why so common in suburbia? Because hunting is prohibited within the populated parts of towns, so deer that move into the towns flourish and reproduce."

Whatever the cause, some people don't mind sharing their living spaces. **Marc Harris** opined that animals are "far more desirable neighbors than my human ones."

Correction

"Teens have higher anaphylaxis risk than younger kids" (*SN: 3/21/15, p. 15*) should have said that pharmaceutical company Mylan markets, not makes, the epinephrine injector EpiPen.

Y. HINGRAT

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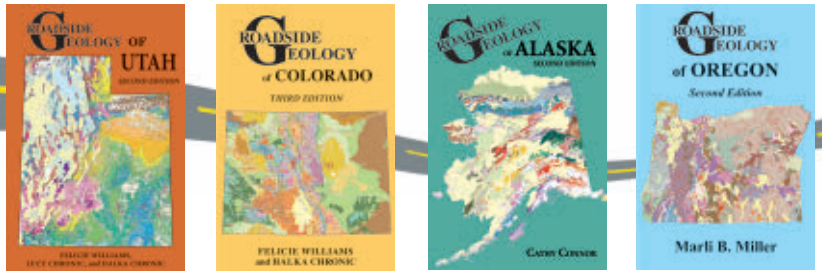

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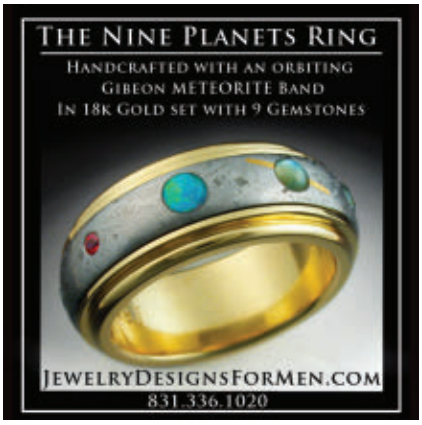

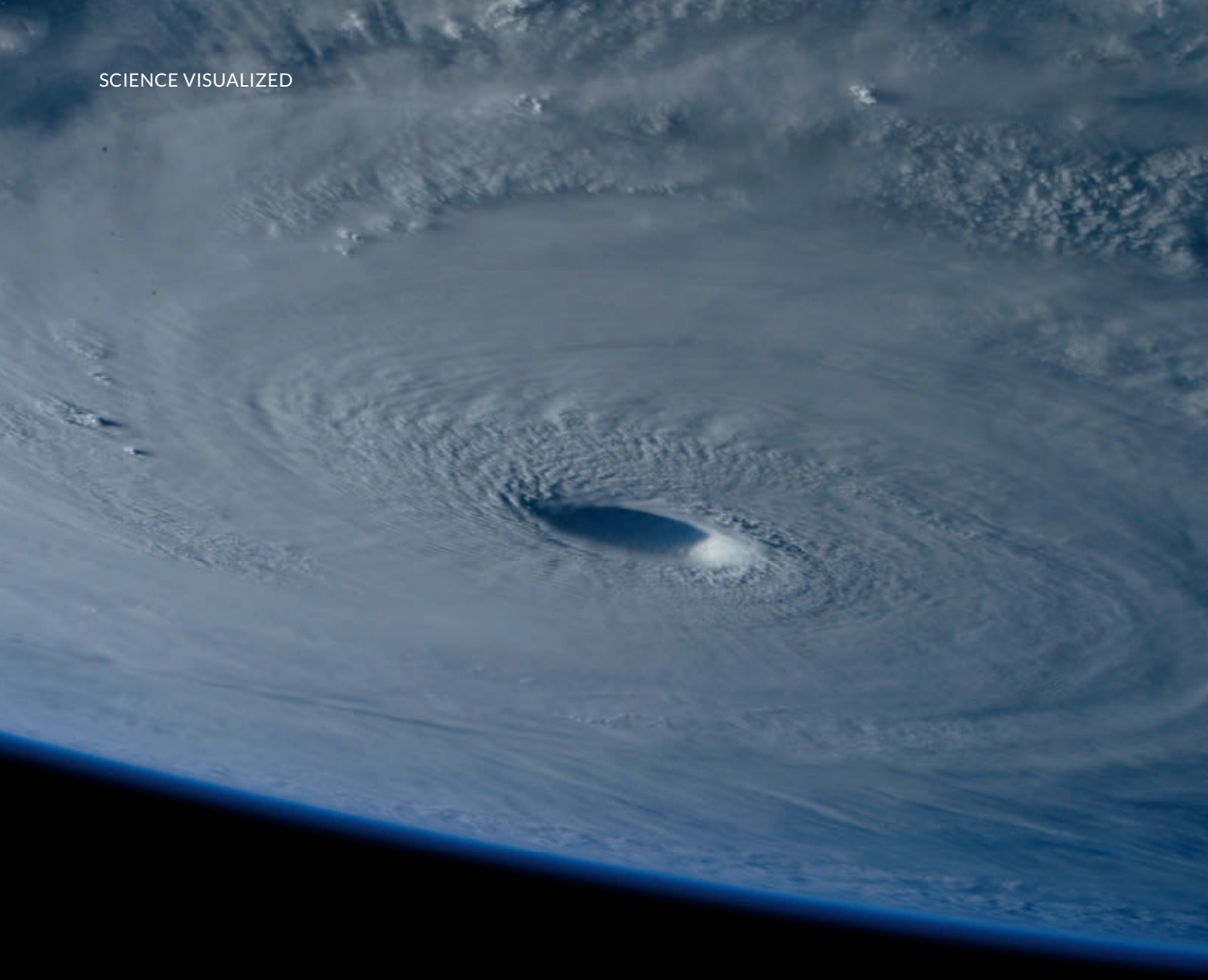

S. CRISTOFORETTI/ESA, NASA

Monster storm in the window

Looking down from 400 kilometers above Earth, astronauts aboard the International Space Station couldn't help but gawk at a huge typhoon churning in the Western Pacific. On March 31, European Space Agency astronaut Samantha Cristoforetti captured this photo of Typhoon Maysak at near-peak strength as it drifted toward the Philippines.

Maysak was the record-breaking second major cyclone to form in the Western Pacific before April, the typical start of the region's typhoon season. Packing winds exceeding 200 kilometers per hour, the storm swirled about a well-formed eye that Cristoforetti's crewmate Terry Virts compared to "a black hole from a sci-fi movie." The typhoon killed five people and caused extensive damage in the Federated States of Micronesia.

The unusually intense preseason typhoons may have stemmed from El Niño, an eastward shift of warm water in the Pacific. Sea surface temperatures that were 1 to 2 degrees Celsius above average provided more fuel for budding storms. On April 9 the National Weather Service estimated that El Niño conditions have a 70 percent chance of continuing through summer. If El Niño sticks around, Maysak may prove a harbinger of a perilous typhoon season. — *Thomas Sumner*

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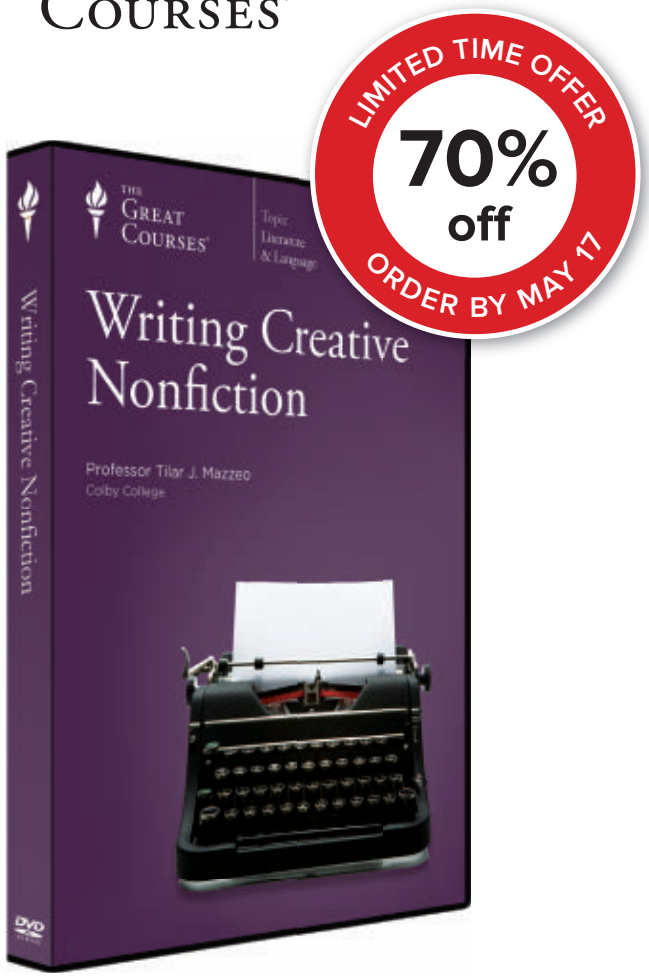

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