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SCIENCE NEWS MAGAZINE
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FEBRUARY 20, 2016

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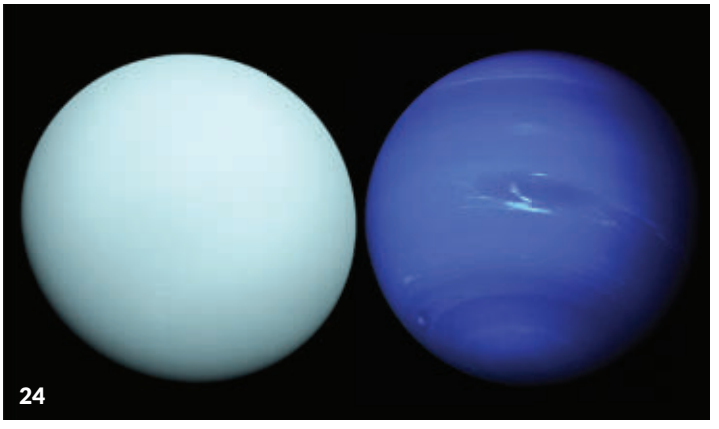

Features

News

CLOCKWISE FROM TOP: JPL-CALTECH/NASA; DARPA; KELSEY ROBERTS/USGS

Departments

COVER A surprising community of microbes is taking advantage of plastic in the oceans. *Becca Clason*

In all sorts of circumstances, life finds a way

Reading Chris Samoray's deep dive into the surprising new marine habitat created by human pollution, I found myself repeating Jeff Goldblum's famous line from *Jurassic Park*: "Life finds a way." It's one of those short memes that sticks with you, but the extended passage from Michael Crichton's book is perhaps even more apropos: "Life breaks free. Life expands to new territories. Painfully, perhaps even dangerously. But life finds a way."

Most articles about the plastic plaguing our oceans describe the threats to marine life. Those dangers could be considerable, given the huge amounts of trash fouling our seas. But the unexpected ways that living things respond should also give us pause. Of course microbes — those adaptable, ubiquitous and entrepreneurial creatures — have found a way to take advantage of our carelessness, sailing the seas on bits of nutrient-coated plastic. As Samoray writes on Page 20, the consequences, good or bad, are still unknown, but the plastisphere certainly offers a fascinating new niche to investigate.

The relentlessness of microbes, and the unintended results of human activity, also fuel the spread of and worry over Zika virus, as Meghan Rosen reports on Page 16. The virus hails from Africa and spread to Asia decades ago. Until recently, it received little attention, producing seemingly few symptoms in those infected. But air travel has given the mosquito-borne Zika (and related viruses such as dengue and chikungunya) a passport to wander the globe. Scientists suspect the ongoing Zika outbreak in Brazil is driving the increasing incidence of a serious birth defect, now recognized as a public health emergency by the World Health Organization. Cases of microcephaly have skyrocketed in the areas hardest hit by Zika. Researchers are now trying to find ways to combat the virus.

Humans, of course, are also included in the life that finds a way — whether trying to genetically re-create extinct species, battle a dangerous virus, deal with ocean pollution or even explore the most distant of territories, such as Uranus and Neptune. Christopher Crockett contemplates how we might tackle that last one on Page 24. — *Eva Emerson, Editor in Chief*

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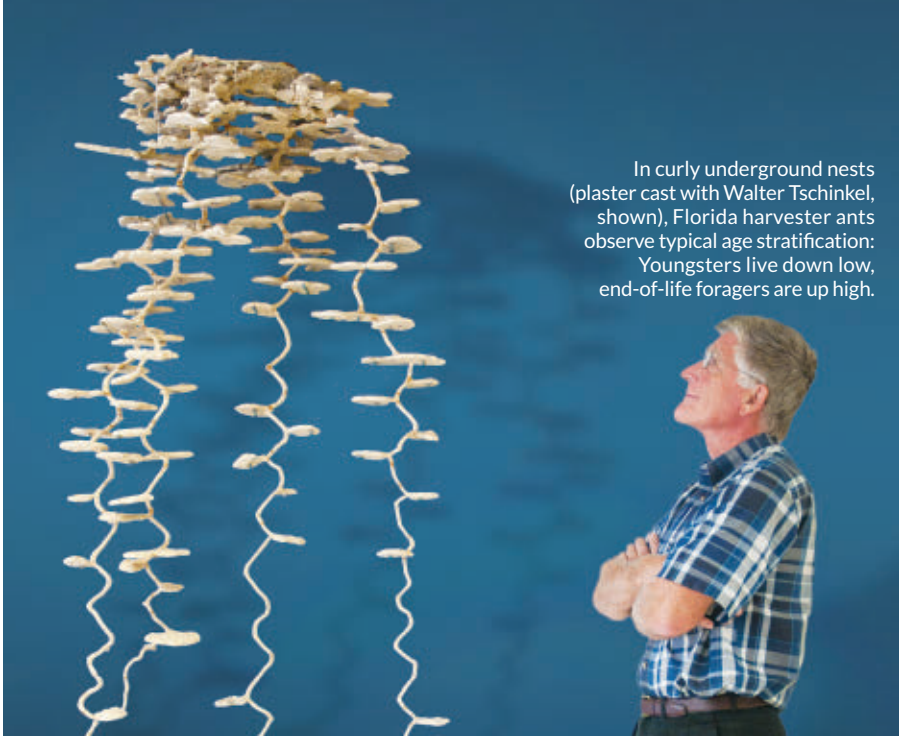
Excerpt from the February 19, 1966, issue of *Science News Letter*

50 YEARS AGO

Soviet TV lands on moon

The first spacecraft to land on the moon without demolishing itself in the process did so on Feb. 3. The Soviet Union sent it, and it proved its feat by sending back photographs of the lunar surface in which objects the thickness of a dime were visible.... Despite their success, however, Soviet scientists said that this did not mean they were going to send a man to the moon in the immediate future.

UPDATE: Just three years later, in July 1969, U.S. astronauts Neil Armstrong and Buzz Aldrin stepped onto the moon. Since the lunar landings, spacecraft have extended their planetary footprint, touching down on Venus, Mars, Saturn's moon Titan, a comet and two asteroids. The Opportunity and Curiosity rovers continue to meander and send back data from the Red Planet (*SN: 5/2/15, p. 24*; *SN: 2/22/14, p. 10*). Just accomplished by SpaceX: nailing a rocket landing on our own planet so the rocket can be refurbished and reused (*SN: 1/23/16, p. 16*).



In curly underground nests (plaster cast with Walter Tschinkel, shown), Florida harvester ants observe typical age stratification: Youngsters live down low, end-of-life foragers are up high.

IT'S ALIVE

Restless architects we don't understand

Florida harvester ants "make a nest that is truly beautiful in its architecture," says Walter Tschinkel. He has poured molten metal or plaster into the underground nests and dug up the hardened casts to reveal their multilevel shapes. Much about these ant nests, however, defies explanation.

For reasons still unknown, colonies of Florida harvester ants (*Pogonomyrmex badius*) abandon their lovely nests about once a year and dig a new one. At a study site Tschinkel calls Ant Heaven, the colonies typically move about two to six meters away from their old homes.

He and his students at Florida State University in Tallahassee have found no pattern to the shifts: no tendency to escape tree shade or seek more of it, or to edge away from big neighbor colonies. And the new nests look like the old ones: a tight cluster of interconnected, cookie-shaped chambers that dangle more chambers below on spiraling tendrils of tunnels.

Ants excavate a new nest in "an amazingly fast process," Tschinkel says. "They just bring soil up — hundreds of workers going all day." A colony, typically about 4,000 ants, can dig and move into a new nest in four to seven days.

During a move, ants bustle back and forth along a well-worn path between the old nest and the new. Workers carry their queen, hundreds of larvae and young ants, plus seeds they've collected and stored for food. "They even move their charcoal," Tschinkel says. And that's another puzzle.

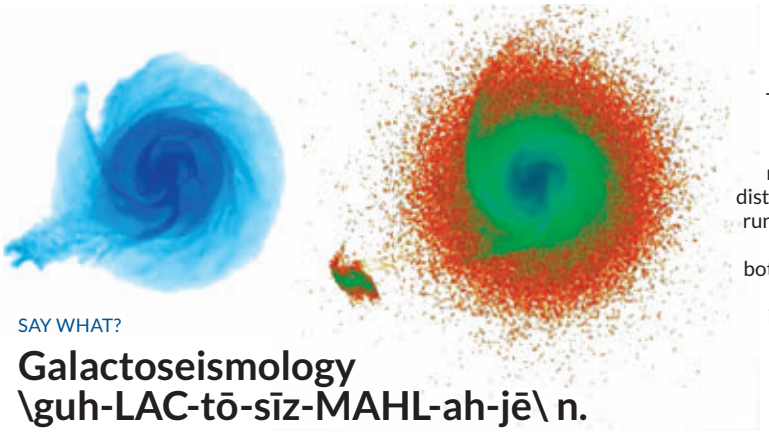
These ants scatter scorched pine needle tips and other charcoal around nest openings, some 77,000 pieces for a big colony. Tschinkel and students have tested more than half a dozen notions about the charcoal's possible benefits, but found nothing convincing. (Deterring intruding ants? No. Retaining water after rain, like mulch? No. Warming the nest? A very little bit.)

Charcoal ranks as a minor enigma compared with what Tschinkel called the "charming, central mystery" in an October overview in the *Journal of Bioeconomics*. Ants share behavioral rules, but their queen has babies, not a blueprint. "Everything they accomplish, they accomplish without a leader... without a plan, without prior instruction, and in the case of subterranean ant nests, in the dark." — *Susan Milius*

Harvester ants gather thousands and thousands of seeds to store underground for future meals.

FROM TOP: CHARLES F. BADLAND; ALEX WILD

Watch the casting of an ant nest at **bit.ly/SN_harvesterants**



The Milky Way's gas (left image) and stars (right) might have been disturbed by a close run-in with a dwarf galaxy (blob at bottom left of both images), as seen in this computer simulation.

SAY WHAT?

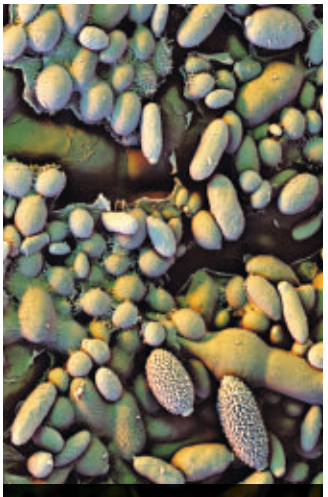
Galactoseismology \guh-LAC-tō-sīz-MAHL-ah-jē\ n.

The study of disturbances in a galaxy's structure (essentially, galaxy quakes) to discover dark, but massive, cosmic objects.

Ripples in the Milky Way's outer layers of gas were the first clue. Now, scientists suspect they have found a small, faint galaxy that brushed past our galaxy a few hundred million years ago. This dwarf galaxy doesn't have many stars, but it is rich in dark matter, the invisible but predominant source of mass in the universe. Sukanya Chakrabarti, an astronomer at the Rochester Institute of Technology in New York, reported the findings January 8 at a meeting of the American Astronomical Society.

Chakrabarti first came up with the idea of a dwarf galaxy hit-and-run in 2009 as a way to explain the puzzling galactic ripples. In 2015, her team reported finding stars where she had predicted the runaway galaxy resided, about 300,000 light-years away in the constellation Norma. Chakrabarti says she has since determined that three of the stars are speeding away at about 200 kilometers per second, compelling evidence that the stars are part of a gravitationally bound system bolting from the Milky Way.

The researchers still need more evidence to prove that they have seen a dwarf galaxy. But if the finding is confirmed, it will mark the first use of galactoseismology to discover an object via the galactic crime scene it left behind. — *Andrew Grant*



This raspberry leaf (in a closeup, colorized electron micrograph) is covered in a biofilm of bacteria and fungi. Rosmarinic acid may keep bacterial visitors from overtaking a plant.

MYSTERY SOLVED

Plants trick bacteria into attacking too soon

Plants protect themselves from bacterial assault with mystery compounds that interrupt the bacteria's best laid plans. Now, researchers have finally identified one of those protective compounds.

Rosmarinic acid is a plant's secret weapon for disarming bacteria, researchers report in the Jan. 5 *Science Signaling*. Tino Krell and colleagues from the Spanish National Research Council in Granada found that rosmarinic acid mimics a molecule that bacteria use to signal each other in response to changes in population density. The compound fools bacteria into sending signals to their peers to invade a plant before the microbes have enough troops, so the plant can fight them off, the scientists speculate.

This defensive chemical might be useful for limiting bacterial crop damage and minimizing hospital infections caused by bacteria, the researchers say. — *Chris Samoray*

FOR DAILY USE

Pill measures gut gas

Gas concentrations in the gut can reveal secrets about digestive tract health, and may be skewed in conditions such as irritable bowel syndrome. But sampling gas in breath or stool doesn't give the most accurate picture of what's bubbling in the intestines. Australian researchers have designed a swallowable gas-sensing capsule that could someday provide an inside look at the gases in the human gut.

Each capsule contains a sensor for hydrogen, carbon dioxide and methane. Every five minutes, as it travels through the digestive system, the capsule sends updates about its gassy surroundings to a smartphone. Too much methane or hydrogen in the gut, the scientists say, could reflect digestive problems.

The team tested the capsule in pigs, which have gas-generating gut microbes similar to humans'. In two pigs fed a high-fiber diet, the pills detected increased carbon dioxide levels in the stomach and small intestine after eating, a shift not seen in two pigs fed a low-fiber diet, the researchers noted in the January *Gastroenterology*.

The capsule is a proof of concept that the researchers are working to shrink down. The preliminary design — about as long as a Brazil nut — may still be a hard pill to swallow. — *Sarah Schwartz*

This 3.5-by-1.2-centimeter capsule can be swallowed to measure gut gases and send its findings to a smartphone. Researchers in Australia tested the device in pigs fed different amounts of fiber.

CLOCKWISE FROM TOP: S. CHAKRABARTI/ROCHESTER INST. OF TECH.; K. KALANTAR-ZADEH *ET AL*/*GASTROENTEROLOGY* 2016; STEFAN DILLER/SCIENCE SOURCE

ATOM & COSMOS

Hunt for Planet Nine heats up

Computer simulations add to evidence for presence of orb

BY CHRISTOPHER CROCKETT

For a planet that hasn't technically been discovered yet, Planet Nine is generating a lot of buzz. Astronomers have not actually found a new planet orbiting the sun, but some remote icy bodies are dropping tantalizing clues that a giant orb is lurking in the fringes of the solar system.

Six hunks of ice in the debris field beyond Neptune travel on orbits that are aligned with one another, Caltech planetary scientists Konstantin Batygin and Mike Brown report (*SN Online: 1/20/16*). Gravitational tugs from the known planets should have twisted the orbits around by now. But computer simulations suggest the continuing alignment could be explained by the effects from a planet roughly 10 times as massive as Earth that comes no closer to the sun than about 30 billion kilometers — 200 times the distance between the sun and Earth. The results appear in the February *Astronomical Journal*.

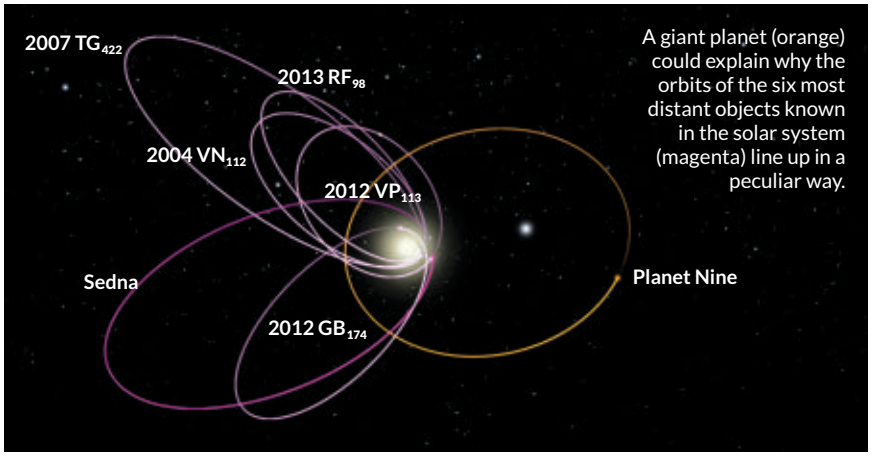
Evidence for a stealth planet is scant, and finding such a world will be tough. Discovering hordes of other icy nuggets on overlapping orbits could make a stronger case for the planet and even help point to where it is in the sky. Until then, researchers are intrigued about a potential new member of the solar system but cautious about a still theoretical result.

"It's exciting and very compelling work," says Meg Schwamb, a planetary scientist at Academia Sinica in Taipei, Taiwan. But only six bodies lead the way to the putative planet. "Whether that's enough is still a question," she says.

Hints of a hidden planet go back to 2014. Twelve bodies in the Kuiper belt, the ring of frozen fossils where Pluto lives, cross the midplane of the solar system at roughly the same time as their closest approach to the sun (*SN: 11/29/14, p. 18*). Some external force — such as a large planet — appears to hold the orbits in place, reported planetary scientists Chad Trujillo of the Gemini Observatory in Hilo, Hawaii, and Scott Sheppard of the Carnegie Institution for Science in Washington, D.C.

This new analysis "takes the next step in trying to find this giant planet," says Sheppard. "It makes it a much more real possibility."

In addition to what Sheppard and Trujillo found, the long axes of six of these orbits point in roughly the same direction, Batygin and Brown report. Those orbits also lie in nearly the same plane. The probability that these alignments are just a chance occurrence is 0.007 percent.



A giant planet (orange) could explain why the orbits of the six most distant objects known in the solar system (magenta) line up in a peculiar way.

R. HURT/IPAC/CALTECH, WORLDWIDE TELESCOPE

"Imagine having pencils scattered around a desktop," says Renu Malhotra, a planetary scientist at the University of Arizona in Tucson. "If all are pointing in the same quarter of a circle, that's somewhat unusual."

A hidden world might explain a couple of other oddities about the outer solar system. Dwarf planets Sedna and 2012 VP_{113}, for example, are far removed from the eight known planets (*SN: 5/3/14, p. 16*). Maybe Planet Nine put them there.

The planet would also stir up some of the denizens of the Kuiper belt into orbits that are roughly perpendicular to the rest of the solar system. Batygin was surprised to learn that a population of five such objects exists. When he and Brown compared their simulations of an agitated Kuiper belt with these bodies' cockeyed trajectories, they found a match. "If there was one dramatic moment in the past year and a half, this was it," Batygin says. "We didn't really believe our own story for the longest time. But here was the strongest line of evidence."

Given what scientists know about how the solar system formed, the proposed planet is not native to its current environment. It probably originated closer to the sun and was kicked to the hinterlands after flirtations with the current roster of giant planets.

This wouldn't be the first time scientists were led to a new world by the odd behavior of another. Astronomer Johann Galle found Neptune in 1846 after mathematicians Urbain Le Verrier and John Couch Adams calculated that an unknown planet could be causing Uranus to speed up and slow down along its orbit (see Page 24).

Uranus was a more clearly defined problem, says Scott Tremaine, an astrophysicist at the Institute for Advanced Study in Princeton, N.J. Le Verrier and Adams were trying to understand why Uranus appeared to defy the law of gravity, whereas Batygin and Brown are piecing together a story of how the solar system evolves.

"When we're talking about history rather than laws, it's always easier to go astray," Tremaine says.

The orbital alignments are striking, he says, and Batygin and Brown have done sensible calculations. But he worries about hunting for statistical significance after noting a possible oddity. "That can be very misleading," he says. "The numbers that won the Powerball lottery are an unusual combo, but that doesn't mean anything."

In the meantime, "the hunt for Planet Nine is on," Batygin says. Data from NASA's WISE satellite, which spent nearly nine months making an infrared map of the sky, rule out the existence of a planet as massive as Saturn out to 4.2 trillion kilometers from the sun, and a Jupiter-like world out to three times as far. If a smaller, cooler planet is out there, it's probably in the outer third of its orbit, which puts it against a dense background of Milky Way stars, a planetary needle in a galactic haystack. "It's not going to be impossible," he says. "It just makes it harder."

The Victor Blanco Telescope in Chile and Subaru Telescope in Hawaii are the best facilities for undertaking the search, Schwamb says. Both have cameras that can see large swaths of sky. If scientists don't mind waiting, the Large Synoptic Survey Telescope will come online in 2023. Currently being built in Chile, LSST will image the entire sky once every three days.

"We would be able to detect Planet Nine even if it was moving slowly," says Lynne Jones, an astronomer and LSST scientist at the University of Washington in Seattle. "We could look for motion from month to month or over the course of a year and quickly pick it out from the background stars."

There's also the possibility, though remote, that a serendipitous picture of the planet already exists. Uranus, Neptune and Pluto were all seen before anyone realized they were planets, dwarf or otherwise. Most observations don't record things as faint as Planet Nine. "But there's lots of archival data," Sheppard says, accumulated in observatories as astronomers gather images of stars, nebulas and galaxies. Planet Nine "could be sitting there somewhere." ■

BODY & BRAIN

Schizophrenia tied to synapse pruning

Variants of immune system gene implicated in mental disorder

BY LAURA SANDERS

From the tangled web of schizophrenia biology, scientists have pulled out one tantalizing thread. Variants of a protein that helps snip connections between nerve cells in the brain may contribute to the disorder, scientists report online January 27 in *Nature*.

"It's not the answer, but it's an answer," says psychiatrist and neuroscientist Henry Nasrallah of Saint Louis University School of Medicine. The findings give scientists a clue that may offer insights into how schizophrenia takes hold of the brain, he says.

This is the first time scientists have moved from genetic studies to a biological insight into schizophrenia risk, says geneticist David Goldstein of Columbia University. "That's why this is a big deal."

The research was sparked by genetic studies that identified a mammoth stretch of DNA on chromosome 6 as particularly suspicious. Called the major histocompatibility complex, or MHC, this DNA chunk carries information used by the immune system to help identify invaders. Why these genes are involved in schizophrenia was a mystery. "The MHC association in schizophrenia was considered an almost intractable problem in human genetics," says study coauthor Steven McCarroll of Harvard Medical School and the Broad Institute.

New ways of analyzing genetic structure gave an answer. It has to do with the snipping of connections, called synapses, between brain cells, McCarroll says. This process, called synaptic pruning, is in full swing during adolescence, when schizophrenia symptoms often appear.

By looking at genetic material of more than 60,000 people with or without schizophrenia, McCarroll and colleagues pinpointed versions of a gene within the MHC called complement component 4, or *C4*, that elevate the risk of schizophrenia. About 1 percent of people get schizophrenia. For people with a version of the *C4* gene that leads to more C4 protein in the brain, the risk increases to 1.27 percent, the researchers calculate.

C4 protein is often found at synapses. In postmortem brains from people with schizophrenia, there were signs that the *C4* gene had been more active than in people without the disorder, the team found. Further experiments with mice showed that C4 protein helps control synaptic pruning. Synapses in the brains of mice that didn't have C4 weren't pruned effectively. That result hints that the opposite might be going on in people with schizophrenia: Too much C4 might cause excessive pruning. A surplus of synapse trimming, particularly during adolescence, may disrupt neural connections and lead to the scattered thinking and hallucinations that often come with schizophrenia.

1 percent
Estimated fraction of people who have schizophrenia

Some scientists had suspected that synaptic pruning goes into overdrive in schizophrenia, Goldstein says. Postmortem brains showed a paucity of synapses, for instance. But this study is the "clearest, strongest evidence we have of synaptic pruning" being implicated in schizophrenia, he says.

Synaptic pruning is probably not the only thing that matters for schizophrenia, Nasrallah cautions. A range of genetic and environmental influences could all contribute to the disorder. "There are so many different ways to become schizophrenic," he says. But studying the link between the gene and synaptic pruning may help pinpoint where and how those influences converge in the brain, he says.

Geneticist Dimitrios Avramopoulos of Johns Hopkins University says that while the evidence for C4-related pruning is interesting, it's "not undisputable proof at this point." ■

EARTH & ENVIRONMENT

PCB levels high in Europe's dolphins

Decades after ban, toxic pollutant remains threat to cetaceans

BY SUSAN MILIUS

Decades after Europe banned toxic PCBs, the region's killer whales and three smaller cetaceans still carry high levels of the pollutants.

"They're still at concentrations we really need to worry about," veterinary specialist Paul D. Jepson of the Zoological Society of London said at a news conference January 12.

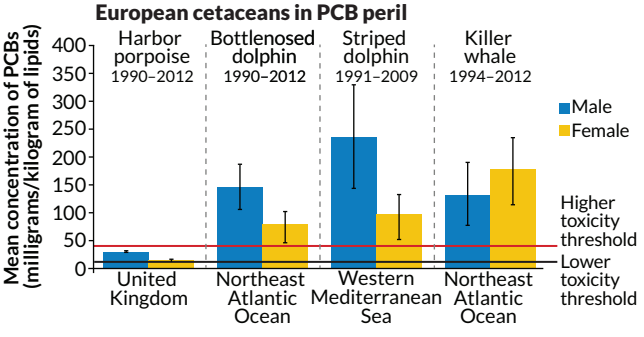
PCBs (polychlorinated biphenyls), once used in electrical equipment, plastics and other products, were banned by many developed nations by the end of the 1980s because of health and environmental concerns. But mean concentrations of the chemicals in the blubber of some of Europe's killer whales still exceed — often by a lot — a high threshold for human health damage. So do PCB concentrations in bottlenosed and striped dolphins, Jepson and colleagues report January 14 in *Scientific Reports*. PCB levels in harbor porpoises were lower but still exceeded a lower threshold above which physiological changes may occur.

A team of researchers from across Europe compiled and analyzed PCB animal contamination information from the early 1990s to 2009 or 2012, depending on the species. The data come from more than 1,000 animals, from either necropsies or blubber samples nipped from living animals. The concentrations represent a sum of the PCB variants detected.

After a modest postban drop, body concentrations of PCBs appear to have remained stable and high around much of Europe, Jepson says. PCBs are probably leaking out of landfills or otherwise working their way to the waters. "There's a lot more PCBs to come," he warns.

What had once seemed a great asset for better living through chemistry has turned out to be a long nightmare for environmental contamination. PCBs resist heat and general degradation. And the chemicals don't just linger; they concentrate themselves in animals. PCBs dissolve in fat and grow more concentrated as contaminated predators get eaten by even bigger predators. Top predators that eat fat-rich prey and live long lives, such as killer whales, are thus especially at risk.

Males keep building up their burden



Over the limits
Some European cetaceans carry high loads of PCBs, scientists find. In some species, these levels exceed thresholds above which physiological effects have been seen in the lab (black line) and reproductive changes have been seen in the wild (red line).

ATOM & COSMOS

Time running out for comet lander

Colder temps make renewed contact with Philae unlikely

BY CHRISTOPHER CROCKETT

Time is running out for the Philae comet lander. The latest attempts to communicate with the probe have failed. And with temperatures plummeting as comet 67P/Churyumov-Gerasimenko races from the sun, Philae is becoming too cold for the robotic explorer to keep its computer running.

On January 10, engineers sent a command to spin Philae's reaction wheels, which helped stabilize the lander during its descent. They hoped to nudge the lander into sunlight or at least shake several months of comet dust off its solar panels. Philae did not respond.

"It's a bit sad," says Stephan Ulamec, Philae manager at the German Aerospace Center in Cologne. "But it would be sad if we concentrated so much on what we couldn't achieve and not on what we did."

Philae's mission got off to a rough start (*SN: 12/13/14, p. 6*). After separating from the Rosetta spacecraft on November 12, 2014, Philae bounced across comet 67P before settling against cliffs. With sunlight blocked, the power drained quickly. Philae spent just 55 hours investigating its new home before shutting down. As the comet moved along its orbit, Philae's solar panels spent more time in the sun. Seven months after going quiet, with recharged batteries, Philae phoned home (*SN Online: 6/14/15*). Contact with the lander has since been intermittent, with its last communication — a 12-minute burst of data — sent July 9.

"The situation gets worse every day," says Ulamec. Now that the comet is traveling away from the sun, less solar power is available to the lander. Once the temperatures drop below −51° Celsius, says Ulamec, the computers will no longer boot up.

"The fact that it worked at all is miraculous," says Jessica Sunshine, a planetary scientist at University of Maryland in College Park. Before Rosetta launched in 2004, researchers knew very little about what comets are like up-close. Landing on a comet "was a gutsy thing," she says.

During its brief active tenure on the comet, Philae got the first intimate pictures of any comet and detected a fog of organic compounds. Its radar found that 67P is porous and uniform throughout. "That was a fantastic measurement," Sunshine says. The lack of layers in the comet's interior suggests that 67P was put together gently, which means the nucleus is a time capsule carting

P.D. JEPSON *ET AL/SCIENTIFIC REPORTS* 2016

of PCBs, but females typically discharge most of theirs while lactating. The bad news: The PCBs go into their milk.

The researchers looked at two thresholds at which PCBs cause physiological effects. A lower threshold of 9 milligrams of PCBs per kilogram of body fat comes from experimental studies, and a higher one (41 mg/kg) is linked to reproductive troubles in ringed seals in the Baltic Sea. In comparison, male killer whales sampled in the United Kingdom had mean PCB concentrations of almost 108 mg/kg.

The survey can't say for certain what problems come from the high concentrations. Previous work suggests that PCBs impair reproduction. Jepson notes that Scotland's small population of killer whales looks as if it's going extinct. Only eight known survivors remain.

The high PCB concentrations don't surprise marine mammal toxicologist Peter Ross of the Vancouver Aquarium. He has studied PCB contamination in aquatic life and hasn't seen much improvement in decades. In terms of spotting a menace to the environment before it spreads, "we learned a very hard lesson with PCBs," he says. ■

around a preserved sample of the detritus from which the solar system formed 4.6 billion years ago (*SN: 8/22/15, p. 13*).

Philae and Rosetta showed that features both tiny and enormous look similar on the comet, Sunshine says. Without context, it's hard to distinguish between the rugged terrain around the lander and the cliffs towering about 900 meters over the comet's midsection. "That's telling us something about how this comet was put together and evolved," she says.

Philae might be done exploring, but it won't be forgotten. Ulamec hopes to get some images of Philae this summer as Rosetta cozies up to get a closer look at how 67P changed during its closest approach to the sun. At the end of the mission in September, Rosetta will crash on the comet, snapping pictures all the way down. "It won't be a proper landing," Ulamec says. But at least Philae will finally have some company. ■

M.M. LAHR, FABIO LAHR

HUMANS & SOCIETY

Massacre hints at early origin of war

10,000-year-old skeletons show signs of lethal violence

BY BRUCE BOWER

This man, clubbed to death sometime between 9,500 and 10,500 years ago, was one of 12 victims of the earliest known example of warfare.

Along the edge of a dried-out lagoon in East Africa, researchers have discovered skeletal relics of the oldest known instance of small-scale warfare.

In a planned assault, attackers killed 12 hunter-gatherers some 9,500 to 10,500 years ago, say biological anthropologist Marta Mirazón Lahr of the University of Cambridge and colleagues. The skeletons unearthed at Nataruk, a site near Kenya's Lake Turkana, show that ancient hunter-gatherers were capable of deadly group raids, a precursor of the more complex forms of war launched by societies and nations, the scientists report in the Jan. 21 *Nature*.

"Lethal raids by competing groups were part of life for hunter-gatherer communities at the time of the Nataruk attack," Lahr says.

The new report adds to the debate over whether war originated tens of thousands of years ago or relatively recently (*SN: 8/10/13, p. 10*).

Lahr's report "is another nail in the coffin of the false idea that mobile hunter-gatherer bands are pacifists," says anthropologist Lawrence Keeley of the University of Illinois at Chicago. Lethal raiding by modern hunter-gatherers, along with the new evidence, supports the view that warfare occurred among similarly nomadic bands of Stone Age people, perhaps by 60,000 years ago, Keeley says.

Biological anthropologist Christian Meyer of the University of Mainz in Germany says the new findings "support the notion that serious intergroup conflict might be as ancient as group identity itself." Group identity is tough to glean from ancient stones and bones. Some researchers suspect that marriages between men and women from neighboring bands fostered alliances and group identities as early as 2 million years ago (*SN: 4/9/11, p. 13*). If so, small-scale warfare originated long before the Nataruk attack, says Meyer, who has studied a 7,000-year-old massacre at a European farming village (*SN: 9/19/15, p. 8*).

Anthropologist Douglas Fry of the University of Alabama at Birmingham disagrees. Group conflicts arose approximately 10,000 years ago as some hunter-gatherers established long-term camps in areas with abundant food and water, he argues. Population growth ensued, as did competition for resources, in his view. That's probably what inspired the Nataruk attack, Fry says.

Excavations by Lahr's team at Nataruk and over a dozen nearby sites indicate that the region was an attractive place to live between about 11,500 and 8,000 years ago. Nataruk was probably a few kilometers from the lake near a lagoon. Fossils show that a variety of animals once lived in and around Lake Turkana, including elephants, antelopes and fish.

Age estimates for 12 human skeletons came from radiocarbon analyses of soil, shells and burned wood, as well as two other dating methods.

Ten of the 12 skeletons had signs of lethal wounds. Five, maybe six, individuals displayed probable arrow wounds to the head and neck. Five people had been hit with clubs, three between the face and ear. Clubs of at least two sizes were used, a sign that there were multiple attackers.

Two obsidian arrow points were found among the skeletons. Obsidian is rare in the vicinity, Lahr says, so the attackers probably came from elsewhere.

The two undamaged skeletons had their hands crossed. These individuals were probably bound, Lahr says. ■

MATTER & ENERGY

Quantum histories get all tangled up

Tracing a particle's past can require multiple chronologies

BY ANDREW GRANT

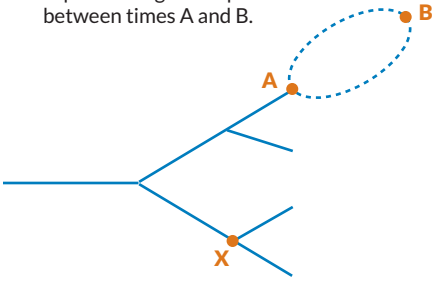
Choose Your Own Adventure books are fun, but they limit readers to only one version of events at a time. Quantum mechanics, a new experiment suggests, requires that multiple adventures occur simultaneously to create a consistent account of history.

Nobel laureate Frank Wilczek of MIT and colleague Jordan Cotler, now at Stanford University, provide evidence for what they call entangled histories in a paper posted online January 12 at arXiv.org.

The researchers proposed and collaborated on an experiment that started and ended by measuring a particular property of a photon; in between, the experimenters subtly probed the photon without disturbing its delicate quantum state. The head-scratching result was that there was no way to create a single chronology that could describe how the photon changed. Instead, there must be multiple chronologies that are entangled, sharing a quantum connection usually reserved for groups of particles rather than chunks of time.

"There really is something very deep going on here about the nature of quantum mechanics and time," Cotler says. "Our best description of the past is not a fixed chronology but multiple chronologies that are intertwined with each other." The experiment may offer a new means of exploring and interpreting quantum weirdness.

Web of history Typically, one sequence of events can explain any observation at a given time (X). But in a new experiment, only multiple sequences occurring in parallel could explain changes to a photon between times A and B.



The quantum world is ruled by probabilities. Typically, physicists monitoring a photon can calculate the odds that it will have a particular characteristic, such as horizontal polarization, when it is measured. But if that photon has an entangled partner, then it becomes impossible to calculate the probabilities for one photon or the other. You can describe only the entire entangled system.

> "Our best description of the past is not a fixed chronology but multiple chronologies that are intertwined with each other."
> JORDAN COTLER

Rather than pondering multiple quantum objects, Cotler and Wilczek thought about individual particles at multiple moments in time. The researchers built on 1984 work by Robert Griffiths, a physicist at Carnegie Mellon University in Pittsburgh (*SN Online: 2/5/14*), and thought about quantum versions of chronologies. If physicists could describe the polarization of a photon at time A and time B, then they should be able to make a coherent timeline charting the photon's polarization changes in between.

Yet Cotler and Wilczek suspected that it wasn't so simple. In a paper last year, they introduced the idea of entangled histories, cases in which a single chronology is insufficient to explain the observed changes in the properties of a particle. Just as the understanding of an entangled particle is impossible without considering its partner, the history of a particle could be incomplete without considering the existence of multiple entangled timelines.

A team of Chinese researchers recently put Cotler and Wilczek's entangled histories to the test. The scientists injected photons one at a time into an interferometer. A photon made it through the interferometer only if it passed through three selective mirrors, each of which discarded light with a particular polarization. For each photon that reached a final detector, the researchers knew the photon's initial and final polarizations as well as clues to the polarization of the photon when it passed through each mirror.

Just as Cotler and Wilczek expected, the experimenters couldn't formulate a chronology that was consistent with both the starting and ending measurements of each photon and the mirror-based evidence in between. The only way to reconcile all the observations, says Cotler, is to conclude that the photon went through multiple histories in parallel. When the researchers made the final measurement of the photon, those alternate timelines merged.

Other physicists are not convinced that the new research goes beyond the ideas put forth by Griffiths and others over the last three decades. MIT quantum physicist Seth Lloyd calls the work "evolutionary but not revolutionary," though he still wants to review the paper's arguments more carefully.

Wilczek is far more optimistic. He calls the experiment "a rather direct realization" of a 60-year-old interpretation of quantum mechanics known as "many worlds," in which measuring photons and other environmental interactions split reality into alternate timelines. Sometimes the different branches are consistent on their own and remain separate, Wilczek says. But in this case, the separate chronologies are intertwined and eventually come back together.

"The deepest and most appealing aspect of this experiment," he says, "is that it allows you in a mathematically precise way to nail what exactly 'many worlds' is about." ■

Editor's Note: Frank Wilczek is on the board of trustees of Society for Science & the Public, which publishes Science News.

E. OTWELL

Humans' arrival in Arctic pushed back

Toolmarks found on 45,000-year-old Siberian mammoth bones

BY CHRIS SAMORAY

A frozen mammoth carcass hints that humans roamed the Arctic earlier than researchers had thought.

Cuts and scrapes on the mammoth's bones, found in central Siberia, came from human hunting weapons. Dating of the animal's bones puts humans well north of the Arctic Circle 45,000 years ago, scientists report in the Jan. 15 *Science*. Researchers had assumed that humans didn't reach the Arctic until between 30,000 and 35,000 years ago.

The find shows that humans worked out how to cope with the Arctic's extreme cold and sunless winters much earlier than experts thought, says Robin Dennell, a paleoanthropologist at the University of Exeter in England who wasn't involved in the new study.

At about 66.5° N latitude, the Arctic Circle skims the top of North America and Eurasia.

A gash on a mammoth bone suggests humans were north of the Arctic Circle 45,000 years ago.

"The mammoth is almost 72 degrees North," says study coauthor Vladimir Pitulko, an archaeologist at the Institute for the History of Material Culture of the Russian Academy of Sciences in St. Petersburg.

Except for one site in eastern Siberia, also reported by the team, other far-north archaeological sites 40,000 years or older sit south of the Arctic Circle, at about 55° N.

That's a huge latitudinal difference between the previously known human habitation sites south of the Arctic Circle and the new mammoth find — about 1,700 kilometers, Pitulko says.

The team pulled the mammoth, a 15-year-old male, from a frozen coastal bluff. Carbon dating of the surrounding sediment and of a leg bone pinned the mammoth's age at 45,000 years old.

Marks on one of the animal's tusks and slices on many of its bones were similar to patterns on mammoth bones from a younger Siberian archaeological site where humans hunted the beasts, the researchers found. Human weapons such as spears probably caused the damage that killed the mammoth.

Humans entering the Arctic by 45,000 years ago represents "a mighty impressive achievement," Dennell says. "What we don't know is whether this was a successful long-term adaptation or a short-lived heroic failure." ■

V. PITULKO ET AL/SCIENCE 2016

LIFE & EVOLUTION

Ocean flora flunk photosynthesis test

Phytoplankton turn more sunlight into heat than cellular fuel

BY CHRIS SAMORAY

Phytoplankton that harvest sunlight in the world's oceans make more heat than food, a new study finds.

The microscopic marine organisms, an important food source in the ocean, use photosynthesis to turn sunlight into cellular fuel. But nearly twice as much of the sunlight energy captured by phytoplankton is released as heat as is used to make food, researchers report in the Jan. 15 *Science*. The finding suggests that phytoplankton are not as efficient photosynthesizers as thought.

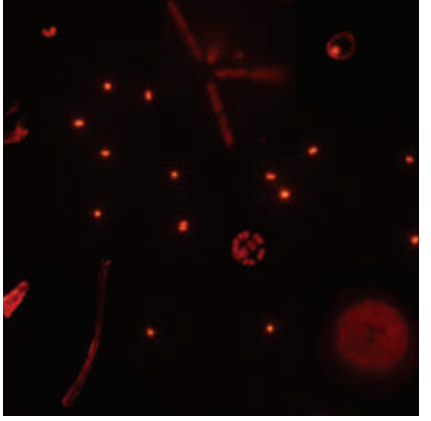
"The photosynthetic efficiency of global phytoplankton is very low, surprisingly low," says coauthor Paul Falkowski, an oceanographic biophysicist at Rutgers University in New Brunswick, N.J.

When phytoplankton harness sunlight, one by-product is fluorescence. Satellites tuned to detecting fluorescent red light have gathered data on phytoplankton. But satellites can't see through clouds, and some red light they pick up comes from particles in Earth's atmosphere.

So Falkowski and his team developed an instrument highly sensitive to the red fluorescence of phytoplankton that could be deployed on research vessels. The scientists gathered over 150,000 phytoplankton fluorescence measurements in the Atlantic, Pacific, Arctic and Southern oceans from 2008 to 2014. From the fluorescence data, the team used equations to infer how much sunlight was directed toward making cellular fuel compared with how much was lost as heat.

While 35 percent of the absorbed light was used to fuel phytoplankton growth, about 60 percent was converted to heat.

In lab studies with nutrient conditions that encourage phytoplankton growth, the team observed the opposite: About 65 percent of absorbed light went to make fuel; less than 35 percent was lost as heat.



Red light emitted by phytoplankton helped researchers determine the tiny organisms are not as efficient at photosynthesis as assumed.

Marine biogeochemist Thomas Browning of the GEOMAR Helmholtz Center for Ocean Research Kiel in Germany called the inefficient photosynthesis "a novel finding."

The team blames the inefficient photosynthesis on nutrient-poor waters, found in 30 percent of the oceans. Without sufficient nutrients, phytoplankton's photosynthesis structures don't work properly and struggle to convert sunlight.

The study illustrates the need for instruments that monitor phytoplankton changes in the future, Browning says. "We want to know how their activity and distribution are changing over time." ■

BODY & BRAIN

Brain waves could guide anesthesia

Network connections weaker in those who go under easily

BY LAURA SANDERS

Signals in the brain can hint at whether a person undergoing anesthesia will slip under easily or fight the drug, a new study suggests. The results, published January 14 in *PLOS Computational Biology*, bring scientists closer to being able to tailor doses of the drugs for specific patients.

Drug doses are often given with a one-size-fits-all attitude, says bioengineer and neuroscientist Patrick Purdon of Massachusetts General Hospital and Harvard Medical School. But the new study finds clear differences in people's brain responses to similar doses of an anesthetic drug, Purdon says. "To me, that's the key and interesting point."

Cognitive neuroscientist Tristan Bekinschtein of the University of Cambridge and colleagues recruited 20 people to receive low doses of the general anesthetic propofol. The dose wasn't designed to knock people out but to dial down their consciousness until they teetered on the edge of awareness.

While the drug was delivered, participants repeatedly heard either a buzzing sound or a noise and were asked each time which they heard, a question designed to gauge awareness. Of the 20 people, seven were sidelined by the propofol and began to respond less. Thirteen participants, however, kept right on responding, "fighting the drug," Bekinschtein says.

EEG measurements that tracked electrical activity in the brain revealed a brain signature that differed between these two groups while on the drug. In people who resisted the propofol, a particular type of brain wave called an alpha oscillation appeared to be strong and efficient, with lots of connections between near and far brain areas. In contrast, people who succumbed easily to the drug had weaker, less efficient alpha wave behavior.

This difference was also present before the drug was delivered, says Bekinschtein. At the beginning of the experiment, people already showed predictive alpha wave signatures. The results raise the prospect that a presurgical EEG measurement could help doctors find the lowest drug dose that would still put a person under while reducing potential side effects.

EEG machines are widely available in clinical settings, and Bekinschtein and colleagues are trying to adapt their results to be useful to anesthesiologists.

Purdon cautions that the results are based on a limited number of people. "It's a preliminary finding in that regard," he says. More work is needed to translate the results so that they can be applied to individual patients. ■

HANZHI LIN

GENES & CELLS

Signs of food allergies seen at birth

Babies' overactive immune cells may prime body for reactions

BY TINA HESMAN SAEY

Some babies are born with immune cells primed to cause food allergies, a new study suggests.

Umbilical cord blood of infants who developed food allergies was loaded with overactive versions of immune cells called monocytes, researchers report in the Jan. 13 *Science Translational Medicine*. Those overexcited cells may push other immune cells to cause allergies, immunology researcher Yuxia Zhang of the Walter and Eliza Hall Institute of Medical Research in Parkville, Australia, and colleagues discovered. The findings may help researchers better understand how food allergies develop and devise strategies to prevent these potentially life-threatening immune reactions.

In the United States, an estimated 4 to 6 percent of children have allergies to such foods as milk, eggs, peanuts and shellfish. In Australia, the rate is even higher: About 10 percent of kids in a recent study in Melbourne had food allergies. Food allergies are on the rise and no one knows why, says Anne Marie Singh, a pediatric allergist and immunologist at Northwestern University's Feinberg School of Medicine in Chicago. Research such as Zhang and colleagues' may help uncover the mechanism behind that increase, she says.

The new results come from the ongoing Barwon Infant Study, which is collecting data on more than 1,000 babies born from 2010 to 2013 in southeastern Australia. The food allergy conclusions come from analyzing data from nearly 700 babies who had blood taken from their umbilical cords after birth. At age 1, 54 of those kids had food allergies.

Children who developed food allergies tended to have monocytes in their cord blood that reacted more strongly to components of bacterial cell walls than did monocytes from kids who didn't get food allergies. How eagerly these white blood cells attack the cell wall component is a measure of immune system activity. For food-allergic kids, the pugnacious monocytes may be an early warning sign that the immune system will go on to attack harmless food proteins.

Overactive monocytes make more inflammation-stimulating chemicals, called cytokines, than normal monocytes do, the researchers found. Those cytokines may push untrained immune cells called T cells into becoming allergy-provoking cells instead of ones that quiet immune reactions, the researchers think. Those cytokines may also prevent T cells from making a protein called IL2, which protects them from morphing into allergy inducers, the researchers say.

Not all of the kids who had the hyperexcitable cells went on to have allergic reactions to foods at age 1, though. "I don't think you could look at our data and cleanly predict a group of children who will go on to develop food allergies," says study coauthor Peter Vuillermin of Deakin University in Geelong, Australia.

James R. Baker Jr. says the new data "fly in the face of some dogma." Usually, a strong inflammatory reaction in babies is associated with a healthy immune response to infections and vaccines, not with allergies, says Baker, an allergist and immunologist at the University of Michigan in Ann Arbor. These results don't indicate how the immune system gets primed, nor do they demonstrate exactly how or why the shift toward allergies happens in some kids but not others.

Singh says she didn't find the results counterintuitive. Evidence suggests that things that occur in pregnancy could influence the development of allergies in kids. But "there are so many complex factors we can't tease out a direct cause and effect," she says. The study picks out "one small piece in a very, very big puzzle." ■

EARTH & ENVIRONMENT

2015 smashed heat records

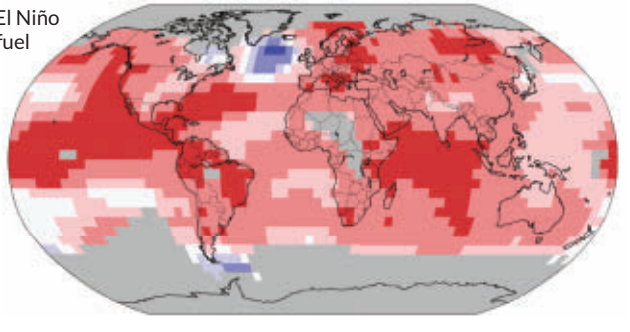
Warming and El Niño pushed global temperatures up

BY THOMAS SUMNER

Things are definitely heating up. Spurred by global warming and a "super El Niño," 2015 became, by far, the hottest year since record keeping began in 1880.

Worldwide surface temperatures were on average 0.9 degrees Celsius higher than the 20th century average of 13.9°, the National Oceanic and Atmospheric Administration and NASA reported January 20 in a joint announcement. That's well above the previous record of 0.74 degrees above average set in 2014.

"2015 was the warmest year because it was warm throughout," Gavin Schmidt, director of NASA's Goddard Institute for Space Studies in New York City, said at a news conference. Ten months set all-time records during 2015. El Niño contributed to higher temperatures near the end of the year, Schmidt said. But even without that extra boost, 2015 "still would have been the warmest year on record," he said. ■



Heating up The ongoing strong El Niño and global warming fueled by fossil fuel emissions made 2015 the hottest year on record. Blue areas were cooler than their long-term averages; red areas were warmer.

NOAA

EARTH & ENVIRONMENT

Altered milk protein cleans up pollution

Amyloid fibers can snatch heavy metal contaminants from water

BY SARAH SCHWARTZ

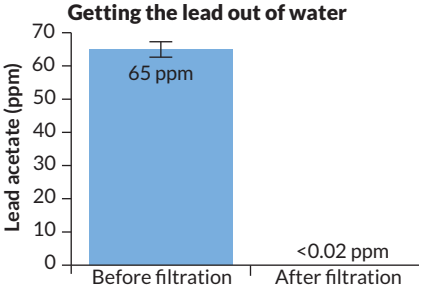
Tenacious proteins similar to those implicated in Alzheimer's disease could help purify polluted water.

A newly designed membrane uses thin amyloid protein fibers to pull heavy metals and radioactive wastes out of water. The membranes can capture more than their own weight in some contaminants, scientists in Switzerland report online January 25 in *Nature Nanotechnology*.

"What's really interesting in this study is that it actually used a protein material, which is novel," says Qilin Li, an environmental engineer at Rice University in Houston. The team converted milk proteins into fibers of durable amyloid protein. Other amyloids are infamous for building up in the brains of Alzheimer's patients, but the team put its amyloids' sticky tendrils to different use.

When paired with strong, porous carbon in a membrane, the lab-made amyloids successfully filtered over 99 percent of toxic materials out of solutions that mimicked severely polluted waters, the scientists report. The amyloids trapped particles of lead and mercury at a molecular site that is involved in turning the original milk protein into amyloid fibers. Radioactive waste particles also got tangled in the membranes. And the membranes snagged gold contaminants, which the team found could later be recovered and purified. A membrane with less than 6 milligrams of amyloids could trap 100 milligrams of gold.

Cleanup crew A new amyloid-carbon membrane filtered over 99.9 percent of lead pollutants out of a contaminated solution, bringing the overall concentration of lead to below a measurable threshold of 0.02 parts per million. SOURCE: S. BOLISETTY AND R. MEZZENGA/ *NATURE NANOTECHNOLOGY* 2016



It's exciting to see that the amyloids can hold more than their own mass in heavy metal particles, Li says. More typical membrane materials, she says, would grab only a fraction of their weight.

The membranes could be developed for small- or large-scale water purification units, says study coauthor Raffaele Mezzenga of ETH Zurich. He estimates the technology would cost roughly $1 per every thousand liters of water filtered. And a membrane can recover hundreds of times its own value in precious metals, Mezzenga says. The simple, flexible membrane design could be adjusted to optimize cleanup or metal recovery, he says.

Li says the membranes need to be tested in real polluted waters, which may have chemical complications such as high or low acidities. But the amyloids' performance is encouraging, she says. ■

MATH & TECHNOLOGY

Web data predict stock movements

Online reading behavior can help warn of financial crises

BY MARK BUCHANAN

Web surfing patterns of people who are reading financial news can be used to make accurate predictions of stock movements up to a couple hours in advance, a new study suggests. The technique may one day help financial authorities monitor markets and fend off emerging crises.

A team of physicists led by Gabriele Ranco of the IMT Institute for Advanced Studies in Lucca, Italy, suspected that better stock predictions might be made by looking at more than the positive or negative sentiment expressed in an article about a company. Another key indicator might be how many people actually click on links to an article, a sign of the article's social influence and how much readers are paying attention.

The team used a year of data collected in 2012–2013 from Yahoo! Finance, an online portal for financial news and data. Looking at the 100 U.S. companies with the most frequent mentions in news articles, the team calculated a measure of sentiment for each article. The team then weighted that measure to reflect reader behavior: Articles counted for more if more readers clicked on links to them.

The result was a moment-by-moment signal for each company showing how sentiment and interest fluctuated during the day, and how strongly. The team compared these signals with actual market fluctuations of prices, volume and volatility for the stocks of the 100 companies. The signals offer a significantly improved predictive capacity for stock movements, especially for movements roughly one hour later, the researchers conclude January 25 in *PLOS ONE*.

Mathematical finance expert Rosario Mantegna of the University of Palermo in Italy suggests that this method could prove useful for financial authorities worried about the potential for explosive financial events — a bank run triggered by a surge of investor fear, for example.

An important aspect of the work is its ability to monitor web activity on timescales as short as a minute, says study coauthor Guido Caldarelli, also at IMT. This kind of analysis, he says, could be carried out in real time if authorities had access to the data.

More generally, the study illustrates the potential of "big data" to provide new means to detect broad social patterns of belief in areas ranging from public health to political polling. "Questionnaires are slow and people don't always give their real views," he says. "An advantage of web data is that people tend to be more sincere when they're browsing." ■

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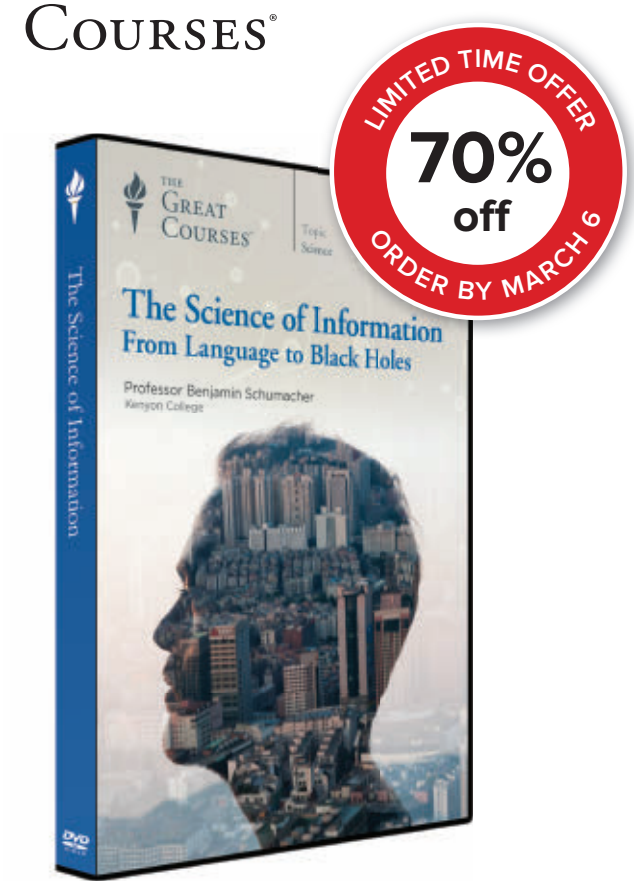

How Is Information the Raw Material of Reality?

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BODY & BRAIN

Rapid spread of Zika virus raises alarm

Disease linked to birth defect is pushing northward from Brazil

BY MEGHAN ROSEN

The latest virus to break out of the tropics may be the most frightening.

Zika virus, which has already blazed across Brazil and pressed northward into Central America and Mexico, is now poised to jump to the United States. Infection typically causes minor or even no symptoms. But in pregnant women, it has been linked to a birth defect called microcephaly, which leaves babies with abnormally small heads and partially developed brains (*SN Online: 12/2/15*).

The mysterious tropical virus is an arbovirus, one of many that are spread by insects such as mosquitoes and ticks. With the rise in international travel, the rapid emergence — and reemergence — of little-known arboviruses such as Zika may be the new normal, Anthony Fauci and his colleague David Morens suggest online January 13 in the *New England Journal of Medicine*.

"Dengue hit with a vengeance in the '90s. Then we had West Nile in 1999, chikungunya in 2013, and lo and behold, now we have Zika in 2015 and 2016," says Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md. "This is a disturbing, remarkable pattern."

Already, travelers have brought Zika home to several states, though the virus doesn't seem to have infiltrated U.S. mosquitoes yet. But the United States, with its warm, humid regions, pockets of poverty and ready fleet of mosquitoes capable of carrying the virus, has all the right ingredients for an outbreak, says Peter Hotez, a pediatrician and microbiologist at Baylor College of Medicine in Houston.

"We've been wringing our hands about Ebola," he says, but "Ebola was never a threat to the Western Hemisphere." Zika is.

Scientists first collected Zika virus in 1947 from a rhesus monkey that was part of an infectious-disease study in the wetland-edged Zika forest of southern Uganda. For decades, the virus flitted between monkeys and mosquitoes, infecting humans only rarely — and until 2007, never outside of Africa and Asia. That's when Zika escaped into the Pacific, causing an outbreak on Yap Island in the Federated States of Micronesia. The virus was spotted in French Polynesia next, in 2013. It came to Easter Island the next year, and in May 2015, the first confirmed cases cropped up in Brazil. There, Zika flourished, gaining a firm foothold in the Americas.

20
percent
Estimated fraction of people infected with Zika virus who get sick

In less than nine months, Zika infected as many as 1.3 million people in Brazil, the European Centre for Disease Prevention and Control reported on January 21, and some estimates put the number even higher. Zika virus has now spread through 25 countries and territories in Latin America and the Caribbean, the Pan American Health Organization and World Health Organization report.

"The cat's out of the bag now," Hotez says. "Zika virus is going to be all over."

On January 15, the U.S. Centers for Disease Control and Prevention issued warnings for people traveling to countries with Zika (*SN Online: 1/15/16*). Pregnant women, in particular, should be especially cautious, the CDC advised. On February 1, WHO declared Zika virus and its possible link to birth defects a "public health emergency of international concern."

A Brazilian boy holds his baby brother, born with microcephaly in 2015. The birth defect may be linked to maternal Zika virus infections.

FELIPE DANA/AP

Some people consider Zika virus a mild cousin of dengue: Only about 20 percent of infected people get sick, and symptoms (typically a slight fever, rash and pinkeye, to name a few) fade quickly. But a growing body of evidence suggests that the virus could also cause a devastating birth defect.

In Brazil, the number of babies born with microcephaly is steadily ticking up. In 2015, the country recorded roughly 20 times as many cases as in previous years, and new cases — sometimes hundreds — appear every week. On January 27, Brazilian health officials reported a total of 4,180 cases since October 2015, 287 more than a week earlier.

Based on the number of babies born in Brazil in 2015 and the number of microcephaly cases that year, public health researcher Ernesto Marques of the University of Pittsburgh estimates that roughly 1 in 150 babies were born with the birth defect.

"This is just a huge number," he says. "And it's in an outbreak that has just started."

That Zika might wreak havoc in fetal brains isn't all that surprising, given the virus's effect on mice and the neurological problems sometimes observed in infected adults, says Carlos Brisola Marcondes, an entomologist who studies disease-carrying insects at the Federal University of Santa Catarina in Brazil. In lab mice, Zika virus makes a beeline for the brain. "It causes serious damage," says Marcondes. Nerve cells break down and brain tissue softens.

Microcephaly was reported in the 2013–2014 French Polynesia outbreak. In addition, at least 73 people developed neurological conditions such as Guillain-Barré syndrome, which can cause paralysis. Health officials have linked that condition to Zika virus infection in the current outbreak as well.

Early this year, scientists discovered

the most concrete clues yet that Zika virus can cause microcephaly: genetic traces of Zika in the amniotic fluid of two pregnant women carrying fetuses diagnosed with the birth defect, and in four babies who were miscarried or died shortly after birth.

"The evidence is very, very strong," says Marques, but only a few babies have been tested.

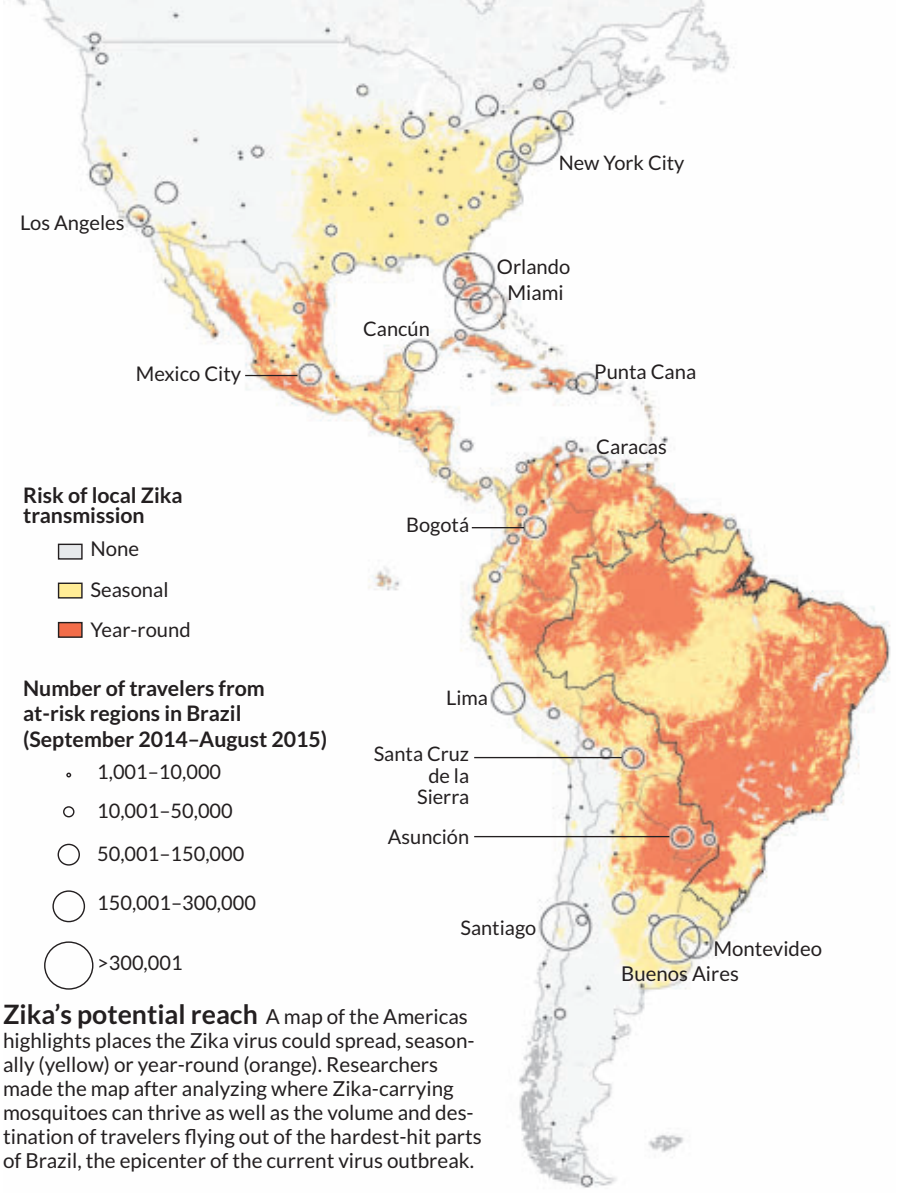
Marques and collaborators in Brazil, England and the United States have begun a study to examine more babies. The researchers aim to enroll 200 infants with microcephaly and 400 infants without the birth defect (all from the hard-hit Brazilian state of Pernambuco) and will look for traces of Zika in maternal blood, umbilical cord blood, amniotic fluid and other tissues.

At this point, Marques isn't expecting to figure out how the virus may cause brain damage; he just wants enough cases to tease out any link between Zika and microcephaly. "If we see signs of viral infection in the placenta or the blood or brain tissue of these babies, that would strengthen the case," he says. The researchers have already begun enrolling people, and Marques hopes to recruit all 600 participants by June or July.

Scientists still have a lot to learn about Zika virus, Hotez says, such as how the virus passes from mother to fetus, and — if infection does cause microcephaly — what exactly Zika virus does to developing brains.

Currently, there's no antiviral therapy for Zika infection and no vaccine. Developing a vaccine could take years, Fauci says. "Even though we started aggressively on it a month or two ago, it's going to take a while before we get one."

In the United States, that could leave millions of people at risk for infection, Isaac Bogoch and colleagues report in the Jan. 23 *Lancet*. Bogoch's team made a global map of places Zika virus could readily spread. The researchers factored in climate, flight patterns out of Brazil and mosquito species that can carry Zika virus, *Aedes aegypti* and *Aedes albopictus*. (Both species hug the U.S. Gulf Coast, and *A. albopictus* fans out across the Southeast and up along the East Coast, ranging as far north as Connecticut.)



Zika's potential reach A map of the Americas highlights places the Zika virus could spread, seasonally (yellow) or year-round (orange). Researchers made the map after analyzing where Zika-carrying mosquitoes can thrive as well as the volume and destination of travelers flying out of the hardest-hit parts of Brazil, the epicenter of the current virus outbreak.

Over 60 percent of U.S. residents live in areas threatened by Zika virus (at least during warm seasons), the team found. For southern states, especially, "there's a potential for ongoing transmission," says Bogoch, a tropical infectious disease physician at Toronto General Hospital.

Still, that doesn't mean a Zika virus outbreak is imminent, or inevitable, he says. The virus doesn't ordinarily pass directly from person to person, although at least one sexually transmitted case has been reported. And it might not move beyond a handful of confined cases. After all, chikungunya (*SN: 6/13/15, p. 16*) and dengue virus, which ride the same mosquitoes as Zika, haven't hit the United States especially hard.

For all these viruses, getting control of an outbreak requires getting rid of mosquitoes, Marcondes advises in a review published online December 22 in the *Journal of the Brazilian Society of Tropical Medicine*. "Preventing breeding is the only way," he says.

Already, Brazil is trying an approach to cut wild mosquito populations by genetically engineering and releasing mosquitoes that can't reproduce.

Fauci agrees that controlling mosquito populations is key. But the recent emergence of so many tropical viruses might also require some new defensive strategies, he says. By finding an antiviral drug that targeted the larger group of viruses that Zika belongs to, for instance, scientists could knock out several threats.

"You would automatically get chikungunya, West Nile, yellow fever, Zika and dengue with one shot," he says. ■

I.I. BOGOCH ET AL/*LANCET* 2016

EARTH & ENVIRONMENT

Ocean heating doubles

The ocean is taking heat. That's the conclusion of a new study that finds that Earth's oceans now absorb heat at twice the rate that they did 18 years ago. Around half of ocean heat uptake since 1865 has taken place since 1997, researchers also report online January 18 in *Nature Climate Change*.

Warming waters contribute to coral bleaching (*SN Online: 10/8/15*), and they take up more space than cooler waters, raising sea levels. While the top of the ocean is well studied, its depths are trickier to query. Researchers at Lawrence Livermore National Laboratory and elsewhere gathered 150 years of ocean temperature data to get a better picture of heat uptake from surface to seabed. They compiled temperature readings collected by everything from a 19th century sailing expedition of the *HMS Challenger* to modern automated probes. The far-flung data sources, combined with computer simulations, offered a timeline of ocean temperature changes, including cooling from volcanic eruptions and warming from fossil fuel emissions.

Ocean warming, which has been on the rise, can contribute to coral bleaching (shown).

About 35 percent of the heat recently taken in by the oceans now resides at a depth of more than 700 meters, the researchers found. They're unsure whether the deep-sea warming has offset warming at the sea's surface. — *Thomas Sumner*

LIFE & EVOLUTION

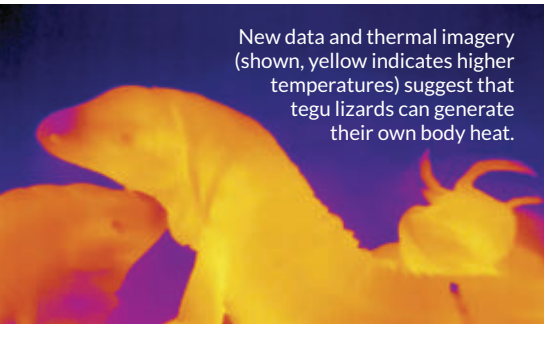
Tegu lizards warm up for mating

Despite their cold-blooded reputation, tegu lizards boost their body heat while on the prowl for a mate, biologists report online January 22 in *Science Advances*.

Like other ectotherms, tegu lizards (*Salvator merianae*) in South America draw heat from their environment, sunning themselves in spring and summer and hibernating in autumn and winter. Upon waking from their seasonal slumber, the males search for a mate.

Researchers from Canada and Brazil monitored body temperature in a group of captive lizards through these seasonal shifts. At night during mating season, both males and females stayed significantly warmer (by up to 10 degrees Celsius) than the air. The lizards maintained a significant temperature difference for up to eight days without the help of sunlight.

During mating season, researchers saw a rise in morning heart rate and body temperature, suggesting that tegu lizards have an unusual ability to produce and sustain body heat. Though the exact mechanism remains unclear, metabolic changes that come with reproduction could drive up the lizards' body temperatures, the researchers suspect. The work is consistent with the idea that reproduction played a role in the evolution of warm-bloodedness. — *Helen Thompson*



New data and thermal imagery (shown, yellow indicates higher temperatures) suggest that tegu lizards can generate their own body heat.

GENES & CELLS

MicroRNAs manage gut microbes

Tiny pieces of genetic material known as microRNAs do a big job: They control gene activity inside bacteria in the intestines, a new study finds. The little RNAs also help control the mix of microbes living in the gut.

Those functions help keep the intestines healthy, researchers report in the Jan. 13 *Cell Host & Microbe*. If the findings hold up, microRNAs may become a tool for shaping the composition of the body's microbes, or microbiome.

Cells lining the colons of both humans and mice pump out microRNAs, Shirong Liu, an immunologist at Brigham and Women's Hospital in Boston, and colleagues discovered. Those microRNAs can slip inside bacteria to control the activity of specific genes, the team found in research with mice. Dialing gene activity up or down could stimulate or suppress growth of certain bacteria.

Mice that couldn't produce microRNAs in their colons were more prone to develop colitis, an inflammation of the colon's lining. When researchers gave the microRNA-deficient mice infusions of normal microRNA mixes, the rodents had less severe symptoms. Those results suggest that mice and perhaps humans use microRNAs to control bacteria and keep their colons healthy. — *Tina Hesman Saey*

GENES & CELLS

Bubonic plague hung out in Europe

The plague bacterium *Yersinia pestis* may have lurked in a medieval European reservoir for at least 300 years, researchers from Germany suggest January 13 in *PLOS ONE*.

The second of two major plague pandemics hit Europe from the 14th to 17th centuries. The new study weighs in on a long-standing debate over what fed the pandemic: strains of the bacterium traveling along with trade from Asia via the Silk Road or a homegrown biological reservoir such as lice.

The team analyzed DNA from 30 skeletons dating to the 14th to 17th centuries. Five had strains of *Y. pestis* that could be analyzed; all strains bore genetic similarity to each other and to strains previously found in European plague victims. Strains from Asia would have injected more genetic variety. Instead, the results suggest that at least one *Y. pestis* strain sparked the outbreak in Europe and stuck around for a long time. — *Helen Thompson*

FROM TOP: KELSEY ROBERTS/USGS; GLENN J. TATTERSALL

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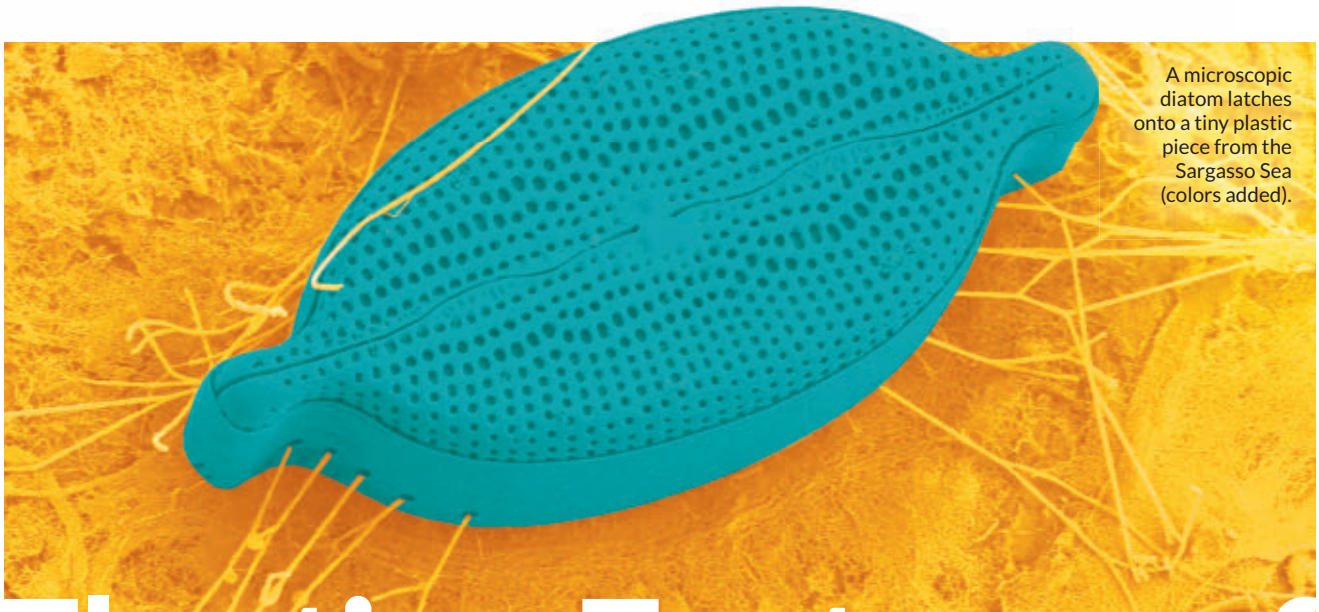


A microscopic diatom latches onto a tiny plastic piece from the Sargasso Sea (colors added).

Floating Fortress of MICROBES

Microscopic creatures take advantage of plastic debris in the oceans

By Chris Samoray

Oceanfront property doesn't come cheap. Except, perhaps, for some seafaring microbes.

Steady streams of tiny plastic pieces making their way into the ocean give microbial squatters a place to take up residence. Each plastic home comes equipped with a solid surface to live on in an otherwise watery world. These floating synthetic dwellings and their microbial inhabitants have a name: the plastisphere.

Microplastics in the ocean run 5 millimeters across or less. Their hard surfaces make them floating oases for some ocean microbes.

Microbes of the plastisphere live in waters from Australia to Europe. They differ by location, are as varied as the plastic they live on and can be a tasty food option for other creatures. What impact — good or bad — the microbe-covered plastic has on the oceans is still in question. Early hints suggest that there may be climate effects and unexpected movement of harmful microbes or other creatures to new destinations. Each study sparks new ideas and new theories.

"This is an opportunity to learn about the ocean from a big experiment that has already been put in place by humans," says marine chemist Tracy Mincer of the Woods Hole Oceanographic Institution in Massachusetts.

As the plastic multiplies

Plastic is everywhere. Finding it polluting the world's oceans has been a worrisome reality for years. But a discovery more than four decades ago shocked a pair of Woods Hole researchers.

In 1972, scientists were trawling the surface of the Sargasso Sea in the North Atlantic Ocean to collect *Sargassum*, a brown algae seaweed. The researchers' interest was diverted, however, by an unexpected catch: tiny plastic particles.

Repeated net tows caught more plastic. The researchers calculated an abundance of 3,500 small plastic pieces per square kilometer, and were left thinking about the future. "The increasing production of plastics ... will probably lead to greater concentrations on the sea surface," the researchers wrote in *Science*.

FROM TOP: E.R. ZETTLER/SEA EDUCATION ASSOC., FALSE COLOR BY E. OTWELL; S.L. WRIGHT *ET AL/CURRENT BIOLOGY* 2013

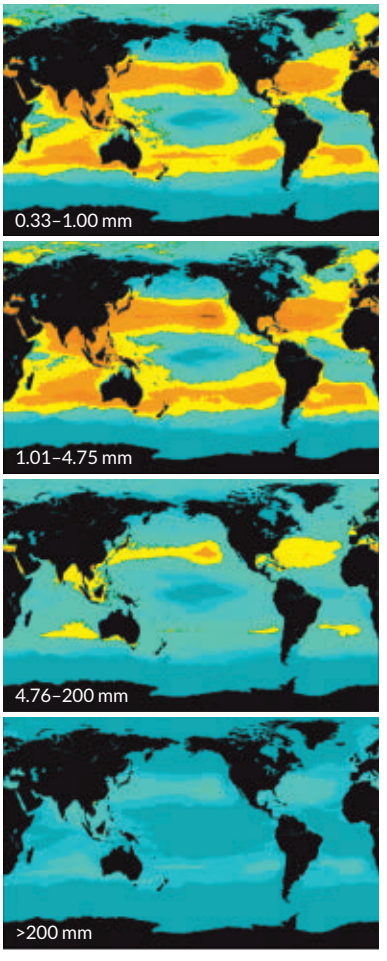
More recent estimates put the amount of plastic floating in the world's oceans at more than 5.25 trillion pieces, weighing more than 268,000 metric tons (*SN: 1/24/15, p. 4*). That translates to as much as 100,000 pieces per square kilometer in some areas of the ocean.

In a few places, the concentration of plastic and other trash has earned a nickname or two. In the North Pacific Ocean, for example, the expanse between Japan and the U.S. western coast is variously known as the "great Pacific garbage patch" or the "Pacific trash vortex."

These floating areas of debris aren't visible to satellites, however. The ocean still looks blue because most of the junk is barely visible tiny bits of plastic.

These microplastics are no bigger than 5 millimeters across and come from many sources. Some are broken bits of larger plastic pieces. Others, such as synthetic fibers from clothing and plastic beads from toothpastes and face washes, escape cleaning filters at wastewater treatment plants and end up in the ocean.

"We treat millions of gallons of wastewater per day in the United States," says Chelsea Rochman, a marine ecologist at the University of California, Davis. She describes the waste as "a concentrated stream" of debris going out into the ocean.



Plastic waves Oceans worldwide harbor lots of plastic, some places more than others. As seen in the top two maps, microplastics smaller than 5 millimeters in size make up most of the oceans' plastic. In some areas, concentrations reach 100,000 pieces per square kilometer.

Diversity rules

During the 1972 expedition, the researchers found a handful of diatom species, single-celled algae, on the microplastics. It wasn't until much later that scientists began to uncover the diversity of microbial life on this plastic flotsam.

In 2013, Mincer and colleagues found an ensemble of microbes thriving on microplastics collected from the North Atlantic Ocean. Some of the microbes made food from sunlight, some ate microbes and some lived on top of other microbes. The colonies grew on two abundant plastics — polypropylene and polyethylene — and were different from microbe populations in the surrounding seawater, the researchers reported in *Environmental Science & Technology*.

Polypropylene, which is often used in packaging, hosted 799 distinct microbe species that weren't found on polyethylene or in the water. Likewise, 413 species were unique to polyethylene, the most common plastic produced worldwide. Seawater samples yielded 1,789 different microbes. Just 53 species populated both the water and the two types of plastic.

These numbers suggest that some microbes living on ocean plastic might not be found in the seawater otherwise. Or they may be present, but in amounts too low to detect. Another possibility is that the microbes hitchhiked on plastic from a different part of the ocean.

Beyond the Atlantic, microbes have been found populating plastics in Australian waters and the vast expanse of water between Hawaii and the continental United States. Coastal northern European countries have collected plastisphere microbes as well. Even the Great Lakes have microbes living on plastic, according to early work by Melissa Duhaime, a microbiologist at the University of Michigan in Ann Arbor.

In many cases, the microbe species differ depending on the water they occupy. There also seems to be a geographic footprint pointing to where the microbes originated, says Linda Amaral-Zettler, a marine microbial ecologist at the Marine Biological Laboratory in Woods Hole and a coauthor with Mincer on the 2013 paper.

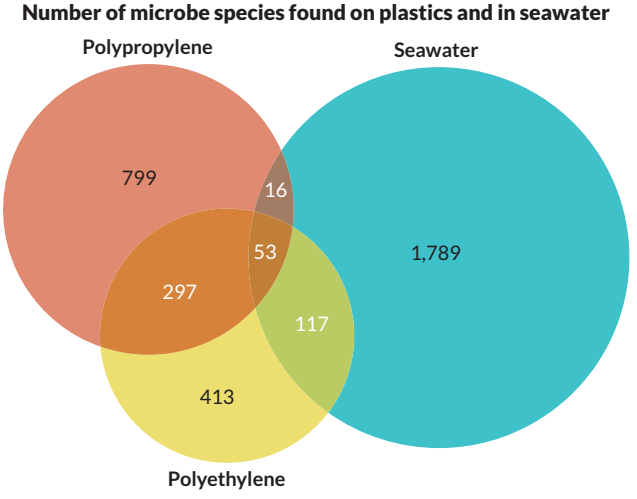
Microbes on microplastics in the North Pacific differed from those in the North Atlantic, Amaral-Zettler, Mincer and colleagues reported in the December *Frontiers in Ecology and the Environment*. Along with geographic variation, the number of microbe species on the plastic pieces also correlated with latitude. Possibly tied to temperature, latitudes closer to the equator had more species than latitudes nearer the poles.

Microbe populations might also change with the seasons, says Caroline De Tender, a marine microbiologist at the Institute for Agricultural and Fisheries Research in Merelbeke, Belgium. "It's something that we suspect is happening," says De Tender, who got a sense of seasonal variety while analyzing plastic pieces from the North Sea near Belgium collected in March and August of 2014. Those results appeared last August in *Environmental Science & Technology*.

Other research supports the idea. Clear differences emerged among microbe communities when researchers left plastic water bottles exposed in the North Sea for six weeks at a time during winter, spring and summer in a study reported in 2014 in *FEMS Microbiology Ecology*. Knowing the geography and environmental factors could help researchers get a better

M. ERIKSEN *ET AL*/*PLOS ONE* 2014, ADAPTED BY E. OTWELL

Different neighborhoods DNA fragments revealed that ocean plastic and seawater host their own kinds of microbes. Two common plastics, polypropylene and polyethylene, had hundreds of microbe species not common in seawater. Areas of overlap show microbes that occupy multiple habitats. SOURCE: E.R. ZETTLER *ET AL/ENVIRON. SCI. TECHNOL.* 2013



handle on the amount of plastic going into the ocean and where it's coming from.

The food chain

To understand the plastisphere, scientists must figure out why microbes congregate on plastic.

For one thing, a hard piece of plastic offers a solid surface to latch on to and grow on in the open ocean. Better still, the plastic acts like a meal plate, serving up an all-day buffet.

"A surface in the open ocean is a real advantage for these guys because it concentrates nutrients that they're competing for," Mincer says.

In the open ocean, the main ingredients of many ocean microbes' diets, such as nitrogen and phosphorus, are often lacking. Like dust on a windowsill, nutrients suspended in seawater will collect on a hard surface. When a piece of floating plastic weighing about one gram is drenched in nutrients, it can grow a microbial community with more biomass than 1,000 liters of open seawater.

While plastic platters of nutrients keep microbes full, they also attract other critters that gobble the microbe-loaded plastic for dinner.

"They smell and taste like something that's good to eat," says Erik Zettler, a microbial ecologist at the Sea Education Association in Woods Hole, who has worked on projects with Amaral-Zettler (his spouse) and Mincer.

It seems that plastic has worked its way up the food chain. Observations of plastic in zooplankton, crabs (*SN: 8/9/14, p. 9*), fish, seabirds and turtles populate the scientific literature.

Rochman, of UC Davis, and colleagues looked for human-related debris such as plastic and textile fibers in fish being sold in Indonesian markets and from fish and oysters for sale in the United States. Out of 76 fish from Indonesia, 21 had plastic in their guts. In the United States, 15 of 64 fish and four of 12 oysters contained human-related debris, mostly fibers from textiles. At least six of the U.S.-sold fish carried plastics, the team reported in September in *Scientific Reports*.

Yet, Rochman says, there's not enough research to say that people shouldn't eat seafood, which is an important source of protein. "What we don't want to do is turn people off to seafood," she says. "I even eat oysters," which can take in a lot of plastic.

Climate impact

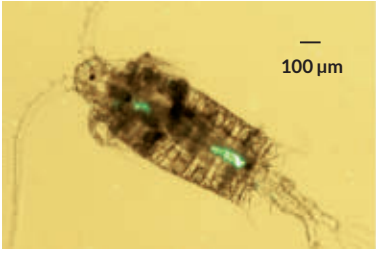
When animals eat plastic, they don't digest it, Rochman says. Any plastic that doesn't get stuck in the digestive tracts of sea critters is let out in the water again. Some scientists think that pooped-out plastic could influence Earth's carbon cycle by releasing climate-warming carbon dioxide back into the atmosphere.

The ocean acts as a big carbon dioxide sink. Normally, microscopic marine plants take up carbon dioxide from the atmosphere. When other organisms eat the plants, they digest what they can and excrete any leftovers as fecal matter that sinks to the ocean floor. That's a good thing, Mincer says, "a geological burial of carbon."

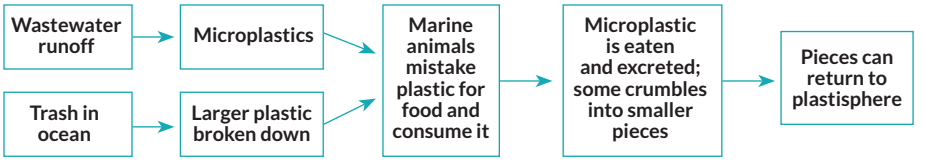
But plastic can destabilize fecal pellets, making them fall apart before they have a chance to sink to carbon-storage depths. When the plastic poop breaks up, it releases nutrients loaded with carbon and keeps carbon at shallow levels.

"What you get is a short-circuiting of [the carbon-storing] pump," Mincer says. "You're not getting effective sequestration and burial of that atmospheric carbon."

Some pooped plastic could make it back to the plastisphere, where it has potential to crumble into even smaller bits. A single 200-millimeter plastic piece, for instance, could potentially split into more than 62,000 pieces. Waves and sunlight can speed the breakdown. Microbes might be helping as well.



Land-to-sea journey Ocean plastic comes from wastewater and trash. Hungry ocean critters, like the copepod to the left, sometimes ingest the plastic (shown in green). After the plastic is pooped out, it can rejoin the plastisphere. SOURCE: M. COLE *ET AL/ENVIRON. SCI. TECHNOL.* 2013



At least a few microbes make pits and grooves on plastic, which might trigger breakage. In the Zettler report from 2013, a few microbes in the North Atlantic made pits in plastics that conformed to their rounded shapes. Similar microbes were found making marks in plastic off the coast of Australia. Whether it's normal microbe wear and tear or a sign that the microbes are consuming the plastic is up for debate.

Even if they are munching on the plastic, microbes probably won't rid the ocean of plastic anytime soon. "Most of what we're finding is not on a timescale that is relevant to human existence," says Duhaime, the Great Lakes microbiologist.

The long life of ocean plastic doesn't just give microbes stable space and ready food. It also has the potential to move organisms outside of their native range, like an unanchored houseboat, ready to spread potentially harmful microbes.

"Ships only go port to port," says David Barnes, a marine ecologist at the British Antarctic Survey. "Plastic goes everywhere."

Ocean currents transport plastic, and anything on it, great distances; computer models show some plastics traveling more than 1,000 kilometers in less than 60 days. Barnes has studied washed-up plastic on islands around the world, and he found one piece that had been afloat for at least a year.

Ocean plastic may have helped spread a coral pathogen that causes skeletal eroding band disease from the South Pacific and Indian oceans to Hawaii and even the Caribbean, researchers reported in 2014 in *Marine Biology*. And that's not the first time a potentially harmful organism has been found on plastic.

Vibrio — a fast-growing group of microbes, some of which can cause disease in fish and humans — has been found living on plastics in a couple of studies. Nearly a quarter of the microbe community from one piece of plastic from the Zettler 2013 study was made of vibrio. Usually, vibrio doesn't make up much more than 1 percent of any microbe community.

Duhaime wonders whether some kind of microbe superbug could populate ocean plastics. In an extreme and entirely hypothetical scenario, such a microbe could embark on a transoceanic, transcontinental journey by traveling via ocean currents to different countries.

The plastisphere, created by human trash fouling the oceans, seems to offer a wealth of opportunity for microbes — a chance to eat well and, possibly, see the world. Scientists are just starting to uncover the complexities of this new ecosystem. With all the variables that can shape microbe communities on ocean plastics, says Amaral-Zettler, it's hard to say what to expect. ■

Explore more

- Erik Zettler. "Life in the plastisphere: What do we know about plastics in the ocean?" COSEE Ocean Systems. April 30, 2014. bit.ly/plastisphere
- Nate Seltenrich. "New link in the food chain? Marine plastic pollution and seafood safety." *Environmental Health Perspectives*. February 2015.

Cleaning the ocean

Since microbes won't be making a substantial dent in the oceans' plastic load anytime soon, creative types have come up with a few ideas to tackle the problem.

Young Dutch inventor Boyan Slat first caught international media attention in 2013 for his plan to clean up the ocean. Just out of high school, Slat proposed using a long V-shaped array of floating barriers to collect ocean plastic. With the help of ocean currents, plastic pieces concentrate in the center of the V and are scooped up by a conveyer belt driven by solar panels and dropped in a collecting station for recycling. A modified version of the 21-year-old's design will be deployed off the coast of Tsushima, Japan, this year.

A floating village called Seawer is an out-there concept that would strain trash from the ocean using a lineup of different-sized filters. Seawer could catch and store big junk, such as refrigerators and tin cans, as well as small plastic particles. To support human inhabitants living topside, the system would produce hydroelectric power and purify seawater for drinking and irrigation.

Other measures work closer to the source. Baltimore's Mr. Trash Wheel removed at least 213 tons of trash from the city's Inner Harbor last year, stopping plastic and other debris before it reached the ocean. Its 2015 roundup included 118,670 plastic bottles and 2.6 million cigarette butts. There's also an app called Marine Debris Tracker that gives beachgoers a chance to log litter finds in a database researchers use to study ocean trash. There soon may be fewer microbeads to tally. In December, President Barack Obama signed legislation banning plastic microbeads in cosmetics. — *Chris Samoray*

The water-powered Mr. Trash Wheel (top) pulls garbage from Baltimore's Inner Harbor. Boyan Slat's solar-powered design (rendering, bottom) uses ocean currents to gather plastics for recycling.

FROM TOP: WATERFRONT PARTNERSHIP OF BALTIMORE; THE OCEAN CLEANUP

SECRETS OF THE ICE GIANTS

Time to shine some light on Uranus and Neptune, our two most far-out planets **By Christopher Crockett**

In the cold periphery of the solar system, two enigmatic sentinels saunter around the sun. One circuit along their vast orbits takes on the order of a century. Seasons are measured in decades. At such great distances from Earth, these worlds give up their secrets slowly. While every other planet in our solar system has been repeatedly poked and prodded by orbiters and landers, Neptune and Uranus, save a brief tour in the 1980s, remain largely unexplored.

Thirty years ago, the Voyager 2 spacecraft tore past Uranus, then flew by Neptune less than four years later. These quick sojourns introduced scientists to two planets that had been vague blue splotches in their telescopes. In the years since, bigger and better instruments have teased out a bit more information and revealed a few surprises.

But there's only so much planetary scientists can learn from a couple billion kilometers away. That's why researchers in both the United States and Europe think it's time to go back to Uranus or Neptune — the solar system's "ice giants." Unlike the show-stopping flyby of Pluto in 2015, a new mission to one of the blue worlds would have more time to take in the view.

In August, NASA's Jim Green gave engineers at the Jet Propulsion Laboratory in Pasadena, Calif., one year to figure out what it would take to put a spacecraft in orbit around Uranus or Neptune. These worlds are "an important frontier," says Green, director of the Planetary Science Division at NASA headquarters in Washington, D.C. "We really don't know much about them." New rocket designs and recent exoplanet discoveries have made the ice giants more accessible and more relevant than ever. "This is a really exciting time for us to be able to study them," he says.

The ice giants aren't frozen orbs; they're actually quite gassy. But Uranus and Neptune have a lot of water, ammonia and methane, which astronomers refer to as ices, whether the compounds are frozen or not. Jupiter and Saturn, by comparison, are mostly hydrogen and helium, which remain gases at nearly any temperature. The inner planets are relatively tiny balls of rock.

Astronomers have learned a lot in the three decades since Voyager. Researchers now know that as the giant planets jockeyed for position more than 4 billion years ago, Uranus and Neptune helped create the Kuiper belt, the ring of icy debris that is home to many comets. And when Voyager 2 departed Neptune in 1989, astronomers knew

The other blue planets Uranus (left) and Neptune (right) have not been visited since Voyager 2 sped by in the late 1980s. Many researchers argue that it's time to go back.

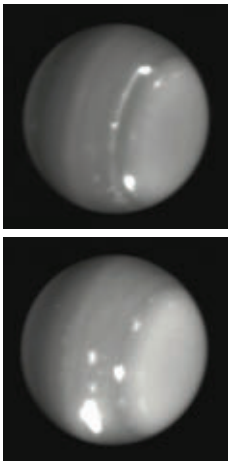
BOTH: JPL-CALTECH/NASA

only of the planets that orbit the sun. Since then, researchers have cataloged about 2,000 planets around other stars, and the Kepler space telescope has shown that the most common type is the size of Uranus and Neptune. Ice giants, or something like them, might be the most popular type of planet in the galaxy.

"We barely understand the two in our own backyard, and we're finding so many around other stars," says Candice Hansen, a planetary scientist with the Planetary Science Institute in Tucson, Ariz. "How do we interpret these planets around other stars if we barely know our own?"

A closer look

Uranus and Neptune are the only planets (sorry, Pluto) in the solar system to be discovered since the invention of the telescope (for hints of a new planet, see Page 6); the others have been known since antiquity. William Herschel stumbled upon Uranus in 1781; astronomer Johann Galle spotted Neptune in 1846, almost exactly where mathematicians Urbain Le Verrier and John Couch Adams predicted an eighth planet should be.



Storms (bright spots) erupt in 2014 on normally sleepy Uranus, seen in these infrared images from the Keck Observatory.

Before Voyager arrived, researchers knew little about the two outliers. "They hold their secrets very tightly," says Heidi Hammel, a planetary scientist at the Space Science Institute in Boulder, Colo. At 2.9 billion and 4.5 billion kilometers from the sun, Uranus and Neptune "are right at the very edge of what we can do with great telescopes," she says.

Scientists had figured out a few properties though. Both planets are about four times as wide as Earth and roughly 16 times as massive. The closer one, Uranus, takes 84 years to orbit the sun; poky Neptune needs nearly double that time. Each has a family of small moons and a set of dark rings (Neptune's rings were suspected, then confirmed by Voyager 2).

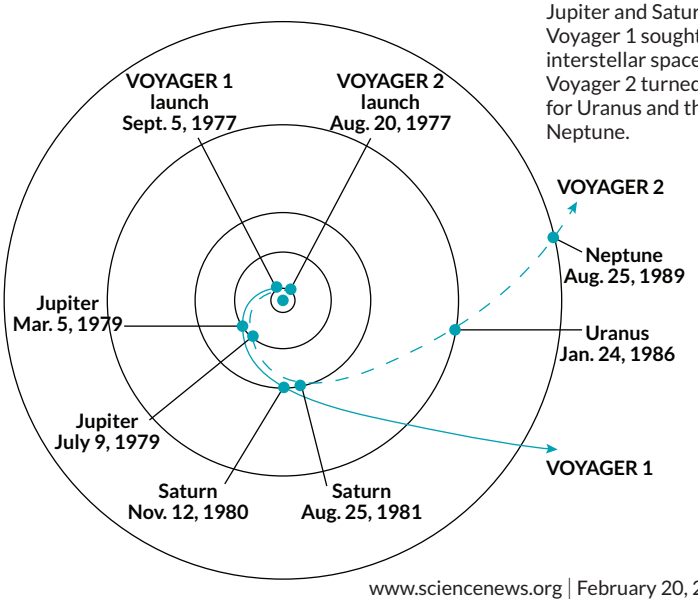
From early on, Uranus stood out as possibly the oddest planet of all: It's a world knocked over on its side, probably by some long ago collision with an interplanetary interloper, leaving it with extreme seasons that endure for decades. Based on observations from Earth, there didn't appear to be a lot happening on Uranus. "It looked just like a cue ball in outer space," Hammel says. Neptune, by contrast, flickered as reflective clouds whipped around the planet, but that was about all it was willing to reveal.

Getting up close and personal was the only way to learn more. When Voyager 2 arrived at Uranus on January 24, 1986, it was greeted by a bland world. The aquamarine cloud deck showed very little activity, earning Uranus a nickname of "the boring planet." Voyager did pick up an unusually complex magnetic field and a few new rings. The spacecraft also got a good look at the planet's posse of icy moons, including Miranda, a strange satellite that looks like someone smashed it apart and then hastily glued it back together.

Three years and seven months later, Voyager 2 soared over the north pole of Neptune, where it found a much more vibrant planet. The royal blue atmosphere churned with storms, and a blemish nicknamed the Great Dark Spot reminded scientists of the colossal red storm on Jupiter. Voyager clocked clouds on Neptune moving at more than 2,000 kilometers per hour — the fastest recorded winds in the solar system. On Neptune's largest moon, Triton, cryovolcanoes erupted over pitted terrains, hinting at geologic engines churning inside.

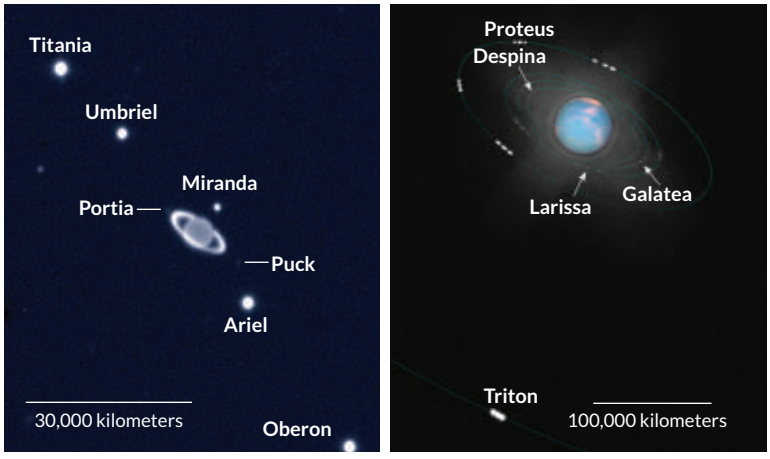
But many mysteries remain that are challenging if not impossible to wrestle with from Earth. Uranus gives off very little heat, while the more distant Neptune is by comparison a planet-sized furnace. Magnetic fields emanating from both worlds are unlike those seen at other planets: The

> "How do we interpret ... planets around other stars if we barely know our own?"
>
> CANDICE HANSEN



Swinging by In 1977, Voyagers 1 and 2 embarked on a road trip that took both past Jupiter and Saturn. Voyager 1 sought out interstellar space, while Voyager 2 turned left for Uranus and then Neptune.

FROM TOP: BOTH: IMKE DE PATER (UC BERKELEY), LARRY SROMOVOSKY AND PAT FRY (U. WISCONSIN), HEIDI HAMMEL (AURA)/KECK OBSERVATORY; NASA, ADAPTED BY J. HIRSHFELD



Distant families The rings and moons of Uranus (left) glow in a 2002 image from the Very Large Telescope. A horde of satellites orbit Neptune (right) in an illustration based on Hubble Space Telescope images taken one Neptune year (164 Earth years) after the planet's discovery.

fields are significantly tilted from the spin axes and appear to be generated far from either planet's core. Neptune's rings clump together into arcs while the ones around Uranus possibly reach down into its atmosphere. Half of the real estate among Uranus' moons remains uncharted.

The Voyagers transformed astronomers' view of the ice giants and did so with instruments built in the 1970s. Both Voyager 1 and 2 launched in 1977, the same year as the first mass-produced Apple computer (the Apple II) and the Atari 2600 video game system. "That's the technology we used to explore the ice giants," Hammel says. "If we put my iPhone on a spacecraft and sent it out there, we'd have better image quality."

Since then, premier observatories such as the Keck telescopes in Hawaii and the Hubble Space Telescope in low Earth orbit have pushed beyond Voyager's legacy. They've picked up rumblings from Uranus, which seems to be waking up. As southern summer on Uranus gave way to fall in the mid-2000s, storms appeared and the atmosphere looked more like Neptune's. "Our idea of a boring blue ball probably wasn't quite correct," says Amy Simon, a planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Md.

But sophisticated telescopes have their limits. "Getting images of the planets is nowhere near enough," says Leigh Fletcher, a planetary scientist at the University of Oxford. "To understand the physics and the chemistry, you need to be there."

Go big or go home

In 2010, researchers in Europe tried to persuade the European Space Agency to pursue a Uranus orbiter as a "medium-class" mission, at a cost of roughly 500 million euros. That failed bid was followed by an opportunity in 2013 for a more comprehensive "large-class" — or 1 billion euro — mission, and a 2014 request for medium-class mission ideas. ESA ranked the ice giant proposals high every time, but not high enough to be funded. The agency will issue another call for medium-class missions this spring, but it's a tough sell, Fletcher says.

One problem for Europe is that it doesn't have access to the nuclear energy needed for travel so far from the sun, where solar panels are useless. NASA, however, is funding production of plutonium-238, a radioactive element whose heat, once transformed into electricity, can power a remote spacecraft. "The whole landscape would change if there was a strong push from NASA to fly one of these missions," Fletcher says.

Fletcher and his European colleagues just might get their wish. In 2011, the U.S. planetary science community ranked Mars, Europa and Uranus as the top priorities in the coming decade for a NASA flagship, its biggest (and most costly) mission class (*SN: 4/9/11, p. 16*). Plans for Mars and Europa are under way. By September, JPL will present NASA with some ideas for an ice giant flagship including details on what the space agency needs to invest in to accomplish its science goals.

What exactly that science entails depends on which ice giant the spacecraft visits. Each planet has appeal. Because Uranus is knocked over on its side, its seasons are extreme; the poles see 42-year stretches of continual sunlight followed by equally long periods of darkness. That makes Uranus a great testing ground for ideas about how planets work, Fletcher says, by seeing how these theories hold up on a sideways planet. Point for Uranus.

On the other hand, maybe Uranus is a little

FROM TOP LEFT: EUROPEAN SOUTHERN OBSERVATORY; NASA, ESA, Z. LEVAY/STSCI; J. HIRSHFELD

A slower pace Time drags on the ice giants (drawn to scale with Earth). Uranus needs 84 Earth years to loop around the sun. New Year's resolutions on Neptune, meanwhile, come only once every 164 Earth years.

too weird. Neptune might be the better target for understanding how a typical ice giant behaves, which is important for understanding many of the planets orbiting other stars. Voyager 2 already showed that Neptune's atmosphere is churning with storms, offering plenty of fascinating details to pore over. Uranus, though starting to stir, is relatively sedate. Point for Neptune.

When it comes to the moons, the situation is reversed. "If we go to Neptune, we'll see a normal planet but not normal satellites," says Mark Hofstadter, a planetary scientist at JPL. "If we go to Uranus, we'll see an oddball planet but normal satellites."

Uranus has five major moons and 22 diminutive ones. Researchers suspect that these are the planet's original satellites and might be a good example of what forms around an ice giant. Because the entire system — planet, rings and moons — is tipped over, Voyager 2 was able to see only one hemisphere of each moon. An entire half of the system remains hidden. "The satellites are really terra incognita," Fletcher says. Point: Uranus.

But Neptune has Triton, a crown jewel of the outer solar system. "It's a fascinating frozen paradise," Hansen says. Like Saturn's moon Enceladus (*SN: 12/26/15, p. 23*), Triton has erupting geysers, possibly linked to a subsurface ocean. The surface has been remodeled in the last 10 million years or so, which is pretty recent by solar system standards and hints at active geology. Point: Neptune.

Triton is also not native to Neptune. The moon, which orbits in the opposite direction of Neptune's rotation, was probably pilfered from the Kuiper belt, the field of frozen fossils where Pluto lives. "It's a cousin to Pluto," Hammel says. "Pluto and Triton are a wonderful matched pair to do comparative studies." Double points for Neptune.

Both planets are such enigmas that a mission to one or the other will have plenty to teach planetary scientists. "Most folks would be happy to go to either one," Simon says. The decision is more likely to come down to logistics: "What's the sweet-spot mission that gets you the most science for your dollar."

Getting to the ice giants won't be easy. A spacecraft needs roughly a decade just to get to its destination. There are ways to shorten the trip such as getting a gravity kick from Jupiter or Saturn, but that depends on the planets being in the right place at the right time.

All things being equal, Uranus is closer and therefore easier (and cheaper) to get to. But if there's a trajectory that grabs an assist from Jupiter or Saturn, Neptune might be the better bet. NASA's Space Launch System, a powerful rocket scheduled to debut in late 2018, could shake things up. "It's the largest rocket that this world has ever produced," Green says. "It has incredible oomph for getting anything into space very fast." A spacecraft launched atop the SLS might need only a few years to reach an ice giant.

Shortening the interplanetary cruise saves time and money, but the faster the spacecraft goes, the harder it must hit the brakes at journey's end. "You have to throw off one of your science instruments to carry the extra fuel to slow down," Hofstadter says. One solution is a daredevil maneuver known as "aerocapture," where the planet's atmosphere does most of the work. The spacecraft has to plow through the atmosphere deep enough to slow down but not so deep that it burns up. Some missions closer to home have used a gentler version of aerocapture to tweak trajectories. No one has used it for orbit insertion.

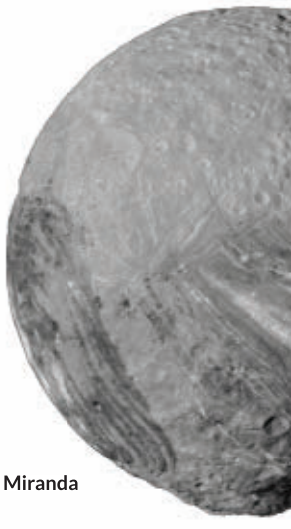
JPL's task this year will be to evaluate those risks and explore mission options for each planet. "Both have stories to tell," Hansen says. "You can't go wrong — either one would be revolutionary."

The New Horizons mission to Pluto showed what can be learned by flying a 21st century spacecraft past an unexplored world (*SN: 12/26/15, p. 16*). Researchers had a good idea of what might be waiting for them, but the reality exceeded expectations. "Pluto is a fabulous example of wherever we look, we discover amazing new things," Fletcher says. "The frontier now lies out at the ice giants." ■

Explore more

- D. Turrini *et al.* "The ODINUS mission concept — The scientific case for a mission to the ice giant planets with twin spacecraft to unveil the history of our solar system." White paper submitted to European Space Agency, 2013.

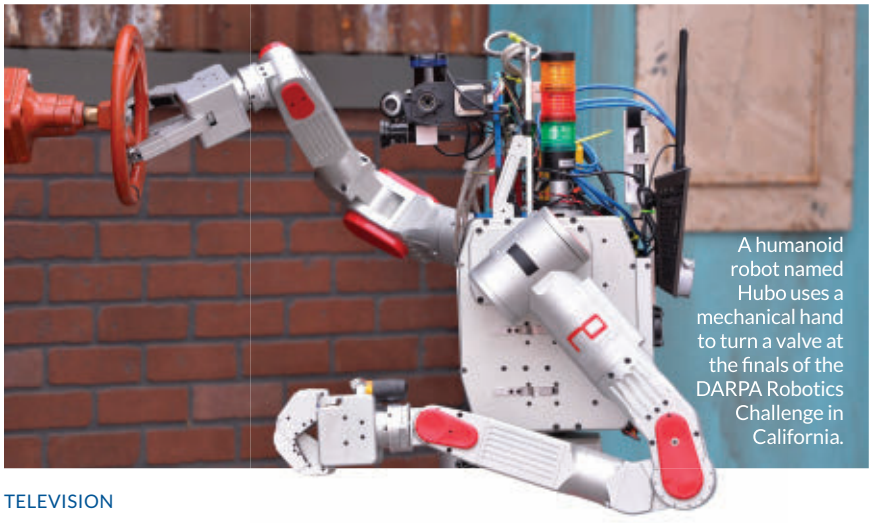
Triton



Miranda

Exotic moons
Neptune's largest moon Triton (top) is an actively changing world and a distant cousin of Pluto. Miranda (bottom), a satellite of Uranus, harbors a hodgepodge of terrains and the tallest known cliff — roughly 20 kilometers — in the solar system.

FROM TOP: JPL-CALTECH/NASA, USGS, JPL-CALTECH/NASA



A humanoid robot named Hubo uses a mechanical hand to turn a valve at the finals of the DARPA Robotics Challenge in California.

DARPA

TELEVISION

Robots (almost) ready to come to the rescue

At the 2013 trials of DARPA's robotics competition in Florida, a high-tech robot named Hubo had just about completed a tricky challenge: climbing up a ladder roughly the height of a small elephant.

Hubo, a 5-foot-tall walking bot, was pitting its skills against a slew of formidable contenders, all in a contest designed to simulate what rescue robots might face in a disaster (*SN: 12/13/14, p. 16*). Hubo had already climbed eight of the ladder's nine rungs — more than any other bot in the competition.

Then, Hubo tipped over and plunged off the ladder, dangling from a safety wire like a dancing marionette.

Rise of the Robots
AIRS FEBRUARY 24
PBS | NOVA

The bot's rise and fall illustrates the state of humanoid robotics today, suggests "Rise of the Robots," a documentary from the TV series NOVA that will air February 24 on PBS. Roboticists have created all sorts of fancy machines that can do all sorts of impressive things, such as cooking, dancing and even folding laundry. But getting these bots ready for rescue work — walking over rubble, picking up debris and driving cars, for example — is an entirely different story.

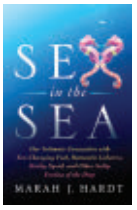
In fact, just getting bots to work outside the lab is tough, say several researchers interviewed in the show. "The real world is like the wild, Wild West," says Tony Stentz, a roboticist at Carnegie Mellon University in Pittsburgh.

"Rise of the Robots" introduces viewers to Stentz's team's bot, a roughly 180-kilogram behemoth named CHIMP, and a suite of other people-sized machines. The documentary follows these robots as they tackle tasks in DARPA's competition, which ended in 2015. Seeing the bots in action is thrilling, but their awkwardness is eye-opening. Humanoid robots have yet to master upright walking on two legs, like people do. It's one of the trickiest problems facing modern roboticists. In the competition, robots trudge slowly, topple over backward and stand motionless for minutes at a time.

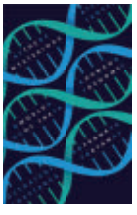
Still, there's plenty to ooh and ah over. The documentary takes a round-the-world tour of some of the hottest robotics labs. In London, a black robotic hand wiggles slim mechanical fingers nearly as deftly as a human. In Florida, a hulking humanoid bot named Atlas balances on one foot, waving arms in the air like the Karate Kid.

At the end of the hour-long show, "Rise of the Robots" brings viewers back to Hubo. The robot has a slick new look and is now competing in the competition's finals. The action is still slow, but viewers will be on the edge of their seats rooting for machines that are steps closer to becoming more human, if not yet there.
— Meghan Rosen

BOOKSHELF

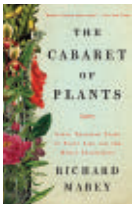


Sex in the Sea
Marah J. Hardt
The seemingly bizarre sex lives of lobsters, corals, whales and other sea creatures not only make for an entertaining read, but are also of vital importance to food security, economics, health and other global issues, a marine biologist argues. *St. Martin's Press, $26.99*



The Mysterious World of the Human Genome
Frank Ryan
This easy-to-read introduction to human genetics recounts the stories of how scientists came to understand everything from DNA and RNA to epigenetics and the viral invaders that have left lasting marks on our genes. *Prometheus Books, $28*

Restless Creatures
Matt Wilkinson
A zoologist offers an unconventional take on the history of life on Earth by concentrating on milestones in the evolution of locomotion. *Basic Books, $28.99*



The Cabaret of Plants
Richard Mabey
This colorful botanical history takes readers on a global tour of the myriad plants that have captivated human imagination for tens of thousands of years. *W.W. Norton & Co., $29.95*

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

SOCIETY UPDATE

CELEBRATING 75 YEARS
INTEL 1998 - 2017
WESTINGHOUSE 1942 - 1998

intel SCIENCE TALENT SEARCH a program of SOCIETY FOR SCIENCE & THE PUBLIC EST. 1942

The Intel Science Talent Search, celebrating its 75th anniversary this March, is the nation's most prestigious pre-college science competition. In January, 40 finalists were selected from 1,750 entrants throughout the country based on their scientific research and overall potential as future leaders of the scientific community. Finalists will travel to Washington, D.C., in March to undergo final judging, display their work to the public, meet with notable scientists and compete for $1,012,500 in awards, including the three top awards of $150,000 each.

Science Talent Search finalists from 1942, the first year of the competition, in front of the U.S. Capitol.

2016 Intel STS finalists

CALIFORNIA **Claire Bernadette Burch**, Mira Loma High School, Sacramento; **Sanath Devalapurkar**, West High School, Torrance; **George Hou**, Arcadia High School, Arcadia; **Anjini Karthik**, St. Francis High School, Mountain View; **Jonathan Ma**, The Harker School, San Jose; **Anin Sayana**, Bellarmine College Preparatory, San Jose; **Pranav Srinivas**, Monta Vista High School, Cupertino; **Maya Varma**, Presentation High School, San Jose; **Asher Justin Willner**, Yeshiva University High School of Los Angeles, Los Angeles; **Clare Zhu**, Northwood High School, Irvine

CONNECTICUT **Helen Liu**, Amity Regional High School, Woodbridge

FLORIDA **Beverly Ge**, Buchholz High School, Gainesville; **Maria Elena Grimmett**, Oxbridge Academy of the Palm Beaches, West Palm Beach

IDAHO **Nathan Charles Marshall**, Boise High School, Boise

INDIANA **Sreya Vemuri**, Carmel High School, Carmel

MASSACHUSETTS **Yashaswini Makaram**, Massachusetts Academy of Math and Science, Worcester; **Amol Punjabi**, Massachusetts Academy of Math and Science, Worcester

MARYLAND **Michael Yifan Li**, James M. Bennett High School, Salisbury; **Arnold Mong**, Montgomery Blair High School, Silver Spring; **Josephine Jessica Yu**, Montgomery Blair High School, Silver Spring

MAINE **Paige Brown**, Bangor High School, Bangor; **Demetri Maxim**, Gould Academy, Bethel

MICHIGAN **Shreya Menon**, Skyline High School, Ann Arbor

MISSOURI **Rachel Zhang**, Parkway South High School, Manchester

NEW HAMPSHIRE **Meena Jagadeesan**, Phillips Exeter Academy, Exeter

NEW YORK **Andrew Ethridge Amini**, Yorktown High School, Yorktown Heights; **Katharine Barr Berman**, Hastings High School, Hastings-on-Hudson; **Soon il Junko Higashino**, Ossining High School, Ossining; **Jessica Li Huang**, Jericho Senior High School, Jericho; **Catherine Jessica Yihui Lai**, The Brearley School, New York; **Allen Liu**, Penfield High School, Penfield; **Rachel Mashal**, John F. Kennedy High School, Bellmore; **Augusta Uwamanzu-Nna** Elmont Memorial High School, Elmont

OHIO **Kavya Ravichandran**, Hathaway Brown School, Shaker Heights

OREGON **Vikul Gupta**, Oregon Episcopal School, Portland

PENNSYLVANIA **Milind Jagota**, Liberty High School, Bethlehem; **Michael Zhang**, Conestoga High School, Berwyn

TENNESSEE **Thomas William Colburn**, Oak Ridge High School, Oak Ridge

TEXAS **Joshua Choe**, St. Mark's School of Texas, Dallas

VIRGINIA **Kunal Shroff**, Thomas Jefferson High School for Science and Technology, Alexandria

Finalists are listed by state, name, high school's name and city.

DECEMBER 26, 2015

SOCIAL MEDIA

Planetary humor

If we gave an award for top Twitter replies of the year, this one from **@MasterMarquette** would most certainly be in the running. When **@NewHorizons2015** tweeted that the team was proud to be named the year's top science story by **@ScienceNews**, he made a quick quip about Pluto's 248-year orbit:

@ScienceNews @NewHorizons2015
Are you referring to an Earth year or a Pluto year, in which case, that is *really* big news.

Join the conversation

E-MAIL editors@sciencenews.org

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

Connect with us

Tussle over top spot

The New Horizons mission to Pluto beat out the breakthrough gene editor CRISPR for the top spot in our list of the 25 most important stories of 2015 (SN: 12/26/15, p. 16). *"CRISPR is a method. It's a story still being written," wrote* ***Eva Emerson****, editor in chief. "Seeing a faraway planet for the first time is whiz-bang; it's a new frontier."*
As we expected, print and online readers were mixed on whether Pluto or CRISPR deserved to be No. 1. Pluto "has already impacted our imaginations powerfully and visually," wrote reader **Robert Walty**, who commended us on the placement. CRISPR, he added, still has the potential "in some of its uses" to be No. 1 in 2016 or 2017. Another reader, **Joe M. Wesley**, adamantly disagreed, writing that the choice was unfounded. "Who in management has a degree in astronomy?" he asked.

Elizabeth Nolan had a more balanced view. "Original, as I sense original, is seeing something for the first time, something that is really there. Uncovering a great unknown that really does exist. Creativity, on the other hand, to me, is putting something together in a new way," she wrote. "In this regard, Pluto seems original; CRISPR, creative. Let's hope they both add positive contributions to our lives."

Best of the rest

Among the stories on our Top 25 list to generate enthusiastic responses on social media was the best evidence yet for water on Mars (SN: 12/26/15, p. 26). *Readers also enjoyed a wrap-up of the year's fossil finds* (SN: 12/26/15, p. 31).
Regarding the Mars find, Twitter user **@gabgar95** wrote: "Wow! The universe is so fascinating, it keeps surprising us every day! Hard to believe some ppl find fake myths more majestic."

"Love dinosaur news," wrote **Sandy Whitney** on Facebook, in response to our video of the top fossil finds. "Years in millions ... unbelievable!" said **Usman Khan**. "This is why I love science," added **Robert Ganson**. "It's not blind faith, it's discovery of facts and it's not afraid to change when change is moving forward with knowledge."

Sue Mandeville wanted to know why this was such a good year for discovering "the oldest" fossils. We don't have a good answer for that. The seemingly large number might simply be an artifact of where journalists focused their reporting. But we did check in with vertebrate paleontologist **Samuel A. McLeod**, a collections manager at the Natural History Museum of Los Angeles County. He suspects that the number of new species discovered in the fossil record each year is in the hundreds. "It's not like you go out in the field and you pick one up and say, Eureka, I've got a new species," he said. "You have to collect them, prepare them, sit down and do all the research. It takes a long time." And discovery doesn't happen at a constant rate, either. "It's like everything; there are dry spells."

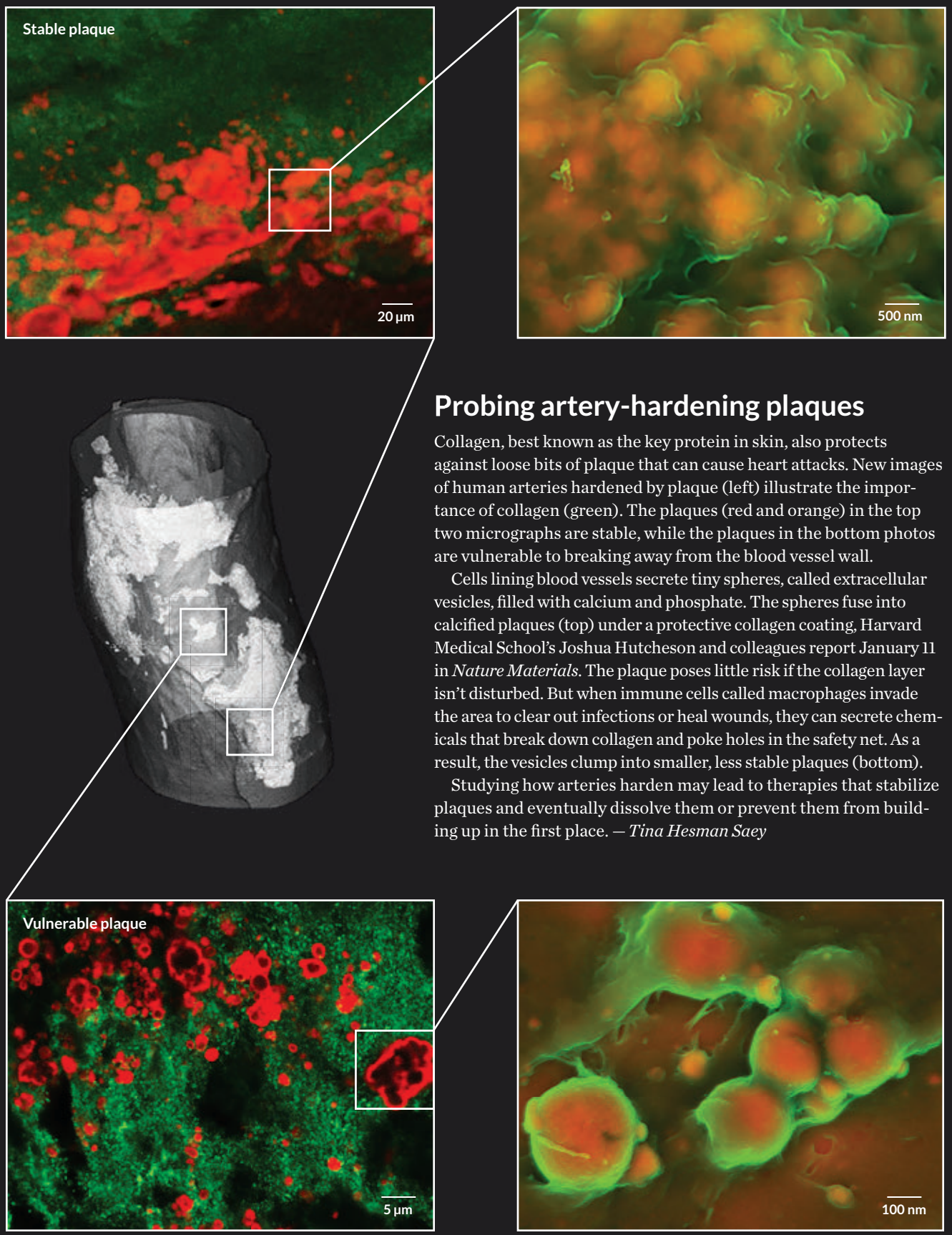
Readers also pointed to some stories they thought we'd missed, including the successful landing of the SpaceX rocket (*SN Online: 12/22/15*). Unfortunately, the rocket wasn't even considered because it didn't stick its landing until after our press date.

Voice therapy

In "Engineered vocal cords show promise," (SN: 12/26/15, p. 9) ***Chris Samoray*** *wrote about bioengineered tissue that hums in tune with human vocal cords. The approach "opens a route to developing new therapies for people who have lost their voice due to surgery or disease."*
Reader **Mike Cord** wondered: Hasn't a currently available prosthesis known as the Blom-Singer valve brought relief to many laryngectomy patients? "It seems to be an overstatement that good treatment is not available," he wrote.

Nathan Welham, who led the study, responded: "Our article describes a treatment to replace impaired or missing vocal fold mucosa, which is the vibrating portion of the larynx that is important for making sound for voice. It is not necessarily a treatment for laryngectomy patients who have had the entire larynx removed."

NASA



Probing artery-hardening plaques

Collagen, best known as the key protein in skin, also protects against loose bits of plaque that can cause heart attacks. New images of human arteries hardened by plaque (left) illustrate the importance of collagen (green). The plaques (red and orange) in the top two micrographs are stable, while the plaques in the bottom photos are vulnerable to breaking away from the blood vessel wall.

Cells lining blood vessels secrete tiny spheres, called extracellular vesicles, filled with calcium and phosphate. The spheres fuse into calcified plaques (top) under a protective collagen coating, Harvard Medical School's Joshua Hutcheson and colleagues report January 11 in *Nature Materials*. The plaque poses little risk if the collagen layer isn't disturbed. But when immune cells called macrophages invade the area to clear out infections or heal wounds, they can secrete chemicals that break down collagen and poke holes in the safety net. As a result, the vesicles clump into smaller, less stable plaques (bottom).

Studying how arteries harden may lead to therapies that stabilize plaques and eventually dissolve them or prevent them from building up in the first place. — *Tina Hesman Saey*

J.D. HUTCHESON *ET AL*/*NATURE MATERIALS* 2016

Doctor ***Designed.*** Audiologist ***Tested.*** FDA ***Registered.***

Hear Better! *Pay Less!* *Superior* Quality for Far Less America's *#1 Value* Hearing Aid

Reported by J. Page

Chicago: Board-certified Ear, Nose, and Throat physician Dr. S. Cherukuri has done it once again with his newest invention of a medical-grade, ALL-DIGITAL, affordable hearing aid.

This new digital hearing aid is packed with all the features of $3,500 competitors at a mere fraction of the cost. Now, most people with hearing loss are able to enjoy crystal clear natural sound — in a crowd, on the phone, in the wind — without suffering through "whistling" and annoying background noise.

After years of extensive research, Dr. Cherukuri has created a ***state-of-the-art*** digital hearing aid that's packed with the features of those expensive $3,500 competitors – at a ***fraction of the price***.

Digital Hearing Aid Outperforms Expensive Competitors

This sleek, lightweight, fully programmed hearing aid is the outgrowth of the digital revolution that is changing our world. While demand for "all things digital" caused most prices to plunge (consider DVD players and computers, which originally sold for thousands of dollars and today can be purchased at a fraction of that price), yet the cost of a digital medical hearing aid remains out of reach.

Dr. Cherukuri knew that many of his patients would benefit but couldn't afford the expense of these new digital hearing aids. Generally they are not covered by Medicare and most private health insurance policies.

The doctor evaluated all the high-priced digital hearing aids on the market, broke them down to their base components, and then created his own affordable version — called the MDHearingAid ***AIR*** for its virtually invisible, lightweight appearance.

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- ✓ Nearly ***invisible***
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- ✓ No suffering with ***'whistling'*** or background noise
- ✓ ***Outperforms*** $3,500 models
- ✓ Amazing ***low price***

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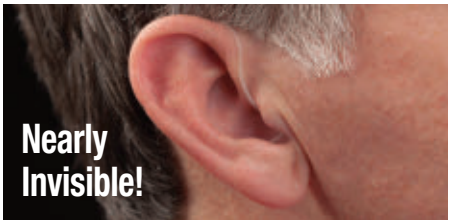
Using advanced digital technology, the MDHearingAid ***AIR*** automatically adjusts to your listening environment — prioritizing speech and de-emphasizing background noise. Experience all of the sounds you've been missing at a price you can afford. This doctor designed and approved hearing aid comes with a full year's supply of long-life batteries. It delivers crisp, clear sound all day long and the soft flexible ear domes are so comfortable you won't realize you're wearing them.

Try it Yourself at Home with a 45-Day Risk-Free Trial

Of course, hearing is believing and we invite you to try it for yourself with our RISK-FREE 45-Day home trial. If you are not completely satisfied, simply return it within that time period for a full refund of your purchase price.

MDHearingAid® AIR

FREE Batteries For A Year!



Ecstatic Users Cheer

"It is very comfortable, light and almost invisible. I can't stop raving about it." — Laraine T.

"I'm a physician, and this product is just as effective as (if not more than) traditional overly-priced hearing aids. I will be recommending (it)." — Dr. Chang

"As a retired advanced practice nurse, I purchased the MDHearingAid AIR after the Wall Street Journal *review. I am so pleased with the quality. You are providing a real service to our affordable health care."* — Ned R.

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The 1958 Aston Martin DB 2/4 Mark III.

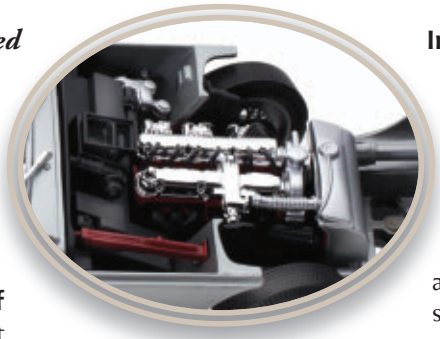
Not actual size.
Shown in classic
Moonbeam Grey

British Spy Not Included.

Vodka martinis... Perfectly tailored suits... The Walther PPK pistol... the Aston Martin.

The legendary British spy has had many vehicles over the span of five decades, but without a doubt the double-O agent's car of choice was, and is the Aston Martin.

What we're about to tell you is sort of classified. While the later DB5 is most often associated with secret agent, the man with a license to kill made his first appearance in Ian Fleming's original novel *Goldfinger* behind the wheel of this sleek and sexy car— the ***1958 Aston Martin DB 2/4 Mark III***.



View the Peppy Straight-6 Engine
Die-cast metal body features doors, hood and trunk that open, steerable wheels that roll, and four wheel suspension. In classic paint color Moonbeam Grey.

Insider Tip: When the story gets out that this is the Aston that started it all, we can't guarantee availability for long. So don't miss your opportunity to own a piece of cultural history and call today.

Your satisfaction is 100% guaranteed. "Test drive" this beauty for 60 days. If for any reason it's not bringing out your inner secret agent, simply return it to us for a refund of the sale price. Even though there's no ejector seat, revolving license plate or champagne cooler, we're sure you can spy a killer deal when you see it.

No gadgets were required to make it a force to be reckoned with, as the Mark III's Bentley®-designed Lagonda® 2.9 liter straight-6 engine purred like a kitten, hitting 60 mph in 9.3 seconds and topping out at 120 mph.

With Feltham-era, hand-built quality and legendary road-ability, this model continues to be highly coveted. In fact, a 1958 Aston Martin DB MK III fetched over $1 million dollars when it went under the hammer at Pebble Beach in 2014.

"A car for connoisseurs...The Aston has many virtues and few faults." —Road and Track Magazine

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