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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MAY 18, 2013

Set adrift

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What's Wrong with Red Meat

Kepler Closes in on Earthlike Worlds

Three Dimensions of Silence

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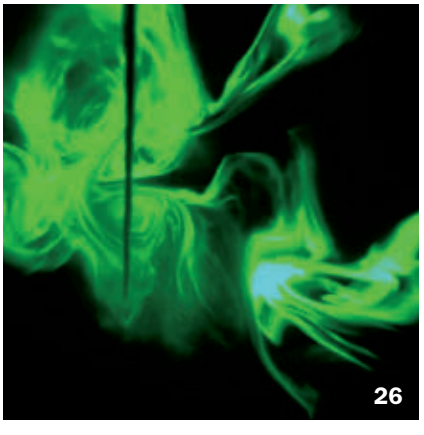

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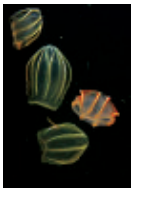

COVER With soft bodies and iridescent cilia, comb jellies look like no other animal. DNA studies argue for their unique place in the tree of life. *George Grall/National Geographic Stock*

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FROM THE EDITOR

Discoveries help reveal our place in the universe

Science News editors have sometimes joked about lightening the workload by installing counters on the website that would just roll over each time another distant world is discovered or another organism's genetic catalog debuts. Once rare and even astounding, such milestones have become more like a full moon: notable but not that surprising.

We have so far resisted that urge. And I'm glad. Two fascinating stories in this issue illustrate why. The first, by physics writer Andrew Grant on Page 5, reports on two new exoplanets that seem the most Earthlike of any yet found. And this, one scientist says, is just the tip of the iceberg. As the search for exoplanets matures, astronomers are converging on their ultimate quarry: a planet just like home. The methods used to find exoplanets favor bigger planets. Giant objects create a larger gravitational wobble on their star and are easier to detect. So are those that tightly orbit their stars, and so cast a shadow across their star's visage more often.

A true Earthlike planet is smaller and orbits a sunlike star as Earth does, once every 365 days or so and at a comfortable distance. Since researchers using the Kepler space telescope require three orbits to verify a discovery, it would take at the least three years to detect an Earthlike planet. And that's not including the many additional months to years it takes to analyze the raw data. Kepler was launched four years ago, which explains why astronomers now feel poised on the edge of a truly great discovery.

Of course, the question at the heart of all this tremendous effort to spy other worlds is a deep desire to know more about ourselves: How rare is Earth? How rare is life?

A similar question echoes through freelance writer Amy Maxmen's piece on comb jellies and animal evolution — another we might have skipped if we had gone to the counter method. On Page 20, Maxmen describes how new studies of these unusual marine animals' genomes are forcing biologists to ask whether complex life is rare or if it may have arisen multiple times: once in comb jellies and again in the ancestor that led to most other animals alive today, including us.

The full moon always delights me, no matter how many times I catch its brilliance. So does learning about the existence of unknown planets, however innumerable they turn out to be, and the hidden secrets written in the DNA of the planet's countless creatures. — *Eva Emerson, Editor in Chief*

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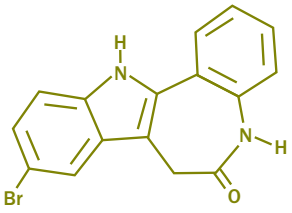

Say What?

Kenpaullone *\ken-PAWL-ohn\ n.*

A synthetic compound that has been studied as a possible treatment for cancer, Alzheimer's and other diseases. Kenpaullone impedes the action of proteins called cyclin-dependent kinases, which affect nerve cell growth and many other cell functions. Daniel Zaharevitz of the National Cancer Institute rediscovered the compound, which had failed as a cancer drug, while searching for such inhibitors in the 1990s. He named the molecule for Kenneth Paull, the creator of the computer program used to identify it, who had died before the paper describing the molecular structure was published. New studies suggest kenpaullone may help nerve cells live longer in people with amyotrophic lateral sclerosis, Lee Rubin of Harvard University and colleagues report in the June 6 *Cell Stem Cell*. *—Tina Hesman Saey*

Science Past | FROM THE ISSUE OF MAY 18, 1963

WHISTLING NOISES GIVE NEWS FROM ATMOSPHERE — The atmosphere whistles while scientists work. Series of whistles—short or long, going up scale or down—keep radio scientists busy

deciphering their messages of the density of charged particles in the outer regions of the earth's atmosphere.... Generated by lightning as it strikes the earth, the radio waves are propagated back and forth in the atmosphere of the earth, in a north-south direction.... By analyzing the duration of the whistle tone, the length of time it lasts, and the changes as it slides up or down the musical scale ... scientists could construct a model of the earth's atmosphere 3,500 to 5,000 miles high. These whistles are recorded at the rate of one or two every second, or once in every few days, at stations that stretch along the meridians from Greenland and Alaska to the South Pole.

Science Future

May 29
The World Science Festival opens in New York City. Read more at bit.ly/SFwsf2013

May 31
Learn about wildflowers at Botany Washington at Seattle's Burke Museum. See bit.ly/SFwf2013

June 2
Get tips on model rocket construction and safety at NASA Goddard Space Flight Center in Maryland. See bit.ly/SFrocket

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See a roundup of some of the latest discoveries about China's H7N9 virus in "New bird flu claims more victims."

ENVIRONMENT
Lake Erie is loaded with tiny pieces of plastic containing toxic pollutants. Read "Puny plastic particles mar Lake Erie's waters."

HUMANS
Male attractiveness relies on a combination of body parts. See "Penis size does matter."

CULTURE BEAKER
Rachel Ehrenberg analyzes how a CEO misunderstood shoppers in "The psychology of J.C. Penney."

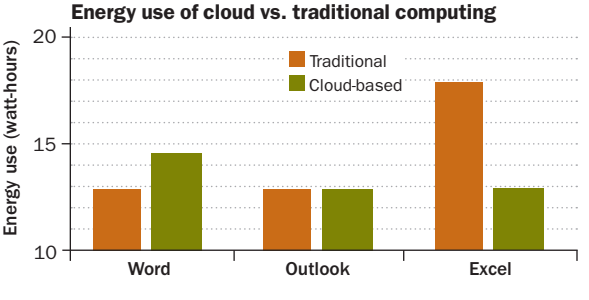
Mystery Solved | TURNING EARTHQUAKES INTO GOLD

Geologists have long known that some gold deposits form in cracks in Earth's crust as dissolved gold solidifies. But it has been unclear how large deposits accumulate, since gold concentrations are normally very low in the crust. Now Australian researchers have an answer: repeated earthquakes. During a quake, fluid-filled cavities expand and pressure plummets. The low pressure vaporizes fluid almost instantly, and any dissolved gold hardens into a thin layer. Later, fluid refills the cavity, and with each subsequent quake a bit more gold accumulates. A 100-metric-ton deposit could develop in less than 100,000 years, the team estimates March 17 in *Nature Geoscience*. *—Erin Wayman*

Science Stats | ENERGY ON THE CLOUD

Cloud computing, which uses software over the Internet, can be more energy-efficient than running programs on individual computers—sometimes. A new analysis finds that Microsoft Excel used less energy on the cloud, but Word, which requires frequent refreshing, used more.

SOURCE: D.R. WILLIAMS AND Y. TANG/*ES&T* 2013



CLOCKWISE FROM TOP LEFT: M. ATAROD; 5GYRES INSTITUTE; FARBLED/SHUTTERSTOCK

“Multiple experiments seeing something at the same mass is pretty exciting.” —KATHERINE FREESE, PAGE 10

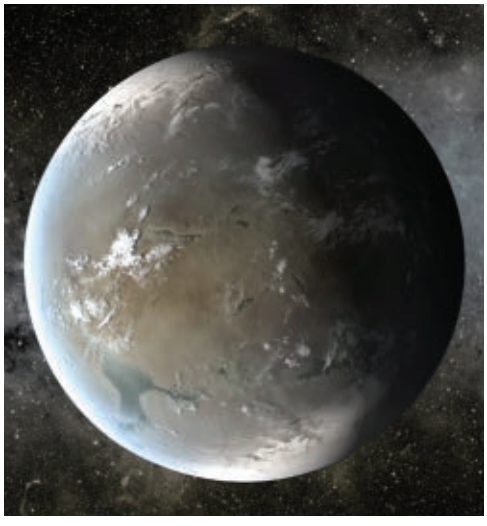
In the News

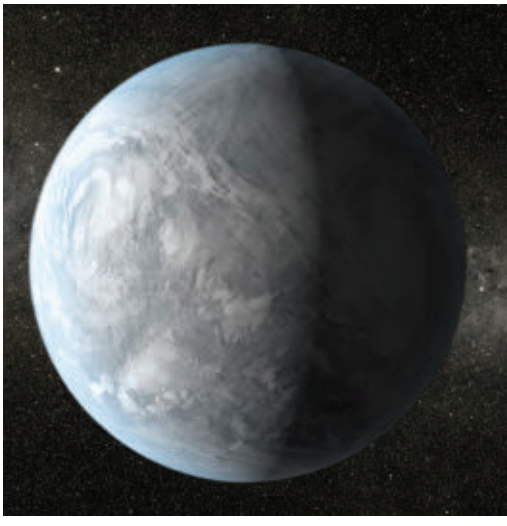
STORY ONE

Kepler closes in on Earthlike orbs

Worlds just larger than ours orbit almost sun-sized star

By Andrew Grant



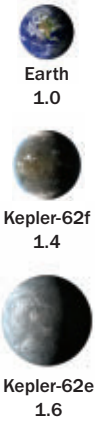


Two recently discovered planets, Kepler-62f (left) and Kepler-62e (right) circle their sun at the right distance for liquid water to be stable on their surfaces. These illustrations imagine how the planets might appear from orbit.

They’re not quite Earth’s twins but they could be its big siblings. Two planets slightly larger than Earth have been found by NASA’s Kepler space telescope. The planets circle their star at a distance seemingly just right for life. Detailed in research published April 18 in *Science*, the two planets are likely the first of many that, at least from a distance, look a whole lot like home.

“It’s just the tip of the iceberg,” says Sara Seager, an astronomer at MIT who was not part of the study. “When one type of object is found, there are many more just under the surface waiting to be discovered.”

Kepler’s latest discovery is a five-planet system around a star called Kepler-62, some 1,200 light-years away in the constellation Lyra. Astronomers found the planets by analyzing nearly three years’ worth of data. The inner three worlds are too hot for life, but planets Kepler-62e and Kepler-62f are far more accommodating. They are 1.6 and 1.4 times the diameter of Earth, respectively, and their orbits are within the habitable zone where scientists think liquid water could exist.



On the big side The Kepler space telescope has found worlds slightly larger than Earth that may be habitable (illustrations shown with size relative to Earth). The most Earthlike planets orbit a star about 1,200 light-years away.

AMES RESEARCH CENTER/NASA, JPL-CALTECH

“They are great candidates for being habitable planets,” says William Borucki, Kepler’s principal investigator, who came up with the idea for the planet-hunting telescope in the 1970s.

Kepler-62f is particularly intriguing, says Rory Barnes, an astronomer at the University of Washington in Seattle. It receives less energy from its star than Earth does from the sun, but if it has a relatively thick, heat-trapping atmosphere, it could sustain a comfortable surface temperature. “It’s not inconceivable to think about walking on the surface of 62f,” Borucki says.

Kepler-62e is less of a sure thing, Barnes says. It may be too close to its star — and therefore too hot — to sustain life. And if 62e is a rocky planet, it’s almost certainly tidally locked with its star, with one half of its surface always illuminated and the other perpetually dark.

But analyses from the Planetary Habitability Laboratory at the University of Puerto Rico, which evaluates the chances for life on every discovered exoplanet, rank 62e as the most Earthlike world ever found.

The biggest uncertainty about both planets is their composition. Kepler detects planets by looking for their shadows as they cross in front of their stars. Just as a golf ball and a ping-pong ball cast similar shadows, a rocky planet crossing in front of its star is indistinguishable from one composed entirely of gas or water with no solid surface.

Kepler began spotting sizzling giant planets in May 2009, almost as soon as it

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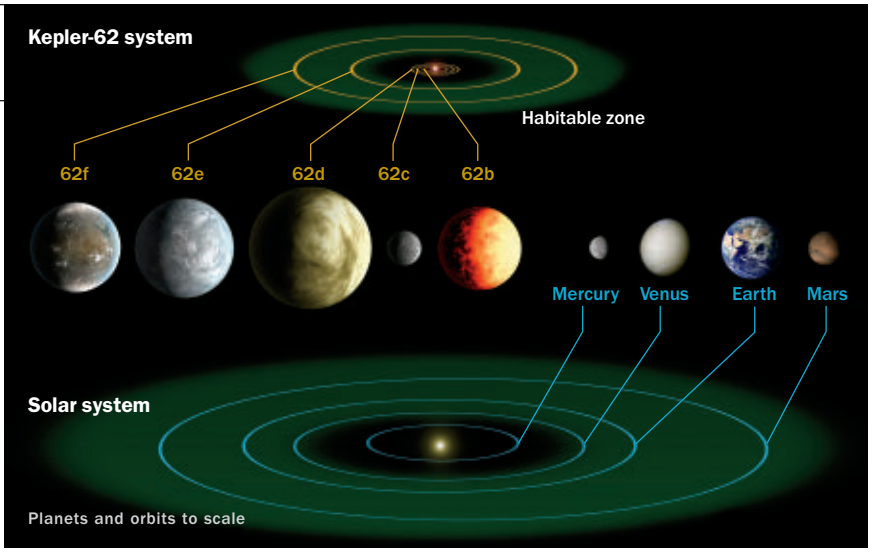
started staring at 170,000 stars for signs of orbiting planets. Lately the mission's discoveries have become considerably more Earthlike. Researchers announced the discovery of the first Earth-sized worlds in December 2011, along with the first Kepler-identified planet to orbit in its star's habitable zone. That planet, Kepler-22b, is so large that it probably resembles a hot, miniature Neptune — gassy, not rocky.

Astronomers are trying to determine how big a planet can be and still be rocky, not gaseous. Unfortunately, the solar system has a huge size gap between the largest rocky planet, Earth, and the smallest gaseous one, Neptune, which is four times bigger. But astronomers have managed to determine both diameter and mass for a handful of exoplanets, and that early evidence supports the optimistic view that at least 62f is rocky. "We expect it to be a rocky planet," Borucki says.

Regardless of whether 62e and 62f are solid worlds teeming with life or sterile balls of gas, Borucki emphasizes that Kepler still has not attained its ultimate goal of finding Earth-sized planets in the habitable zones of sunlike stars. To Borucki, 62e and 62f are slightly too big and their star slightly too small; Kepler-62 is about two-thirds the diameter of the sun, with a temperature of about 4,900 kelvin compared with the sun's 5,800.



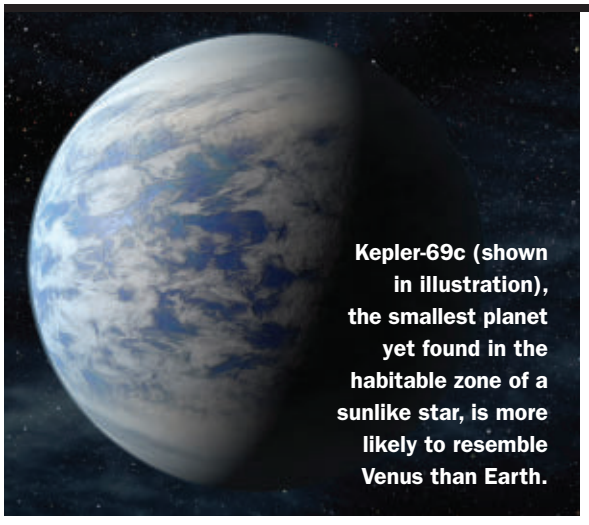
Small but cozy An illustration comparing the Kepler-62 planetary system (top) with the inner solar system (bottom) reveals that two of the five planets in Kepler-62 lie in the star's habitable zone (green). Of the sun's planets, Venus, Earth and Mars are all potentially habitable.

Seager is already celebrating. "This is the first time they've found what they're looking for," she says, noting that even a planet 75 percent larger than Earth is potentially habitable. "I'm really excited to be living in a time when finding Earth-sized planets in the habitable zone is going to become routine."

That is exactly the plan: While individual planet discoveries are nice, Kepler is a statistical mission trying to detect enough Earth analogs to estimate how many exist in the galaxy. Next-generation missions like the Transiting Exoplanet Survey Satellite, which NASA approved in April for launch in 2017, will take on the task of finding planets nearer to Earth that astronomers can study in more depth.

Borucki hopes Kepler will observe through 2017 to ensure a greater census of Earthlike planets. In addition, the computers that pore through Kepler data have flagged more than 350 Earth-sized candidates that have not yet been confirmed as planets. For all we know, Kepler has already found a true Earth twin that remains buried in terabytes of data.

Borucki hopes that a big discovery will come within the next year. "I consider 62e and 62f golden discoveries," he says. "But we're hunting for platinum." ■



Kepler-69c (shown in illustration), the smallest planet yet found in the habitable zone of a sunlike star, is more likely to resemble Venus than Earth.

Back Story | ALMOST HOME

Though Kepler-62e and 62f are less than twice the size of Earth, they orbit a star that is substantially weaker than the sun. Finding planets in the habitable zones of sun-sized stars will be harder than detecting the Kepler-62 planets because such worlds have longer orbits and cast smaller shadows as they pass across the faces of their suns. But Kepler is beginning to identify alluring planets around sun-sized stars, mission scientists report April 18 in the *Astrophysical Journal*. The Kepler team identified two planets around the sunlike star Kepler-69, some 2,700 light-years away in the constellation Cygnus. One of those planets is 1.7 times Earth's size and teeters on the inner edge of the habitable zone. "It's probably more of a super-Venus than a super-Earth," says Penn State planetary scientist James Kasting. But the discovery provides another reason to believe Kepler will find an Earth analog soon. —*Andrew Grant*

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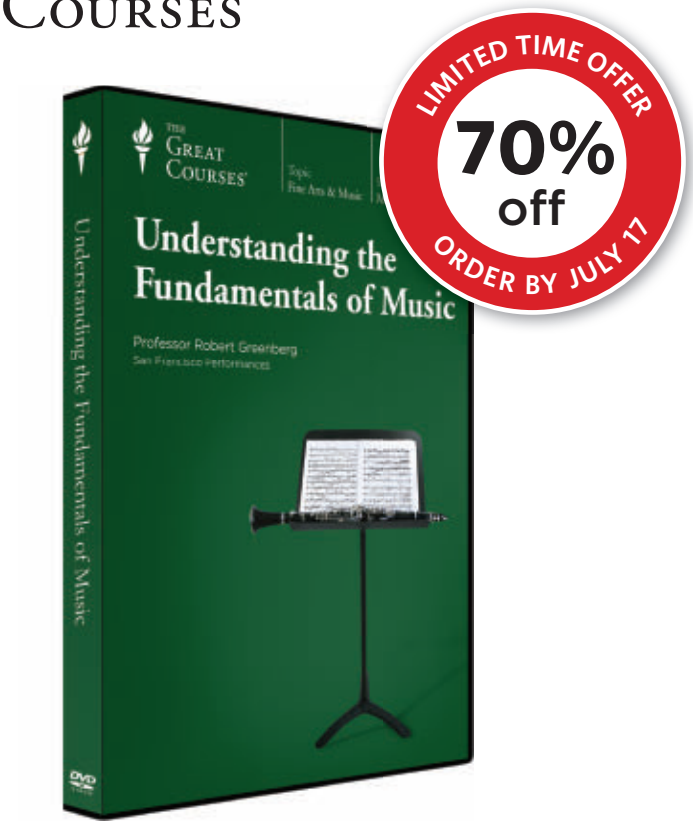

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Matter & Energy

"The light goes right around any obstacle, which is pretty remarkable." —MICHAL LIPSON

Etched glass lets light pass around

Optical topological insulator transparent on surface only

By Andrew Grant

Throw some electrons onto the surface of a topological insulator and they seemingly become invincible, effortlessly bypassing obstructions along their route. Now researchers have crafted a structure that empowers particles of light to do the same thing. The first demonstration of a topological insulator for photons, reported April 11 in *Nature*, could lead to improved optical transmissions that are crucial for global communication.

"I think it's wonderful," says Michal Lipson, a physicist at Cornell University who was not involved with the study. "The light goes right around any obstacles, which is pretty remarkable."

Materials are typically either conductors or insulators, but topological insulators such as bismuth telluride are exotic hybrids: They block electric current in their interiors yet allow electrons to flow along their surfaces.

What's more, these surface electrons can move unimpeded through bumps and grooves that would normally block their path. That useful property makes topological insulators intriguing candidates for future electronics.

The ability to enable electrons to surf along the surface and avoid obstacles is so enticing that some physicists have investigated whether other particles, particularly photons, could do the same thing. Electrons flow through chips in computers and smartphones, while photons are the information carriers that enable high-speed communication over fiber-optic cables. One key to faster, more efficient communication networks is minimizing the scattering of photons when they encounter obstacles.

With that goal in mind, physicist Mordechai Segev and his team at the Technion-Israel Institute of Technology in Haifa, along with colleagues from Friedrich Schiller University Jena in Germany, set out to demonstrate the first photonic topological insulator. They started with a block of glass and etched in hundreds of helical waveguides, which are essentially wires for light. The waveguides were tightly packed in a honeycomb-like structure so that light trying to make its way through one waveguide interfered with light in the others and canceled out.

The only part of each waveguide that didn't cancel out light was its outer edge. As a result, photons got steered along the outside of the bundled waveguides, confining this light to the block's surface.

When the researchers shined a beam of red light on one face of the glass, the photons moved along the surface, easily made a turn once they reached an edge and then continued on their way along the surface. None of the light got scattered by surface imperfections.

Segev says the team's photonic topological insulator will lead to improved optical transmissions. Jacob Taylor, a physicist at the University of Maryland's Joint Quantum Institute, adds that the impressive light-harnessing properties of Segev and his colleagues' creation could allow people to send more data over a popular type of wire known as a multimode optical fiber.

L. SANCHIS *ET AL*

Sound cloak silences in 3-D

A simple plastic shell has cloaked a three-dimensional object from sound waves for the first time. With some improvements, a similar design could eventually be used to reduce noise pollution or to allow ships and submarines to evade enemy detection. The device is described March 20 in *Physical Review Letters*. Instead of preventing sound waves from hitting an object—in this case an 8-centimeter plastic sphere—electrical engineer José Sánchez-Dehesa of the Polytechnic University of Valencia in Spain and his colleagues built a cloak to eliminate the waves of sound bouncing off the sphere. Using computer algorithms, the researchers came up with a design of 60 rings of various sizes that form a cagelike structure around the sphere (shown). Simulations indicated that sound waves scattering off the sphere and the ringed cloak would interfere with each other and cancel out. The researchers hung their creation from the ceiling of an echo-free chamber, pointed a speaker at it and played a range of sound frequencies. At a frequency of 8.55 kilohertz—an audible high pitch—the cloaked sphere became imperceptible to the sensors behind it. —*Andrew Grant*

Mind & Brain

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A see-through view into the brain

Replacing fatty molecules turns mouse organs transparent

By Puneet Kollipara

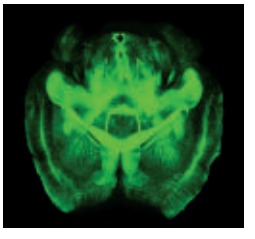
To usher in a big advance in brain imaging, scientists simply had to cut the fat. Washing out light-blocking fatty molecules turns mouse brains almost fully transparent while retaining their structure and nearly all their important features, researchers report April 10 in *Nature*.

The new method could help researchers image the whole brain and its circuitry while also doing detailed molecular and cellular analyses, says Clay Reid, a neurobiologist at Harvard University and the Seattle-based Allen Institute for Brain Science. "It's a lovely paper, and it's something that a lot of people will want to be using," says Reid, who was not involved in the study.

Typically researchers create thin slices of the brain for detailed looks at cellular and molecular anatomy. But that's at the expense of learning how neurons are wired to faraway brain regions. Moreover, using light-based microscopes to look at the whole brain has its pitfalls. Light can't penetrate deep into organs mainly because lipids — a category of molecules that includes fats — can block and scatter it. Lipids help maintain the brain's structure, and removing them could cause the brain to fall apart.

Karl Deisseroth of Stanford and colleagues devised a method that minimizes those trade-offs. The researchers removed brains from mice and put them in a chemical solution that included a plastic-like substance. When heated, the chemical cocktail transformed into a clear gel that clung like glue to everything in the brain except the lipids.

Then the researchers flushed a detergent through the brains. The result: The brains were see-through, yet the neurons, connections, proteins, DNA and other crucial components remained in place.



A new technique that turns mouse brains transparent makes it easier for researchers to look at how neurons (green) are linked.

The brains were so transparent that the researchers could use light microscopes to see fine details such as neurons and nerve fibers. The scientists could also measure levels of particular molecules in the brain using labeling techniques that stained certain types of molecules or made them glow.

Mental puzzles make music fun

Brain activity reflects how much people like new tunes

By Meghan Rosen

Whether you're rocking out to Britney Spears or soaking up Beethoven's classics, the enjoyment of hearing a tune for the first time may stem from the music stimulating a guessing game in your brain.

This mental puzzling helps explain why humans like music, a new study suggests. When people hear a new song they like, a clump of neurons deep in their brains bursts into excited activity, researchers report April 12 in *Science*. The blueberry-sized cluster of cells, called the nucleus accumbens, helps make predictions and sits in the same part of the brain that floods with feel-good chemicals when people eat chocolate or have sex.

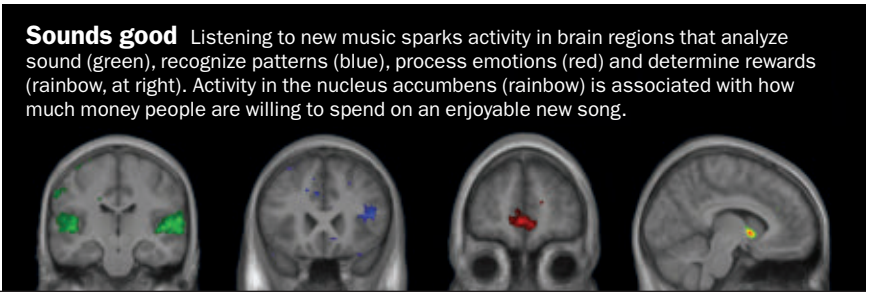
The berry-sized bit acts with three other regions in the brain to judge new jams, functional MRI scans showed. One region looks for patterns, another compares new songs with sounds heard before and the third checks for emotional ties.

As our ears pick up the first strains of a new song, our brains hustle to make sense of the music and figure out what's coming next, explains coauthor Valorie Salimpoor, who is now at the Baycrest Rotman Research Institute in Toronto. When the brain's predictions are right (or proven wrong in a pleasant way), people get a little jolt of pleasure.

The researchers examined brain activity in 19 people listening to short clips of new music in an MRI machine. At the end of each clip, volunteers could choose to buy songs they liked, using their own money.

Amid the bustle of activity in the brain, the nucleus accumbens leapt to life when people heard songs they wanted to purchase.

Teaming neuroimaging with a system for buying music was "a very clever idea," says cognitive neuroscientist Aniruddh Patel of Tufts University in Medford, Mass. "It's a nice application of new technology."



Sounds good Listening to new music sparks activity in brain regions that analyze sound (green), recognize patterns (blue), process emotions (red) and determine rewards (rainbow, at right). Activity in the nucleus accumbens (rainbow) is associated with how much money people are willing to spend on an enjoyable new song.

FROM TOP: KWANGHUN CHUNG AND K. DEISSEROTH/HOWARD HUGHES MEDICAL INSTITUTE AND STANFORD UNIV.; COURTESY OF V. SALIMPOOR

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Experiment finds hints of WIMPs

Three potential signals of dark matter detected

By Andrew Grant

Ultracold crystals designed to catch particles of dark matter deep underground have come up with three potential detections, physicists reported April 13.

The researchers do not have enough evidence to say they have discovered dark matter particles, but the finding qualifies as a rare clue in the frustrating quest to understand the universe's most elusive substance.

"We do not believe this result rises to the level of discovery," said Kevin McCarthy, the MIT physicist who made the announcement. "But it does call for further investigation."

Dark matter has confounded scientists since the 1930s. A galaxy's stars, gas and dust cannot account for all of its mass, so astronomers think that some sort of elusive matter that does not absorb or emit light must outweigh ordinary matter by more than 5 to 1. Because astronomers cannot see dark matter, its identity has been difficult to figure out.

Theoretical physicists have put forth some ideas for particles that might constitute dark matter, including one called a weakly interacting massive particle, or WIMP. The hope is that even though dark matter doesn't often interact with regular matter, WIMPs may do so occasionally.

The experiment that made the newly reported detections is designed to pick up the signal of a WIMP as Earth passes through the Milky Way's sea of dark matter. The Cryogenic Dark Matter Search consists of a network of silicon and germanium crystals cooled to near absolute zero. The detectors sit in the Soudan Underground Laboratory in Minnesota, a former iron mine more than 700 meters beneath the surface.

A researcher examines detectors in the Cryogenic Dark Matter Search, deep underground in Minnesota. Vibrations of crystals have captured three possible signs of long-sought dark matter.

If WIMPs exist, one should very occasionally slam into the nucleus of a silicon or germanium atom, causing a release of energy and a detectable vibration in the crystal. The hundreds of meters of earth above the experiment prevent other particles, such as protons and neutrons, from reaching the crystals and triggering a false positive (*SN: 8/28/10, p. 22*).

McCarthy reported that between July 2007 and September 2008, two of the experiment's 11 silicon detectors picked up a total of three signals consistent with those expected from WIMP interactions. If the signals were caused by WIMPs, McCarthy estimates the dark matter particle would weigh about 10 times the mass of the proton, well below many theoretical estimates. The results also appear in a paper posted online April 15 at arXiv.org.

While the crystals' underground setup provides plenty of shielding, some non-WIMP particles, such as electrons on the crystals' surface, can cloud the results. The CDMS researchers say it's extremely unlikely that three events would show up from nonWIMP sources.

But the energy released by the potential WIMPs is at the very lower limit of the detectors' sensitivity, warns Richard Gaitskell, a physicist at Brown University, making erroneous detections more likely. He also has concerns that the two crystals that picked up the signal could be more susceptible to false positives than the rest.

CDMS physicist Enectali Figueroa-Feliciano of MIT joins Gaitskell in remaining cautious about the new data. In 2009, CDMS reported that its germanium detectors had snagged two potential WIMPs, but further analysis revealed them to be surface electrons.

Figueroa-Feliciano says he would be more convinced if the detectors had picked up 10 or 12 signs of WIMPs rather than just three. Even then, a definitive detection would require multiple experiments worldwide to converge on the same characteristics for a dark matter particle.

Many other experiments around the world are on the case. One in Italy called DAMA, short for Dark Matter, has made bold claims of dark matter detection that have drawn skepticism from many scientists. Other experiments have claimed to find signals at masses similar to this latest CDMS calculation but have not definitively said they have observed WIMPs.

"I'm more excited than I should be, but I can't help it," says Katherine Freese, a theoretical astrophysicist at the University of Michigan in Ann Arbor. "Multiple experiments seeing something at the same mass is pretty exciting."

The difficulty is that each experiment uses a different detection technique and has its own protocol for distinguishing WIMPs from background noise, making it hard to compare results.

As for CDMS, the silicon detectors that found these signals are no longer collecting data. Researchers recently upgraded the Soudan facility with supersensitive germanium detectors. Over the next few years, these germanium detectors will move to a new, deeper underground home in Sudbury, Ontario, about 2 kilometers below the surface.

FERMILAB

MEETING NOTES

Classifying the Crab

In 1054, eyes turned to the sky when a giant star 6,500 light-years away exploded as a supernova. Today, what's left behind is a colorful shell of gas and dust known as the Crab Nebula. The Crab supernova confounds astronomers because it packed less energy than a typical explosion of a star of its size, yet a large portion of that energy seemed to show up as visible light—so much so that Chinese astronomers reported seeing the supernova in the daytime sky for 23 days. The Crab Nebula is the product of a rare type of supernova called a Type 2n-P, astronomer Nathan Smith of the University of Arizona proposed April 15. He surmises that a large star rich in oxygen, neon and magnesium exploded and sent out a shock wave that heated up interstellar material to temperatures that maximize the emission of visible light. The brightness of Type 2n-P explosions observed in 1994, 2009 and 2011 plateaued for a few months before plummeting, which Smith says is consistent with observations from 1054. —*Andrew Grant*

Fossils show bacteria may have eaten supernova's iron

Ancient bacteria may have gobbled up the radioactive remains of a star that exploded more than 2 million years ago. Only a few giant stars explode as supernovas close enough to Earth to deposit shrapnel on the planet. A rock recovered from the Pacific Ocean nearly a decade ago suggested one such supernova occurred about 2.2 million years ago. Researchers from the Technical University of Munich made that determination in 2004 by analyzing the rock's concentration of iron-60, a radioactive isotope spewed by supernovas. Shawn Bishop, a physicist from Technical University who was not involved in the prior research, wondered whether he could find any radioactive iron from the supernova in the fossil record. He looked to bacteria that live beneath the seafloor and process iron to produce magnetic crystals. Bishop and his team obtained a sediment core from the Pacific and analyzed it for iron-60. The radioactive isotope was nonexistent in most of the core, but showed up in very small amounts in sections from around the time of the supernova, Bishop reported April 14. —*Andrew Grant*

Humans

Pottery cooked from the start

Ancient hunter-gatherers heated seafood in vessels

By Bruce Bower

Ancient leftovers indicate that the earliest pottery was used by hunter-gatherers for cooking, thousands of years before farming communities began heating their food in vessels.

Chemical analyses of charred food clinging to pottery fragments from sites across Japan indicate that hunter-gatherers who lived there between 15,300 and 11,200 years ago cooked freshwater or marine animals in ceramic vessels, say bioarchaeologist Oliver Craig of the University of York in England and his colleagues.

Concentrations of a certain form of nitrogen in crusty morsels attached to ceramic vessels from the ancient Jōmon culture indicate that these people used the pots for cooking, Craig's team reports in the April 18 *Nature*. Fatty acids extracted from food remnants on pottery from two Jōmon sites confirmed that fish or other aquatic creatures had been cooked.

Fatty acids don't tend to survive in burned crusts, but the scientists worked with what they could find on the ancient containers. "We weren't expecting to get such conclusive results from charred deposits of this age," Craig says.

Previous chemical analyses of pottery stains, which unlike burned deposits often preserve fatty acids, have dated the origins of cheese making to 7,400 years ago in Eastern Europe (*SN: 1/26/13, p. 16*) and of cattle milking to 9,000 years ago in what's now Turkey.

Ancient Jōmon pottery, such as this vessel dating to around 15,000 years ago, yields chemical evidence that early hunter-gatherers used ceramic containers to cook seafood.

Until the 1990s, researchers traced the origins of pottery in Japan to rice farmers living no more than 2,300 years ago. An excavation in the early 1990s of a large Jōmon settlement containing buildings, graves and numerous pottery fragments first challenged that view.

Further discoveries have shown that ancient hunter-gatherers across East Asia made pottery. A study published last year traced the world's earliest known examples to about 20,000 years ago in China. But none had directly connected the ancient pottery to cooking.

Craig's finding raises the possibility that East Asian hunter-gatherers, rather than Middle Eastern farmers, may have introduced pottery making into Europe, suggests archaeologist Simon Kaner of the University of East Anglia in Norwich, England.

Craig's team assessed the carbon and nitrogen content of charred deposits on 101 Jōmon vessels from 13 sites across the Japanese islands. More than three-quarters of these samples displayed chemical signatures typical of freshwater or marine animals.

Researchers sampled food crusts on pottery pieces from seven Jōmon sites. Samples from two inland settlements contained fatty acids characteristic of fish or seafood oils. Inhabitants there were close enough to the sea for regular visits and could also have caught salmon that traveled up nearby rivers, Craig proposes.

His group hopes to perform chemical analyses of the 20,000-year-old Chinese pottery remains to find out whether they, too, were used for cooking. ■

Sediba may be human forebear

A surprising mix of apelike and humanlike features from head to toe supports a controversial contention that a 2-million-year-old member of the human evolutionary family gave rise to the genus *Homo*. An international team of researchers reports the details in six papers published April 12 in *Science*. Lee Berger of the University of the Witwatersrand in Johannesburg and his colleagues assigned two partial skeletons and other fossils found in a South African cave in 2008 to a species they named *Australopithecus sediba* (reconstructed skeleton shown). Among the group's new findings: *A. sediba*'s teeth suggest that this hominid evolved into a *Homo* species, but had no links to earlier East African hominids often regarded as *Homo* ancestors. Those hominids include 3.2-million-year-old *Australopithecus afarensis*. *A. sediba*'s relatively long arms were suited to hanging out in trees, consistent with its relatively narrow, apelike upper rib cage. But the hominids also had narrow, humanlike lower rib cages and lower backs that were longer and more flexible than those of people today. — *Bruce Bower*

FROM TOP: COURTESY OF L. BERGER/UNIV. OF THE WITWATERSRAND; TOKAMACHI CITY MUSEUM

Ardipithecus had humanlike skull

Fossil analysis pegs East African species as hominid

By Bruce Bower

One of the most controversial proposed members of the human evolutionary family, considered an ancient ape by some skeptical scientists, is the real hominid deal, an analysis of a newly reconstructed skull base finds.

By 4.4 million years ago, *Ardipithecus ramidus* already possessed a relatively short, broad skull base with a forward-placed opening for the spinal cord, an arrangement exclusive to ancient hominids and people today, William Kimbel of Arizona State University in Tempe reported on April 11.

Although features of the skull's floor evolved substantially in *Homo* species leading to modern humans, Kimbel said, those changes appeared piecemeal starting at least a couple of million years earlier in hominids such as *Ardipithecus*.

A. ramidus is best known by the partial skeleton of an adult female, dubbed Ardi, described in 2009 (*SN: 10/24/09, p. 9*). Elements of Ardi's build related to tree climbing, such as grasping feet and an elongated lower hip bone, have raised suspicions that she and her kind come from apes that evolved a rudimentary ability to walk upright without being hominids. However, Ardi's discoverers argue that she was a hominid whose species split time between slow, awkward walking and shuffling along tree branches while grabbing upper branches for support.

The new skull reconstruction, which fits that view, relied on a partial *A. ramidus* skull base described in 1994, long before Ardi's remains were painstakingly removed for analysis from rock that had encased the partial skeleton in Ethiopia.

By examining 79 skull bases of chimps, gorillas, modern humans and ancient hominids, Kimbel's group identified relationships among anatomical landmarks that distinguish apes from people and hominids. The researchers estimated the total length of *A. ramidus*' skull base and found that it fell within a range characteristic of hominids, not apes.

Like more recent members of the *Australopithecus* genus, such as the 3.2-million-year-old partial skeleton nicknamed Lucy, *A. ramidus* displays a relatively short, humanlike skull base, Kimbel said.

A new analysis of Ardi's pelvis, also presented April 11, finds a mix of monkey, ape and hominid characteristics. Although not confirming a consistently upright gait, this version of Ardi's hips doesn't undermine her proposed hominid status, said Nicole Webb of City University of New York. ■

MEETING NOTES

Ötzi's Neandertal ancestry

A 5,300-year-old man found sticking out of an Alpine glacier in 1991 possessed more genes in common with Neandertals than Europeans today do. The man's Neandertal heritage is a preliminary sign that Stone Age interbreeding occurred more frequently than many scientists assume. Two researchers determined that the previously analyzed genome of Ötzi the Tyrolean Iceman (*SN: 3/24/12, p. 5*) includes roughly 4 to 4.5 percent Neandertal genes. Modern Europeans' genetic library includes an average of 2.5 percent Neandertal genes. Human groups that migrated into Europe after 5,000 years ago mated with continental natives and diluted traces of Neandertal genetic ancestry in Ötzi, proposed Aaron Sams of Cornell University on April 12. *—Bruce Bower*

Organic material may be oldest example of human skin

The earliest preserved swatch of hominid skin may have been found by discoverers of South African fossils assigned to a nearly 2-million-year-old species called *Australopithecus sediba*, a possible precursor of the *Homo* genus (see facing page). Reddish brown material on the skull of an *A. sediba* boy shows similarities to human skin, Rachelle Keeling of the University of the Witwatersrand in Johannesburg reported on April 11. Microscopic analyses of the substance revealed irregular lines resembling blood vessels, as well as depressions characteristic of fat pockets and hair follicles. Chemical tests confirmed that the stuff is organic and has a molecular structure like that previously found in the skin of mummified human bodies. *—Bruce Bower*

Hominid's brain cast by computer

A virtual cast of the inside of a 7-million-year-old cranium suggests that hominid evolution kicked off with big neural changes. The skull, unearthed in Central Africa in 2001, belongs to *Sahelanthropus tchadensis*, a species controversially proposed as the earliest known member of the human evolutionary family. X-rays enabled a research team to see through the rock-filled cranium and reconstruct its brain surface. That 3-D reconstruction reveals a hominid-like setup, said Thibaut Bienvenu of the University of Poitiers, France, on April 12. The front and back of *Sahelanthropus*' brain, as well as the tilt of its brain stem, matched corresponding features for 2- to 4-million-year-old hominids and modern humans. An upright posture and two-legged gait stimulated neural reworking in *Sahelanthropus*, Bienvenu speculated. *—Bruce Bower*

Health & Illness

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Kidney rebuilt using fresh cells

Stripped to scaffolding, organ successfully grown in lab

By Nathan Seppa

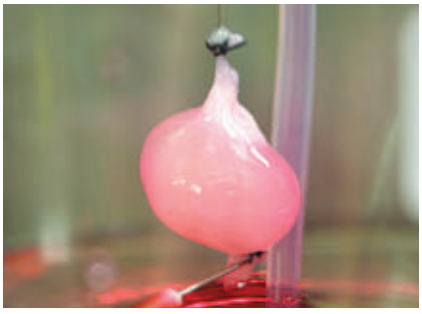
By stripping a rat kidney of its cells and repopulating it with new ones, scientists have shown that a bioengineered kidney can function to some extent like a normal one. The work, published April 14 in *Nature Medicine*, reveals that the kidney's protein scaffold provides the architecture and chemical cues that cells need to adopt the roles of kidney cells.

The results may one day help alleviate the transplant organ shortage by providing patients with refurbished kidneys. If bioengineering can make scaffolds from animal or cadaver kidneys that would otherwise have been discarded, it could provide many organs for transplant, says Shay Soker, a cell biologist at Wake Forest University in Winston-Salem, N.C., who was not involved in the study.

The kidney is a complex organ that filters waste out of the blood and keeps sodium and other electrolytes balanced. When kidneys fail, a person's only options are dialysis or a kidney transplant. But candidates for kidney transplant far outnumber available donors.

For the study, Harald Ott of Harvard Medical School and colleagues started by surgically removing a rat cadaver's kidney and using a detergent to strip the organ of its cells. The approach leaves intact the extracellular matrix, the collagen and other compounds that support and hold together the kidney.

Ott's team then "seeded" the kidney scaffold with healthy neonatal kidney cells from rats and blood vessel cells from humans. Over several days, the cells latched onto the kidney structure and proliferated. The cells also produced proteins essential for kidney function, grew into structures that resembled the filtration units in mammal kidneys and even made small amounts of urine.



A rat kidney was stripped of its cells and repopulated with human and rat cells. Researchers transplanted the organ (shown) into a rat, where it functioned to produce urine and filter impurities from blood.

OTT LAB/CENTER FOR REGENERATIVE MEDICINE/MASSACHUSETTS GENERAL HOSPITAL

The researchers then transplanted the freshly minted kidney into a live rat that had had a kidney removed. Inside the rat, the bioengineered kidney produced a small amount of urine. The authors say this experiment proves the principle that a regenerated kidney may work in a live mammal.

Meat molecule tied to heart disease

Gut bacteria transform compound into artery hardener

By Meghan Rosen

A nutrient found in red meat and added to energy drinks and supplements may crank up people's risk of heart disease, a new study suggests. Gut bacteria digest the nutrient, L-carnitine, and help turn it into an artery-hardening chemical — particularly in meat eaters, researchers report April 7 in *Nature Medicine*.

The intestinal microbes of vegetarians and vegans didn't make much of the chemical, even when researchers fed them an 8-ounce sirloin steak.

High blood levels of the bacterial by-product of L-carnitine, called trimethylamine N-oxide, or TMAO, were an "astoundingly good" warning sign of impending heart attack, stroke and death, says study coauthor Stanley Hazen of the Cleveland Clinic. A test for TMAO, which will become commercially available this year, could give physicians a new tool for gauging heart disease risk.

"L-carnitine is not good for you. It's not good as a supplement and it's not good in red meat," says cardiovascular researcher Ishwarlal Jialal of the University of California, Davis Medical Center, who was not involved in the study.

Scientists have long known that eating red meat jacks up a person's chances of developing heart disease. But recognized risk factors such as cholesterol and fat don't fully explain meat's link to heart disease, Hazen says.

Hazen's team first linked gut microbes to heart disease in 2011, when they spotted TMAO in blood collected from people who later suffered heart attacks, had strokes or died (*SN Online: 4/7/11*).

For the new study, volunteers — a mix of omnivores, vegetarians and vegans — ate steak and L-carnitine capsules, and then researchers measured TMAO levels in the participants' blood. Only meat eaters could make TMAO from L-carnitine, Hazen's team found, and they needed their gut bacteria to do it. TMAO production shut down when researchers wiped out volunteers' intestinal microbes with antibiotics.

Hazen's group also found that blood levels of TMAO and L-carnitine could predict heart disease risk, which they learned by collecting blood samples from 2,595 patients and tracking their health for three years.

The findings are exciting but need confirmation, Jialal says. "We've been down this road so many times before."

"L-carnitine is not good for you. It's not good as a supplement and it's not good in red meat." —ISHWARLAL JIALAL

Promise in treating ovarian cancer

Experimental medicine uses seek-and-destroy technique

By Nathan Seppa

WASHINGTON — A drug candidate featuring an antibody that totes a tumor-killing toxin can knock down ovarian cancer in some patients. In the first test of the experimental drug in people, scientists gave it to 44 patients with advanced ovarian cancer that was resistant to the effects of platinum-based chemotherapy, a standard treatment.

One patient showed what the researchers called a "complete response," meaning her tumors became undetectable. Four other patients had a partial response, which means their tumors shrank by at least 30 percent, said Joyce Liu, a medical oncologist at Harvard Medical School. The results, presented April 6 at a meeting of the American Association for Cancer Research, represent a considerable improvement for a patient group with few treatment options.

"Most [ovarian] cancers will recur and become increasingly resistant to chemotherapy," Liu said.

Among gynecological malignancies, ovarian cancer is the leading cause of death in the United States, killing more than 14,000 patients each year.

The experimental drug is called DMUC5754A. The sharp end of the stick in DMUC5754A is a toxin called monomethyl auristatin E, or MMAE, which must be wielded carefully. The toxin is "very, very powerful," said Louis Weiner, director of the Lombardi Comprehensive Cancer Center at Georgetown University in Washington, D.C.

Liu's findings in patients suggest the antibody is capable of delivering the toxin where it is needed. Such conjugate therapies "are examples of where this field is going in the future," Weiner said.

The antibody portion of the compound binds to a large protein called MUC16 that shows up in 80 percent of ovarian cancers, Liu said. Only patients with high levels of MUC16 had a good response in this early trial, she said.

While that caveat may limit the number of patients who could benefit, it also means that tests showing high levels of MUC16 could reveal to doctors which cancer patients might best benefit from the experimental drug.

MUC16 also shows up in people who have pancreatic cancer, Liu said. Researchers are recruiting volunteers with pancreatic cancer to test the drug candidate.

Life

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A giant tortoise by any other name

Lengthy battle ends with moniker for Indian Ocean reptile

By Susan Milius

One of taxonomy's most passionately disputed arguments over a scientific name has finally come to an end. After nearly two centuries of ambiguity, years of fierce debate and a record number of formal comments on the proposed name, a commission has declared *gigantea* the one true species term for the Aldabra giant tortoises.

Officials have voted to use *gigantea* as part of the species name describing the iconic giant tortoises of the Aldabra Atoll in the Indian Ocean.

That species descriptor will be used as part of a two-word Latin name that puts the species into a genus with its near relatives. Meet *Aldabrachelys gigantea*.

The International Commission on Zoological Nomenclature oversees standards in the naming of animals. Naming debates can get "fractious" says executive secretary Ellinor Michel.

Confusion about the name built over centuries. Biologists have used 49 different Latin names for the giants of the Aldabra Atoll in the western Indian Ocean. The tortoises can weigh several hundred pounds and live for more than a century. Taxonomic rules call for rigorously determining the earliest valid name and designating a single specimen as a benchmark "type." The naming code also calls for stability.

The issue came to a head in 2008, when Ecuador-based zoologist Jack Frazier, with the Smithsonian Institution's National Museum of Natural History, asked the commission to recognize *gigantea* as the valid species descriptor for the tortoise and to use a specimen he described in 2006 as the benchmark.

Frazier argued that *gigantea* is now the most commonly used Latin term for the species. At Frazier's urging, conservationists and other nontaxonomists who use the species name chimed in.

Normally each of the 40 or so naming disputes the commission considers in a year draws a couple of commentaries in response, Michel says. The tortoise dispute inspired more than 80 responses.

But Frazier's call for nonspecialist opinions wasn't appropriate, protested taxonomist Roger Bour of the French National Museum of Natural History in Paris. "Should zoological nomenclature be regulated by a set of rules or by 'polls' open to anyone?" he asked in a commentary he sent to the commission. The tortoise case "was initiated by nontaxonomists apparently unschooled in the rules of zoological nomenclature and unwilling to abandon a name that they have become used to."

The argument against *gigantea* is long and intricate. Just one of the problems: The earliest candidate for a type specimen was either lost or mislabeled for at least 90 years. The preserved animal was moved in 1808 along with other natural history specimens from the royal collection in Lisbon to Paris after Napoleon invaded Portugal. In Paris, a young physician studying natural history dubbed the recently arrived prize a new species, *Testudo gigantea*.

But his account notes that the specimen had been collected in Brazil. If that origin was correct, the physician had named a South American tortoise *gigantea*, not the one from Aldabra. And what happened to the specimen next is contentious.

By 1915, searches of the Paris museum collection failed to turn up the original specimen, and without access to it scientists couldn't check its characteristics or origin. And starting in 1835, some taxonomists had used the Latin name *gigantea* for tortoises from Aldabra, not Brazil.

The specimen was actually in Paris all along but labeled under a different name, Bour announced in 2006. He identified the specimen as the one that came from Lisbon based on such clues as its measurements and the kind of fiber stuffing and painted wooden eyes the specimen sported. And it's now clear that it's not an Aldabra tortoise but a South American species that has its own Latin name. In the end, Bour concluded that applying the rules of the code would not call for naming the Aldabra tortoise *gigantea*.

One of the ICZN commissioners, Philippe Bouchet, also of Paris' National Museum of Natural History, says he told Bour, "You are technically right, but you are socially wrong." Sometimes what best serves society is ratifying a widely used name for an iconic animal.

After allowing several years instead of the more usual one for debate, the ICZN announced March 31 that commissioners favored Frazier's proposal for *gigantea* and the Smithsonian type specimen.

The debate has greater implications than the name of one tortoise, says ICZN Commissioner Richard L. Pyle of the Bishop Museum in Honolulu. Keeping clear names for species, he says, is "as fundamental to information about biodiversity as IP addresses are to the Internet."

As someone who works with the tortoises in their native land, Nancy Bunbury of the Seychelles Islands Foundation says she's "relieved and delighted." At last the tortoises have a name. ■

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MIND & BRAIN

Bats make mental maps on the fly

Flying mammals build 3-D mental maps of the world that appear to work differently from the 2-D maps that rats and other ground-dwelling animals construct, researchers report in the April 19 *Science*. Researchers implanted electrodes in the brains of Egyptian fruit bats (*Rousettus aegyptiacus*) and strapped lightweight wireless recording devices to the animals' heads. The devices measured neural activity as the animals flew up, down and around a room. Individual neurons known as place cells perked up when bats zoomed through particular spaces, report Michael Yartsev and Nachum Ulanovsky of the Weizmann Institute of Science in Rehovot, Israel. Just as spots on a map represent locations, each place cell corresponded to a specific area of the room. Like cartographers charting new lands on paper, bats sketch mental maps of spaces they fly through. But unlike cartographers — or rats, which researchers have studied walking across flat surfaces — bats use their place cells to represent three dimensions. — *Meghan Rosen*

EARTH

Yangtze's age revealed

The world's third-longest river has a new age: The 6,300-kilometer Yangtze existed at least 23 million years ago, geologists report April 22 in the *Proceedings of the National Academy of Sciences*. Geologists have debated the river's age for more than a century, with estimates ranging from 2 million to 45 million years old. A team led by Hongbo Zheng of Nanjing Normal University in China investigated the Yangtze's age by studying rocks in the Jianghan Basin, downstream of the Three Gorges Dam. The researchers found rocks similar to the river's modern sediments and dated them to roughly 23 million years ago. Older sediments of a type that can't form in the presence of flowing water put an upper limit of 36.5 million years on the Yangtze's age. The researchers say the timing of the Yangtze's birth corresponds with changes in China's topography caused by the uplift of the Tibetan Plateau. Asia's summer monsoon rains also intensified around that time, which would have fed the fledgling river. — *Erin Wayman*

Buried crustal remnants last eons

Bits of crust that sink into the planet's interior can last for billions of years, geologists report in the April 25 *Nature*. Rita Cabral of Boston University and colleagues discovered traces of ancient crust in one of the South Pacific's Cook Islands while analyzing lava that erupted 20 million years ago. The rock contains different forms, or isotopes, of sulfur in ratios that could have originated only in an atmosphere with little oxygen sometime before 2.45 billion years ago. The researchers suspect that the sulfur was originally part of a slab of oceanic crust that slid beneath another tectonic plate and plunged into the mantle more than 2.45 billion years ago. The slab sank so low in the mantle that it was effectively in a crustal graveyard, the team suggests, where convection was weak and the crust could stay intact. Later, parts of that crust rose back to the surface in a plume of buoyant mantle material and fueled the volcanic eruptions that gave rise to the Cook Islands. — *Erin Wayman*

ATOM & COSMOS

Comet's water persists on Jupiter

In July 1994, Comet Shoemaker-Levy 9 plowed into Jupiter, producing dark scars in the giant planet's atmosphere that were visible for weeks. The comet also left behind a more permanent deposit: millions of gallons of water. The impact still accounts for at least 95 percent of the water in Jupiter's upper atmosphere, researchers report April 23 in *Astronomy & Astrophysics*. Astronomers used the European Space Agency's Herschel Space Observatory to map water vapor throughout Jupiter's atmosphere. Led by Thibault Cavalié at the Laboratory of Astrophysics of Bordeaux in France, the researchers found that the concentration of water peaked in the planet's southern hemisphere, right in the region where the comet hit. — *Andrew Grant*

HEALTH & ILLNESS

Colic linked to later migraines

The inconsolable crying some infants go through, known as colic, is associated with migraine headaches later in childhood, researchers report in the April 17 *Journal of the American Medical Association*. Luigi Titomanlio of Paris Diderot University and colleagues identified 208 children and teens, ranging in age from 6 to 18, who had been diagnosed at an emergency department with migraines. The scientists examined a control group of 471 children of matching ages who had shown up at emergency rooms for minor traumas. The researchers then obtained health histories for both groups. While 73 percent of the kids with migraines had had colic, only 27 percent of the controls had. Children with migraines were also more prone to childhood abdominal pain. — *Nathan Seppa*

LIFE

Genetics distances coelacanths from first land animals

Lungs, not limbs, propelled the aquatic ancestor of land animals out of the ocean, according to a new analysis of the coelacanth genome. The stubby-finned fish have been proposed as living approximations of the earliest animal lineage to crawl onto land. But lungfish may be a closer fit, an international group of researchers reports April 18 in *Nature*. Even though coelacanths are not the closest living relatives to the first land dwellers, comparing the fish's genome to those of other vertebrates should help pinpoint genetic changes that enabled animals to live on land. — *Tina Hesman Saey*

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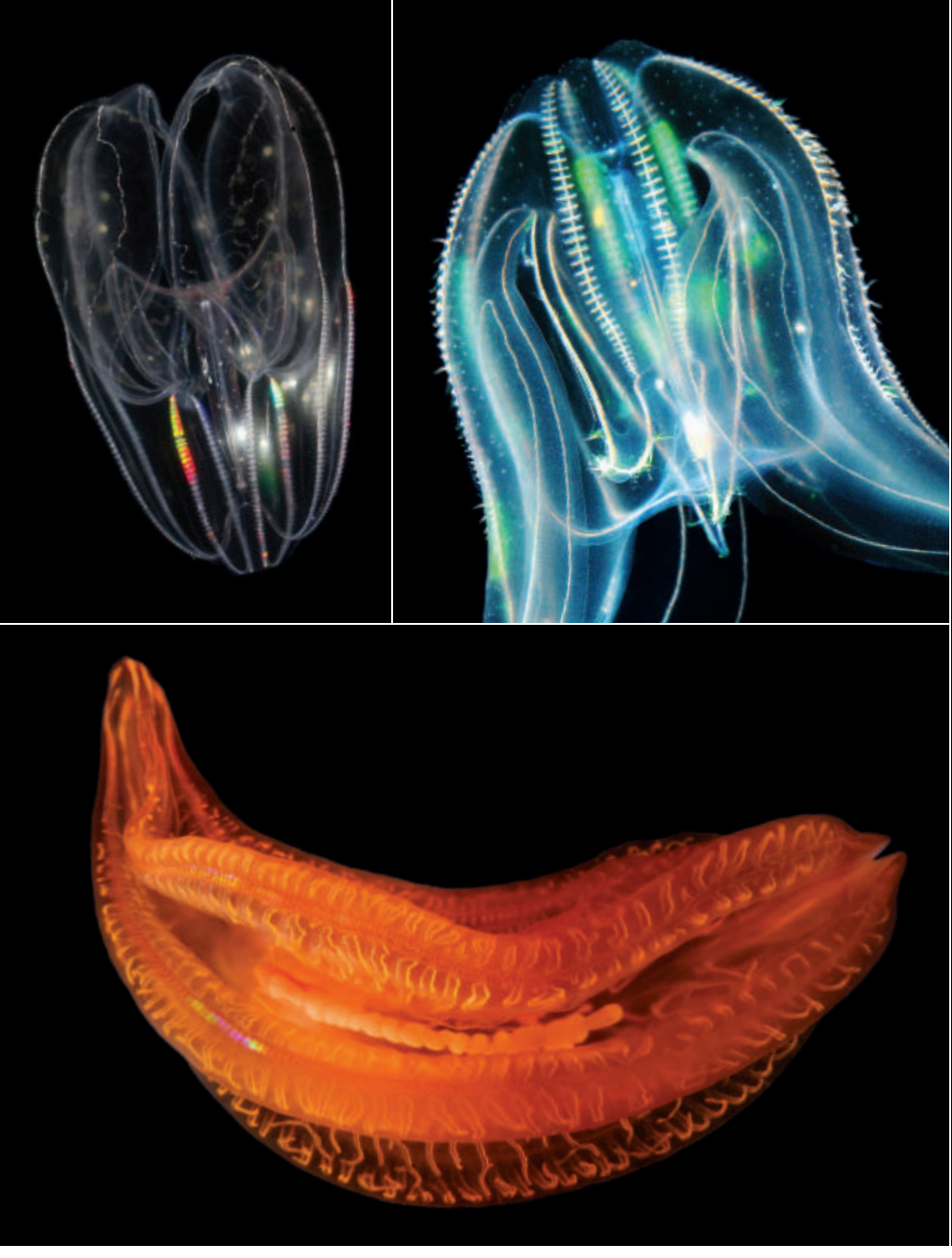
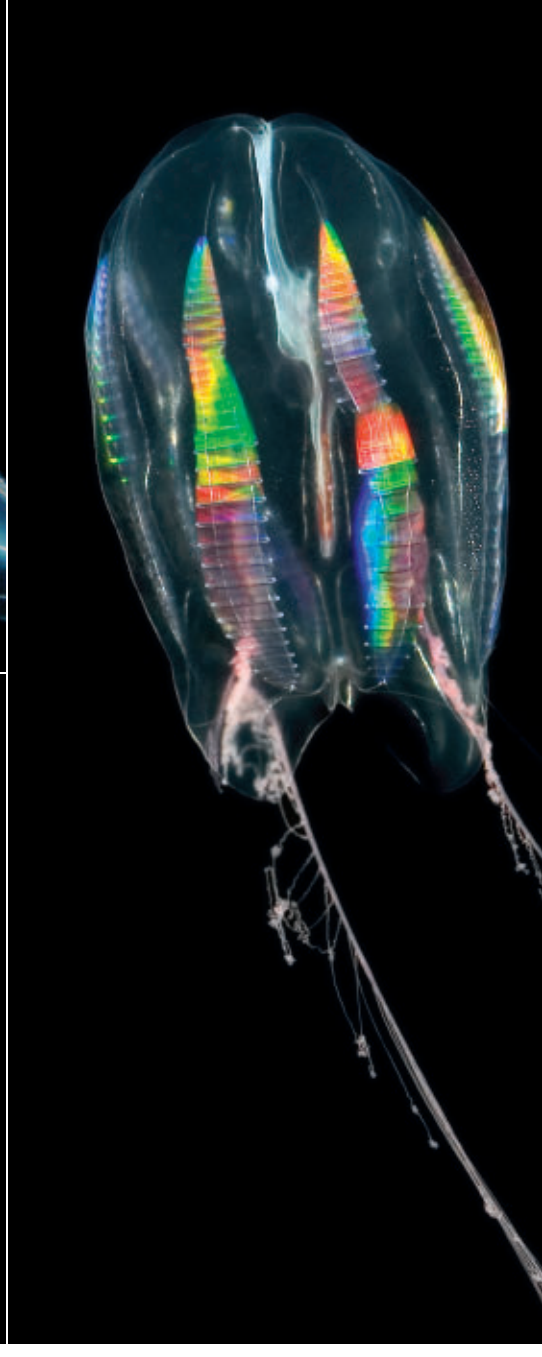




Evolutionary ENIGMAS

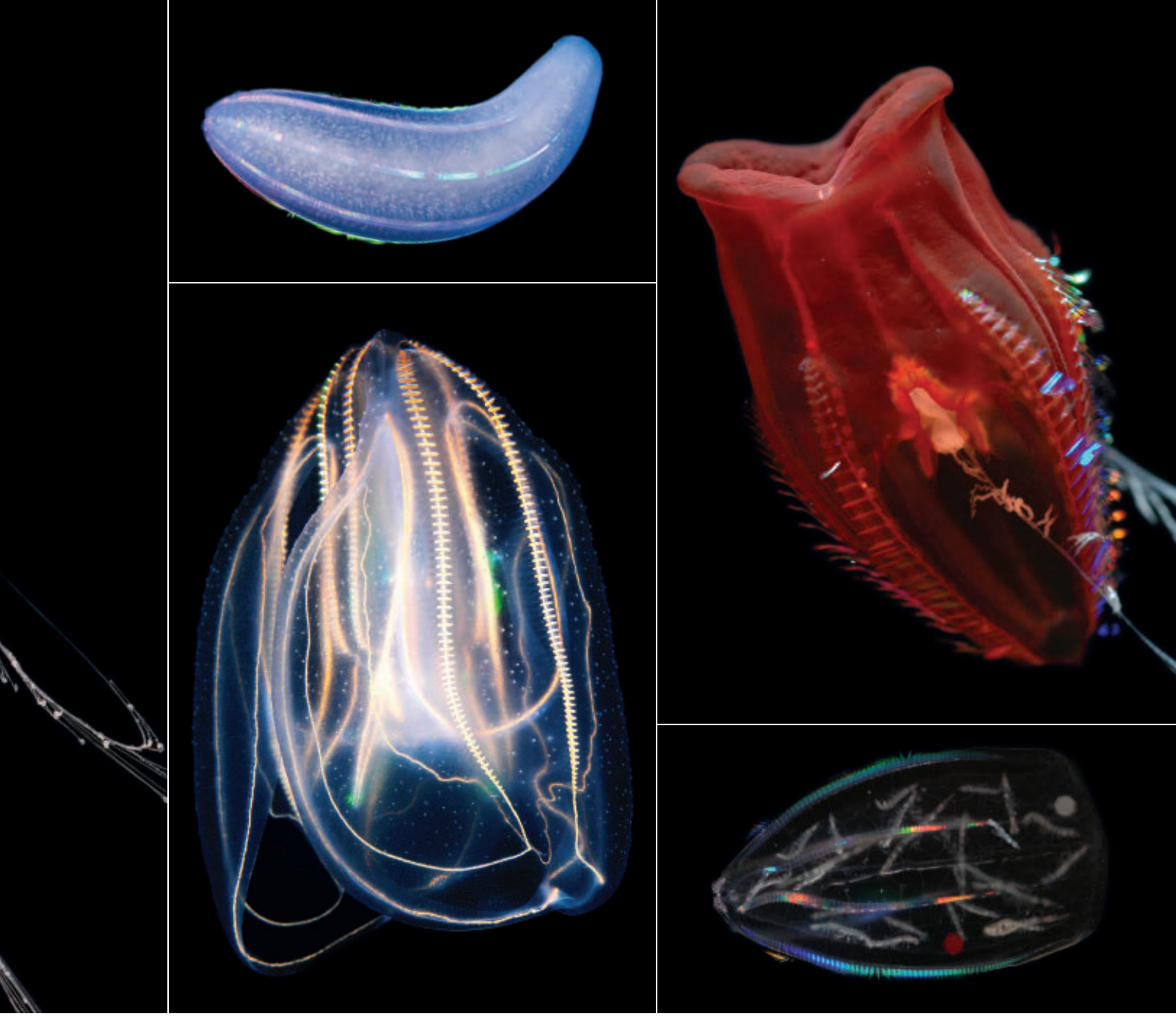
Comb jelly genetics suggest a radical redrawing of the tree of life

By Amy Maxmen

Steve Haddock remembers every detail about his first ocean encounter with a comb jelly. The open water was a bottomless deep blue. The animal, about the size of a tennis ball, shimmered with bioluminescence. "It was just cruising along like a hover craft," says Haddock, a marine biologist at Monterey Bay Aquarium Research Institute in Moss Landing, Calif. "Comb jellies are more alien than any aliens people imagine," he says.

Start with their appearance: The marine animals resemble translucent balloons rigged with flashing, colored

CLOCKWISE FROM TOP LEFT: L.L. MOROZ & M. CITARELLA/UNIV. OF FLORIDA; DIMIJIAN GREG/GETTY IMAGES; © INGO ARNDT/MINDEN PICTURES/CORBIS; CASEY DUNN/BROWN UNIV.



CLOCKWISE FROM TOP LEFT: BORIS PAMIKOV/SHUTTERSTOCK; S. HADDOCK; S. HADDOCK; DIMIJIAN GREG/GETTY IMAGES

Translucent swimmers, comb jellies come in a variety of forms. New genetic data suggest that these relatively complex animals may have evolved before, not after, sponges.

lights. Some species glow. When startled, some flash electric blue. Vertical rows, or combs, made of hundreds of iridescent, hairlike cilia run the lengths of their globular bodies (thus the name comb jellies). In some species the cilia are 2 millimeters long — 200 times the length of cilia in other animals — and they beat in coordinated waves, propelling the jellies forward, backward and diagonally in search of prey.

It's not just their appearance that is wondrous: Slice a comb jelly embryo in two and you get two half-adults that can fertilize themselves to give birth to a perfectly whole offspring. Some can reproduce while they're still larvae. Though jellies lack eyes, Haddock and his colleagues have discovered proteins that comb jellies use to sense light. Comparative biologists like to joke that on the eighth day, God created comb jellies.

Comb jellies are gelatinous like jellyfish, but the similarity ends there. In body plan, jellyfish resemble the largely sessile, almost plantlike sea anemones, corals and other cnidarians: a group that dates back at least 550 million years. While jellyfish and other cnidarians have nerve cells that form a loose network in their bodies, comb jellies have a more sophisticated nervous system with a rudimentary brain and cellular connections called synapses that are also found in flies, humans and most other animals.

Yet, detailed looks at the genomes of two species of comb jellies suggest, surprisingly, that they are the more primitive animals, and not the jellyfish, sea anemones or corals, as has long been thought. It's even possible that the sophisticated comb jelly lineage

may have evolved before the brainless, gutless, muscle-less sea sponges.

With just 150 known species, comb jellies represent only a small slice of the animal kingdom. But their strangeness, right down to their DNA, threatens much of what scientists thought they knew about the origins and early evolution of animals.

The notion that comb jellies may elbow out sponges from the base of the animal tree of life is a radical one. If true, it means that comb jellies evolved nerves, muscles and other complex features, which in some ways resemble our own, independent of the ancestor that led to most animals.

Alternatively, and even more difficult for biologists to accept, is the possibility that the last common ancestor of all animals might have possessed complex features that remained in the comb jellies but were lost without a trace in the sponges, jellyfish and their kin. Both options muddle traditional assumptions that multifaceted features do not pop up and vanish willy-nilly over evolutionary time.

Leonid Moroz, a neurobiologist at the University of Florida's Whitney Laboratory for Marine Bioscience in St. Augustine, recently sequenced the genome of the sea gooseberry comb jelly, *Pleurobrachia bachei*. The new genetic findings imply that "there may be many ways to make a complex animal," he says.

Others disagree. "It would be remarkably fascinating if comb jellies evolved neurons and muscles independently, and astonishing if they were at the base of the tree," says Graham Budd, a paleontologist at Uppsala University in Sweden. "It is effectively saying animals evolved twice. Frankly, I'm not ready to believe it."

Tree of life — as a sapling

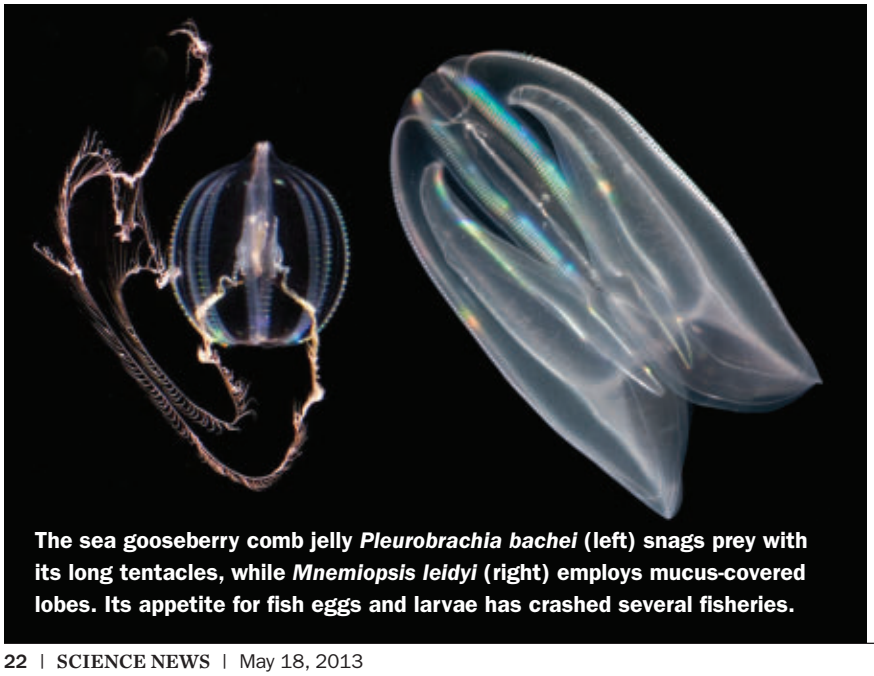
Long before Charles Darwin described evolution as descent with modification, zoologists noticed that animals shared certain structures. For example, humans, birds, lizards and fish all have a backbone composed of several bony vertebrae that protect a spinal cord. Rather than independently evolving this complicated structure along each of their evolutionary branches, Darwin suggested that these animals inherited a backbone from a common ancestor, which was modified over time in different lineages. That is why some snakes have 400 vertebrae and humans have 33.

When scientists draw evolutionary trees, they compare and contrast traits for clues on how animals are related. In general, biologists favor the simplest solution — usually the one in which most lineages radiating out from a common ancestor share most of the ancestor's features. This concept of simplicity, called parsimony, has long guided thinking on animal origins.

All animals alive today descended from a clump of cells that were able to communicate and adhere to one another more than 800 million years ago. This event appears to have happened once, as did other milestones in animal evolution such as the organization of cells into tissue layers, says Claus Nielsen, a biologist at the Natural History Museum of Denmark in Copenhagen and the author of the textbook *Animal Evolution*.

In traditional trees of life, the sponges branch off first, as multicellular animals without much specialization. Jellyfish, sea anemones and corals are thought to come later, from an ancestor with multiple cell types, and some cells organized into an outer layer of tissue surrounding the body and an inner tissue layer lining the gut. An animal with all these features plus nerve cells, a rudimentary brain and a middle tissue layer that forms muscles is traditionally thought to have given rise to comb jellies and the rest of the animals.

With the earliest animal lineages arranged in this order, major transitions paved the way for further innovations. This is evident not only in body structures that look alike, but in shared molecular underpinnings. In the case of multicellularity, many of the same proteins stick cells to one another and communicate messages between cells in all living animals. The same concept holds true for muscles and the central nervous system, which consist of several distinct parts built by networks of proteins encoded by genes. The fact that many of the interacting components are shared by all animals leaves Nielsen and many others resistant to the idea that comb jellies originated the parts on their own and then converged on a common design. "The more complicated a shared structure, the less likely it is to be convergent," or to have evolved independently, says Nielsen. "One cannot exclude the possibility of convergence, but there is a big difference



The sea gooseberry comb jelly *Pleurobrachia bachei* (left) snags prey with its long tentacles, while *Mnemiopsis leidyi* (right) employs mucus-covered lobes. Its appetite for fish eggs and larvae has crashed several fisheries.

FROM LEFT: L.L. MOROZ & M. CITARELLA/UNIV. OF FLORIDA; WILLIAM BROWNE/UNIV. OF MIAMI

between possible and probable."

In the 1990s, biologists predicted that studies of animal genomes would mirror the gradual addition of anatomical complexity in early animal evolution. Where humans have about 22,000 genes in their genome, it was expected that sponges, sea anemones and comb jellies would have far fewer. Yet in 2007, biologists were taken aback by a report in *Science* showing that the starlet sea anemone has nearly as many genes as a human. The genetic potential for complexity, it seemed, existed early on.

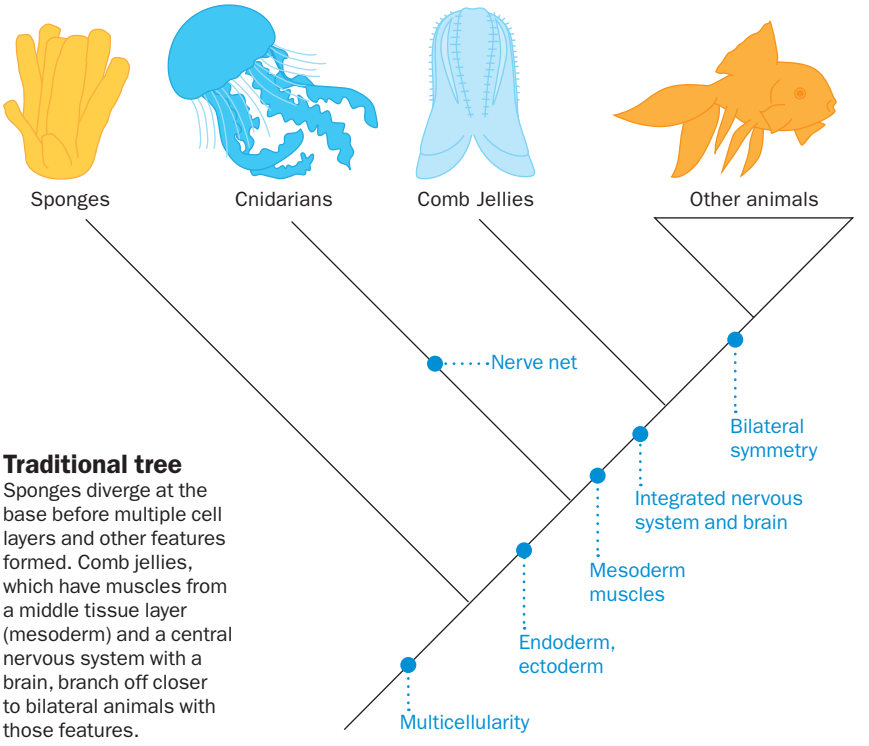
Comb jellies made a splash a year later. An evolutionary tree built according to similarities in select stretches of DNA, rather than shared anatomical traits, placed the comb jellies below the brainless sponges. At the time, scientists largely dismissed the finding, calling it a result of imperfect tree-building algorithms. In fact, the team initially left the finding out of its paper. "But the reviewers wanted us to say something, so we noted the result and said it needed further analysis," says Andreas Hejnol, a coauthor on the 2008 report in *Nature* and an evolutionary developmental biologist at the Sars International Centre for Marine Molecular Biology in Bergen, Norway. "But privately among ourselves, we talked about what it would mean if [comb jellies] are at the base," Hejnol says. "It would mean that they evolved complexity independently, or that the sponges lost a massive amount of complexity."

Finding convergence

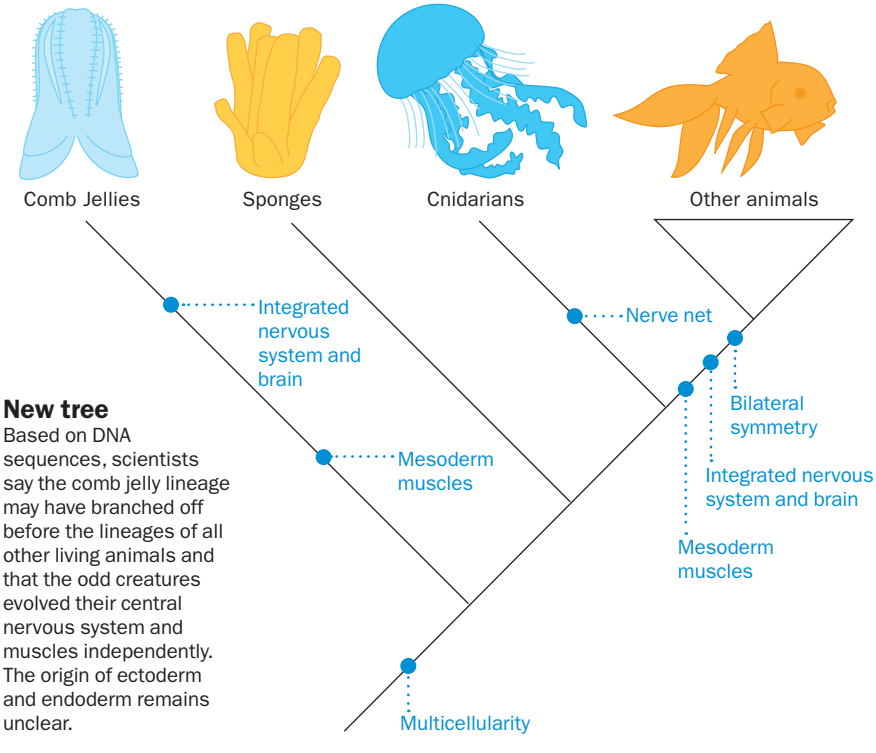
To explore that question and others, a group of biologists decided to tackle an entire comb jelly genome. They chose a walnut-shaped jelly, *Mnemiopsis leidyi*, which could be collected easily off the coast of Cape Cod, Mass., and reared in the lab.

In January, Andy Baxevanis, a lead investigator on the *M. leidyi* genome project and a comparative biologist at the National Human Genome Research Institute in Bethesda, Md., presented his team's results in San Francisco, Calif., at the annual meeting of the Society for

Tree of life Diagrams depict the history of animal lineages as they evolved over time. Each branch represents a lineage that shares an ancestor with all of the animals that branch after the point where it splits from the tree. Biologists traditionally build trees by comparing species' anatomies; now they also compare DNA sequences.



Traditional tree
Sponges diverge at the base before multiple cell layers and other features formed. Comb jellies, which have muscles from a middle tissue layer (mesoderm) and a central nervous system with a brain, branch off closer to bilateral animals with those features.



New tree
Based on DNA sequences, scientists say the comb jelly lineage may have branched off before the lineages of all other living animals and that the odd creatures evolved their central nervous system and muscles independently. The origin of ectoderm and endoderm remains unclear.

E. FELICIANO

Integrative and Comparative Biology. According to one mathematical model that compared thousands of portions of the comb jelly's genome to those of other organisms, comb jellies belong at the base of the animal tree of life. However, another analysis placed comb jellies below jellyfish and their kin, but it could not resolve whether sponges or comb jellies came first.

Baxevanis' team scanned the comb jelly genome for some of the most widespread and fundamental gene families in the animal kingdom. Animal cells communicate and adhere to one another with molecules called the LIM proteins, for example, but comb jellies have fewer genes encoding these proteins than other animals. Molecular components of signaling pathways involved in cell growth and metabolism are missing in comb jellies and sponges. The *Hox* genes, key to early development and responsible for signaling where the brain, limbs or other body parts should form, are also absent in comb jellies and sponges. And comb jellies may be the only animals that lack both gene-regulating molecules called microRNAs as well as the molecular machinery to create them.

Baxevanis says the simplest explanation for the missing genes is that they evolved after comb jellies branched off from the ancestors of other animals, arguing for an earlier spot on the tree for the jellies.

More support for the dramatic repositioning of the comb jelly emerged at the San Francisco meeting, where in addition to Baxevanis' talk there were 13 other presentations and posters related to the jelly genomes. Most important were new data from the group led by Moroz, which had just finished analyzing the genome of the gooseberry comb jelly — *P. bachei*, a symmetrical beauty with eight combs of iridescent cilia and two long sticky tentacles. In his team's new tree of animal evolution, comb jellies also diverge at the bottommost branch, below the sponges.

Moroz, a neurobiologist, was prompted to study comb jellies out of his interest in the origin of the nervous system. He had suspected that the one in comb jellies could represent a very early form of our own.

Like Baxevanis, Moroz and his colleagues found a slew of genetic differences between the gooseberry comb jelly and the other types of animals they compared it with.

Moroz lingered on the findings that both comb jellies and sponges lack multiple genes thought to be crucial to a functioning nervous system. The result makes sense for sponges because they have no nerves, he says, but for comb jellies, "that's shocking because they have a brain, a nervous system and complex reactions." Comb jellies are active: Some species chase down prey and others cast out their tentacles like fishing nets. Yet neither team located genes encoding serotonin, dopamine and most other classic neurotransmitters that send messages between neurons in other animals. Absent too are proteins that, in other animals, guide the growth of neurons.

Also not present in the comb jellies' genomes were the usual lineup of genes associated with muscles in other animals. And the muscle genes that were present in comb jellies appeared to function in unusual ways. For instance, genes that in other animals form the middle tissue layer (from which muscles arise) turned on in nerve cells in comb jellies.

Parallel evolution

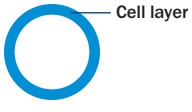
Comb jellies clearly have muscles, nerve cells and a rudimentary brain. So jellies may just use a distinct set of genes to build these parts. Or the familiar genes are lurking but have mutated so much that they are unrecognizable. At the moment, no one knows which genes underlie comb jellies' muscles and nervous systems because scientists don't know what to look for.

The uniqueness of the comb jellies' muscles and nervous systems on a genetic level makes the proposition that comb jellies evolved these features independently sound less preposterous. If Moroz's assertion that comb jellies "developed complex animal innovations in parallel with other animal lineages" is true, the creatures might have started simple when they arose more than 550 million years ago. Furthermore, if the ancestor of the comb jellies was simple, sponges and the jellyfish group need not have lost complexity, even if comb jellies represent the oldest living lineage.

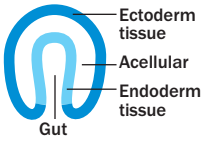
It's impossible to determine what comb jellies looked like originally because gelatinous animals leave hardly any mark on the fossil record. However, paleontologists who study the Ediacaran Period (635 to 542 million years ago) say life in this era, before most modern animal lineages arose, was seriously strange. Shaped like wrinkled lips, bubbly ferns and squashed, spiral galaxies, many Ediacaran fossils cannot be neatly placed in any modern-day category.

Cell layers Animals develop their main tissue layers as embryos; the layers give rise to muscles, skin and organs. Biologists traditionally have believed that animals with one or two tissue layers originated before animals with three.

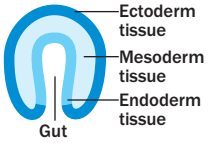
Single cell layer
The body is made up of a single layer of cells, which can be arranged in canals and chambers.



Diploblastic organism
Two tissue layers (endoderm and ectoderm) develop as one side of the embryo invaginates to form the gut.



Triploblastic organism
A middle cell layer (mesoderm) forms; this is where muscles and the vertebrate skeleton originate.



FROM TOP: OCEAN IMAGE PHOTOGRAPHY/SHUTTERSTOCK; RITU MANOJ JETHANI/SHUTTERSTOCK; JOHN WOLLWERTH/SHUTTERSTOCK

Jellies' missing genes Scientists who analyzed the genetic blueprint of the comb jelly *Mnemiopsis leidyi* argue for an ancient origin. Certain elements of the basic animal genetic toolkit are missing from the comb jelly genome, including some genes with important functions.

	Comb jelly	Sponge	Cnidarian	Bilaterians
DNA polymerase important for cell replication	X	X	X	X
***Wnt* hairpin 3** involved in embryonic development and cell division			X	X
HOX proteins pattern bodies during development and help form nerve cells			X	X
microRNA helps to regulate gene activity		X	X	X
Drosha cooperates with Pasha to make microRNA		X	X	X
Pasha cooperates with Drosha to make microRNA		X	X	X
Voltage gated channels (types L, N/P/Q and T) for nerve cell communication			X	X
PAX Homeobox proteins help embryos develop features such as eyes		X	X	X

SOURCE: A. BAXEVANIS/NHGRI

"In a sense, the Ediacaran biota may be failed experiments in animal multicellularity," explains Douglas Erwin, a paleontologist at the Smithsonian Museum of Natural History in Washington, D.C.

Could comb jellies be the only survivors of an otherwise extinguished dynasty dating back to the Ediacaran? "I would entertain the idea," Erwin says. "Maybe they are the sole extant representatives of what was an attempt to make something fast and predatory with an early genetic toolkit," he speculates. In contrast, the sponges may have shared a similar toolkit but laid low. With around 8,000 species of sponges alive today, that strategy evidently worked.

Despite the evidence, many biologists are reluctant to accept that muscles and the central nervous system evolved more than once, although most accept the idea that these features have been highly modified over evolutionary time. Joseph Ryan, an evolutionary biologist at the Sars lab and a member of the *M. leidyi* team, attributes this conviction to human bias: "People are convinced that our nervous system is the greatest thing in the world, so they ask 'how could it happen twice?' "

Understanding the true evolutionary tree would do more than shed light on animal relationships. It would also reveal whether convergent evolution is more common than biologists have assumed. If the comb jelly lineage branches off at the bottom of the tree, parsimony suggests that the comb jellies independently gained complex features. Muscles and an integrated nervous system would evolve once along their branch, and also in an animal that evolved after the sponges and the group containing jellyfish split off. The alternative — that an animal ancestor had all these features — means the features were lost once in sponges and again in the jellyfish group. Sponges, both living and fossilized, show no sign of ever having these features or the tissue layers that would be required to build them.

The fact that the comb jelly lineage landed in different places depending on the analyses Baxevanis' team ran highlights the difficulty of reconstructing the single, true tree of life. Despite the genomes, the scientists are not there yet. But a better view of the earliest branches on the tree may not be far off. Techniques used to analyze species relationships improve every year, and new gene data from more species should help.

Studies into how comb jellies develop and operate their body parts might also reveal differences overlooked in the past when the common origin — and therefore the presumed similarity — of the muscles and nervous system was taken for granted. Mark Martindale, an evolutionary biologist at the Whitney Marine Laboratory in Florida who works on the *M. leidyi* project, points out that differences between animals might turn out to be beneficial.

Perhaps the proteins that help a comb jelly to regenerate its brain, nerves and muscles could reveal a potential to do the same in humans, he says. The comb jelly genome also contains elements that cause cancer in mammals, such as a notorious gene called *Myc* that leads to unfettered cell growth. Maybe the jellies have discovered ways to keep cancer-causing genes in check. "The bright side of all of this convergence is that by studying it comparatively, you can come up with new remedies for old problems," Martindale says.

In December 2012, Baxevanis' team posted the *M. leidyi* comb jelly's annotated genome online, and while both teams have revealed their findings at meetings neither has published its magnum opus: the definitive comb jelly genome manuscript announcing its more ancient origin and its independent evolution of complexity.

The challenges the teams will face when they do publish are clear. But Moroz has some advice: In Darwin's time, the theological argument was that complex systems couldn't evolve without a creator, he says. Now, the dogma is that complexity can evolve, but not often. "It's like we are brainwashed about complexity," he says. If more biologists would only devote their attention to the comb jelly, he argues, they'd learn how innovative evolution can be. ■

Explore more

- *Mnemiopsis* genome project: http://research.nhgri.nih.gov/mnemiopsis

Amy Maxmen is a freelance science writer in New York City.

Spinning the CORE

Laboratory dynamos attempt to generate magnetic fields the way planets and stars do **By Alexandra Witze**

SANTIAGO ANDRÉS TRIANA

Daniel Lathrop spent seven years and $2 million building the stainless steel sphere in his laboratory. It's two spheres, actually — nestled one within the other like a pair of Russian dolls. Only these dolls contain 12 tons of molten metal and spin independently at astonishing speeds.

With his contraption, Lathrop, a physicist at the University of Maryland in College Park, hopes to re-create the Earth's spinning metal heart. As the planet rotates on its axis, electrically conducting liquid iron churns thousands of kilometers down in the outer core. The iron's sloshing motion, in a process called a dynamo, creates and sustains Earth's magnetic field.

Given the crucial role the planet's magnetic field plays in guiding navigators and protecting Earth from solar storms, scientists know surprisingly little about it. Geophysicists don't know exactly how the magnetic field got started billions of years ago or how it has managed to sustain itself for so long. It's even a mystery why Earth has a magnetic field in the first place. Not all planets do. Tiny Mercury has one, for instance, while Mars has none. Stars like the sun generate powerful internal dynamos as well, and laboratory models filled with superhot metal might be able to re-create them.

Lathrop's goal is to provide some hard science about where Earth's magnetism comes from. His Russian dolls live in a laboratory at the university, where they stand in as a miniaturized version of the Earth. Liquid sodium filling the space between the inner and outer spheres replaces the planet's liquid iron outer core. Lathrop hopes that the swirling sodium will create its own dynamo and generate a self-sustaining magnetic field.

If the experiment works, Lathrop's team will be able to study the forces that drive Earth's dynamo and determine what might happen to our magnetic field in the future. It has flipped quasi-regularly in Earth's past, so that magnetic north becomes magnetic south, and vice versa. Some scientists think the planet is due for another flip. "We could be headed for a reversal right now, but that's just a hunch," says Lathrop. "We're stuck between hunches and science."

Since last spring, when his device was first filled with sodium, Lathrop has turned it on about once a month. Flip a switch on Monday morning, and by midday Tuesday all the sodium — which is solid at room temperature — has gotten hot enough to melt. Flip another switch and the spheres begin whirling like dervishes, churning the liquid sodium between them.

Instruments around the device gather information about how the liquid is flowing and whether it is generating any magnetism. No dynamo yet, but the device allows the team to generate huge amounts of data very quickly. "Every one second in our experiment mimics 5,000 years of Earth's history," says Lathrop. "In a few hours, I can deliver millions of years of high-quality data."

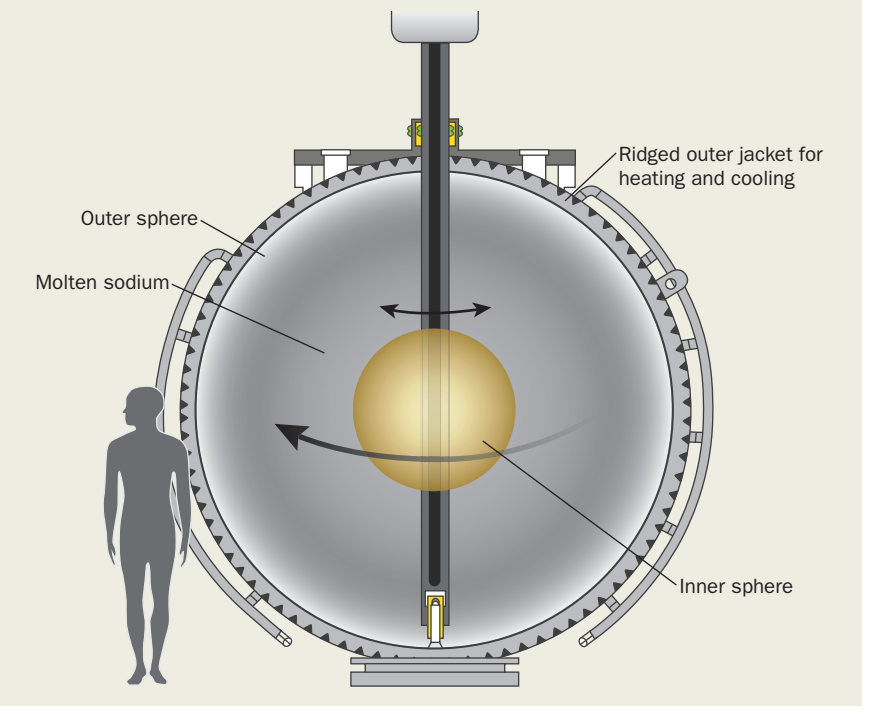
Building a better dynamo

"What's interesting from an experimental point of view is that dynamos are a threshold phenomenon — you either get one or you don't get one," says Peter Olson, a geodynamicist at Johns Hopkins University. "You have two options for making one: You can start with the most Earthlike configuration and try to work up to that threshold, or you can start with a less realistic configuration, make a dynamo and then start removing the unrealistic bits."

The latter approach is how three groups have already achieved dynamos in a lab. The first two were reported in 2000, in Riga, Latvia, and in Karlsruhe, Germany. Both forced liquid sodium in cylindrical tanks to flow in a helical pattern — a twisty motion that was enough for the fluid to generate a dynamo.

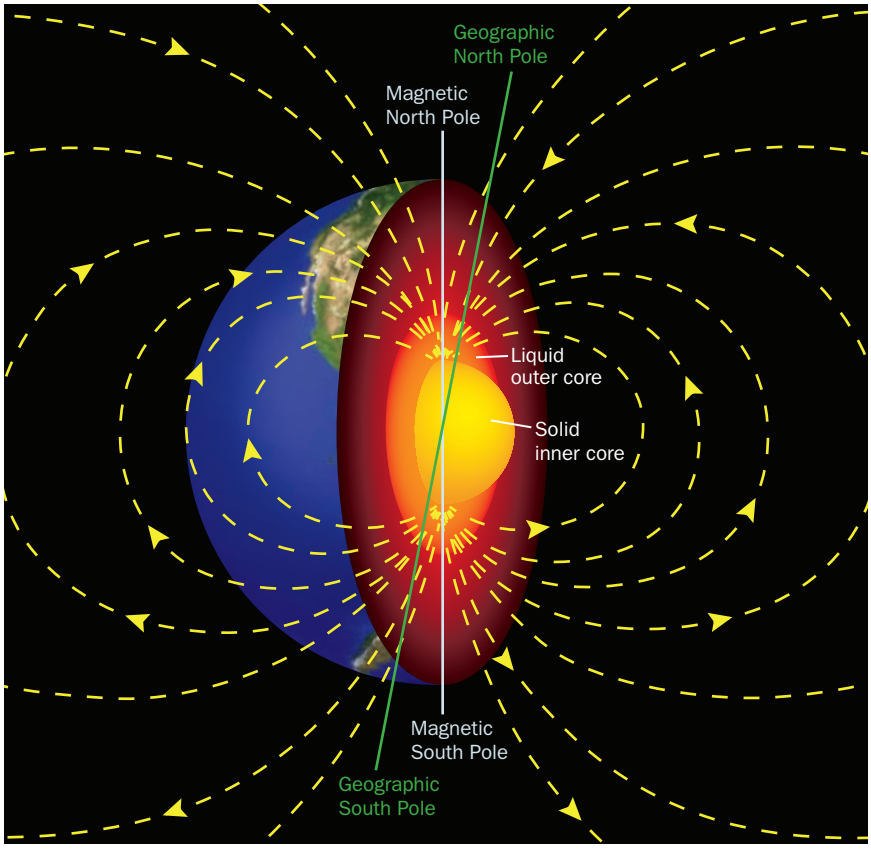
Building on that, physicists put together a third sodium experiment in Cadarache, France. "It's modeled after a

Dynamics of a dynamo To simulate Earth's dynamo, the space between the inner and outer spheres of the University of Maryland device is filled with liquid sodium. The spheres rotate independently at varying velocities. The setup allows the team to study how heat and rotation might affect the movement of the iron in Earth's outer core. SOURCE: S. YOUNG/*NATURE* 2011



The dynamo experiment at the University of Maryland is the biggest ever made with whirling molten sodium.

M. ATAROD



Giant magnet Circulating electric currents in the molten iron outer core give rise to Earth's magnetic field, which is like a bar magnet tilted 11 degrees from the spin axis of the planet and thus from the geographic poles. Lines of the field converge where magnetic force is strong, at the poles, and spread out where it is weak.

French washing machine — a great agitating device," says Olson. It uses a copper cylinder filled with liquid sodium stirred by a disk at each end. The disks can rotate in the same or opposite directions, essentially pushing or pulling the sodium and setting up all sorts of chaotic flows.

In 2006, the Cadarache experiment generated a dynamo. The device shows a much richer variety of magnetic behavior than the earlier two. For example, the direction of the magnetic field in the device reverses direction every so often, as Earth's does.

But the machine works only because it contains some of those unrealistic bits Olson refers to. In particular, it makes a dynamo only if one or both of the stirring disks are made of iron. That introduces an extra magnetic force that helps the dynamo get going. Take out the iron, and the Cadarache machine no longer crosses the threshold.

The latest suite of sodium experiments uses spheres, not cylinders, to rotate the fluid in a more planetlike scenario. Earth is, after all, round. None of these experiments has yet achieved a dynamo, but they have contributed to some important discoveries that may help Lathrop create his. In particular, researchers have learned a lot about turbulence, the unpredictable changes in direction that a flowing liquid sometimes takes.

Imagine a fast-flowing river in which eddies carry the water from the center current to the stationary banks. Those eddies — the turbulence — suck speed from the middle of the river and move it to where it rapidly decays. Turbulence of the same sort normally plays havoc with an experimental dynamo, says Cary Forest, a physicist at the University of Wisconsin–Madison.

Forest and his colleagues have been working with a sodium experiment smaller than Maryland's. In 2006, they reported that turbulence within the sodium flow in their device generates its own weak magnetic field. That, in turn, lowers the conductivity of the sodium, making it hard to get enough electrical charges flowing fast enough to set off a true dynamo.

"That's a big killer," says Forest. "You have to spin your system five times as fast to get it up to the point where you thought you had to be." Nevertheless, the discovery helped explain why the new generation of sodium experiments hasn't been able to generate dynamos yet.

On the other hand, if you get a dynamo going in the first place, turbulence may not be so much of a problem. In an experiment in Grenoble, France, scientists have forced a strong magnetic field onto the flowing sodium. Because of that they can essentially suppress much of the turbulence that usually roils the liquid, says team leader Henri-Claude Nataf of the University of Grenoble.

That, Nataf says, indicates what is happening in planetary cores. Once a planet like Earth starts spinning and generating its own magnetic field, that magnetism tamps down turbulence. The scientists at Grenoble can now study how that happens inside the flowing sodium in their experiment.

Meanwhile, back in Maryland

Lathrop's spinning spheres at Maryland are without a doubt the big daddy of the sodium experiments, and while the sodium portion is just getting under way, the team tested the experiment with water several years ago to be sure all the mechanical parts worked before tanking up with a liquid metal that can give off a highly flammable gas.

Even then, the scientists began discovering unexpected things. The water showed flows forced by Earth's precession, the wobbling of the planet's rotational axis in space. That observation, Lathrop says, supports the idea that similar flows exist in Earth's core.

Starting in late 2011, the Maryland

GLOBE: UMBERTO SHTANZMAN/SHUTTERSTOCK, ILLUSTRATION: M. ATAROD

scientists drained the water from between the spheres to make way for sodium. The metal is commercially available for making indigo dye for blue jeans, and Lathrop's team ordered 62 barrels of the stuff. Just heating it up enough to liquefy it and then loading it all in took almost five months.

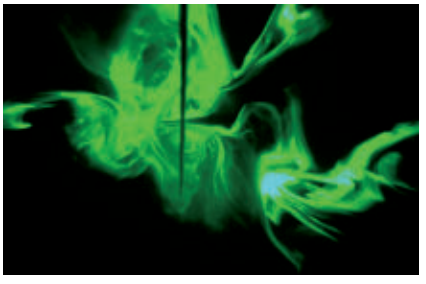
"I wouldn't want to do that again," says Lathrop. He and local fire safety officers had to get creative because liquid sodium is so dangerous. They invented a new way to put out laboratory fires in case of any accidents. And for safety's sake the experiment initially ran at two revolutions per second, which is half of the fastest speed it can achieve.

Even at that speed, and before achieving a dynamo, the Maryland machine is hinting at new discoveries. The team has documented 15 different flow states. Like weather patterns in Earth's atmosphere, each flow comes with its own complications. "We are sailing out into uncharted territory," Lathrop says.

He thinks the machine will have no problem generating a dynamo once it powers up to full speed, probably later this year. Among other things, Lathrop will be looking for magnetic field reversals like those seen on Earth.

Ever since scientists generated the first global model of Earth's magnetic field nearly 180 years ago, its strength has decreased by some 10 percent. That might indicate that the planet is heading into a reversal right now (the last one happened 780,000 years ago; they generally take about several thousand years from start to finish). If Lathrop's machine can generate a dynamo and then start flipping direction, scientists might have more insight into what triggers such changes on Earth — and how likely it is that we are headed for another one.

Turbulence (seen here in water dyed green) complicates experiments trying to create a dynamo and a magnetic field by swirling hot liquid sodium.



FROM VIDEO BY DANIEL P. LATHROP, SANTIAGO A. TRIANA, DANIEL S. ZIMMERMAN

Beyond sodium

Not all scientists are content with sodium experiments, even very big ones. At Wisconsin, Forest is trying to take the idea of a dynamo up a notch. Quite a few notches, actually — with the superheated state of matter known as plasma.

Liquid metals are a good generalization for studying Earth's core, Forest says. But most dynamos in the universe, those within stars, are entirely different beasts. They operate in magnetic regimes far beyond Earth's.

Lathrop hopes that the swirling sodium will create its own dynamo and generate a self-sustaining magnetic field.

Scientists measure the strength of a dynamo with something called the magnetic Reynolds number. A low magnetic Reynolds number means that the dynamo is weak and could soon dissipate. A high number means that the dynamo is powerful. Earth's magnetic Reynolds number is on the order of 100. The sun's is on the order of 100 million. And plasma streaming between galaxies can have a magnetic Reynolds number more like a million billion.

Forest designed his plasma experiment to mirror magnetic regimes far beyond Earth's. If successful, it could give researchers an unprecedented glimpse of what happens around black holes and within the hearts of stars. "There's so much to learn," he says.

The problem is that plasma is difficult to contain. In research machines such as fusion reactors, scientists use strong magnetic fields to confine plasma, but those fields interfere with seeing what might happen during a natural dynamo. "It's almost impossible to study how magnetic fields come into being using plasma because you need a magnetic field there to begin with," says Forest. "It violates the rules of the dynamo game."

Forest figured out a work-around by putting the whole machine in a sort of magnetic bucket and then attaching 3,000 strong magnets to the surface of the outer sphere. The surface magnets clear out the plasma in the outermost portion of the device and stir the plasma remaining within to create turbulent flows for study.

At 3 meters in diameter, the Madison plasma experiment is the same size as the Maryland sodium one. Forest's team can pump in a little helium or argon gas, add voltage and create a plasma at some 50,000° to 100,000° Celsius. "It looks even more cool than Dan's," Forest says. A clear window on the side of the outer sphere offers a view of the glowing plasma flickering within, like the ethereal dance of the northern lights.

Forest and his colleagues created plasma for the first time in the device last fall, and since then have been measuring its density, temperature and other properties. Some of the flows zip along at nearly 10 kilometers per second, allowing them to achieve very high magnetic Reynolds numbers.

Already, the team is seeing quirky viscosity in the flows. Forest thinks the machine is on the verge of mimicking astrophysical phenomena such as accretion disks of gas and dust swirling into a black hole.

So the race is now on to see which team might achieve a dynamo first: the Madison plasma experiment or the Maryland sodium one. Both are so huge that they may succeed out of sheer size. If so, then physicists are going to be busy for a very long time, says Forest: "Nobody's ever built anything like this." ■

Explore more

- For more information about the University of Maryland sodium experiment: http://complex.umd.edu
- P. Olson. "Experimental dynamos and the dynamics of planetary cores." *Annual Review of Earth and Planetary Sciences*. 2013.

Gulp

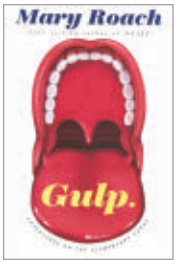
Mary Roach

It's no coincidence that the word "visceral" refers both to entrails and to the sensation one feels on a roller coaster. We humans have a love-hate relationship with our guts, and Roach's latest book capitalizes on that mix of fascination and repulsion to lure us into reading about the digestive system.

Gulp explores the alimentary canal, moving like a bolus of food from mouth to stomach to lower gastrointestinal tract. Along the way, Roach visits scientists studying the various elements of eating, digesting and eliminating.

Roach has an eye for the odd. Rather than write a treatise on the properties of stomach acid, for instance, she tells the story of surgeon William Beaumont and his career studying the fistulated stomach of Alexis St. Martin. An 1822 shooting accident left St. Martin with a fistula, or hole, through which the doctor could slip pieces of food and study their digestion. The rest of the book proceeds with similarly quirky research on saliva, chewing, gut bacteria and more.

Like her four previous books, *Gulp* is a whirlwind tour. Luckily, Roach makes you feel as if you're on the tour bus with your funniest friend providing running color commentary. She's completely fearless, perfectly happy to plunge her hand — nay, her entire arm — into a cow's stomach to feel its digestive caress. The next thing you know, she's off to a lab where she hopes a researcher "might be able to whip up a batch of artificial flatus."



Some may say it's all a bit silly, but Roach embraces the puerile attraction of her topic. "I don't want you to say, 'This is gross,'" she writes. "I want you to say, 'I thought this would be gross, but it's really interesting.'" And it is.

— Erika Engelhaupt

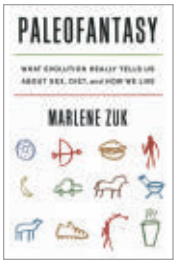
W.W. Norton & Co., 2013, 348 p., $26.95

Paleofantasy

Marlene Zuk

Proponents of the paleo diet believe the mismatch between today's Western lifestyle and that of early humans is making us fat and sick. Our bodies haven't had time to adapt to our new ways of life, the thinking goes, so eating like our ancestors is the ticket to good health.

This notion that our lives are out of sync with the way humans were meant to be is a fallacy, or a "paleofantasy," claims Zuk, an evolutionary biologist. With piles of evidence from recent genetic and anthropological research, she offers a dose of paleoreality.



Homo sapiens emerged about 200,000 years ago, but humans haven't stopped evolving. "No organism gets to a point of perfect adaptation, heaves a sigh of genetic relief, and stops," Zuk writes. In the last few thousand years, for example, Tibetans in the Himalayas have adapted to living at high elevations. And as animal herding and agriculture spread, groups developed adaptations that allow people to digest milk as adults and starch from grains and tubers.

Since humans have always been evolving and migrating to new places, you can't pinpoint a single ancestral environment where *H. sapiens* grew up, Zuk explains. Contemporary hunter-gatherers vary in many ways, including diet, food procurement, sexual division of labor and child rearing. None of these societies is a model of an ideal human ancestor, because each one has changed over time.

Zuk doesn't deny that sedentary lifestyles cause health problems. But living like a caveman — whatever that means — isn't the answer. Her advice is sensible: Just put down the bag of chips and get off the couch. *— Erin Wayman*

W.W. Norton & Co., 2013, 328 p., $27.95

Toms River

Dan Fagin

The story of a small New Jersey town's struggle with industrial pollution explores both toxicology and legal dramas. *Bantam, 2013, 538 p., $28*

A Palette of Particles

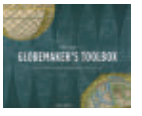
Jeremy Bernstein

A guide to the subatomic realm uses the metaphor of a painter's palette, with protons, neutrons and electrons as primary colors and more exotic particles adding new shades. *Belknap, 2013, 212 p., $18.95*

Between Man and Beast

Monte Reel

Victorian explorer Paul Du Chaillu heads into African forests in 1856 to find a mysterious creature then just a rumor in the Western world: the gorilla. *Doubleday, 2013, 331 p., $26.95*



A Renaissance Globemaker's Toolbox

John W. Hessler

Meet Johannes Schöner, a 16th century mathematician and scientist who collected and corrected the star charts and maps of his day. *Library of Congress, 2013, 176 p., $29.95*

Pieces of Light

Charles Fernyhough

A psychologist outlines a new understanding of how the brain forms memories, not by taking snapshots but by re-creating them each time. *Harper, 2013, 305 p., $26.99*

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Ethics of humanized mice

The recent stories "Human cells rev up mouse brains" (*SN: 4/6/13, p. 16*) and "Of mice and man" (*SN: 3/23/13, p. 22*) drove home to me that human-animal hybrids are now reality. In science fiction stories with such hybrids, a big part of the plot is the resultant ethical gray area: There are certain standards for animal research, and much stricter standards for human research. What standards apply to animals that have a significant payload of human cells? Brain research has the most obvious ethical implications, but what makes a "human" is complex and probably involves other parts such as the immune system. (I would be interested if mice with humanized immune systems showed changes in learning ability.)
Virginia Brock, Rock Island, Ill.

Flu facts

The graph of influenza and humidity ("Damping down flu," *SN: 4/6/13, p. 4*) was most interesting. I would refer you to the February 28, 1948, edition of *Science News Letter* and the article "Humidity Kills Germs." It seems we are rediscovering the past. Why flu is more prevalent in winter and how to slow its spread has been known for 65 years. Yet we continue to build the heating systems of hospitals, schools, stores, et cetera with little or no consideration for humidity.
Mark Davidsaver, via e-mail

Randomness not so random

The article on the Planck view of the microwave background (*SN: 4/20/13, p. 5*) contains an excellent picture of the distribution of temperatures of the microwave background radiation. As one who has spent a lot of time pondering microscopic images of distributions of one phase in another, I can't help but wonder if we're just seeing randomness in this picture. After all, random images of particulate materials in a clear matrix look very much like this picture, as do random number tables and packages of multicolored jelly beans. Random distributions are not spatially perfect, but strongly clustered. In fact, today we recognize clustering as an attribute of randomness, rather than a disproof of it.
Lou Floyd, via e-mail

The reader makes a good point about randomness. It's not surprising that fluctuations in the cosmic microwave background radiation cluster together in spots. In fact, these localized clusters led to the clumping of matter into stars and galaxies. But it is surprising and maybe not random that when scientists zoom out and look at the whole universe, there are clear differences between one half of the sky and the other. —Andrew Grant

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The Science Life

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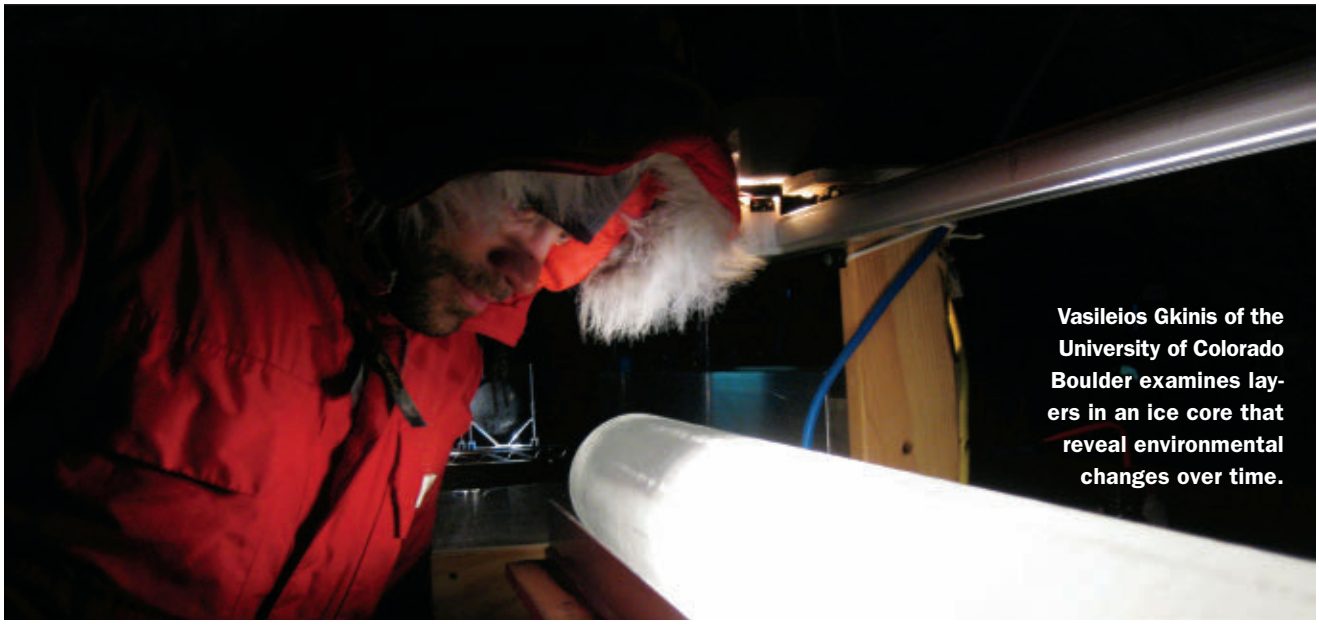

Vasileios Gkinis of the University of Colorado Boulder examines layers in an ice core that reveal environmental changes over time.

The ice keeper

DENVER — "I'm a little tired of the cold," Geoff Hargreaves says with a sigh.

No surprise there: Hargreaves works in a deep freeze — 38 degrees Celsius below zero (–36° F). As curator of the National Ice Core Laboratory, his job is to keep ice cores from Antarctica and Greenland frozen.

These cylinders — which would stretch more than 17,000 meters if laid end-to-end — are precious. They contain records of past climate and atmospheric chemistry, trapped in tiny bubbles that formed thousands of years ago and froze in chronological layers like tree rings. Melting is the enemy, destroying the layers and releasing trapped gases.

And that's where Hargreaves (left) comes in. Cores arrive in refrigerated trucks at his sprawling facility in Denver. He tucks the shiny, meter-long core tubes onto shelves in the lab's deep freezer. When a scientist requests a core to study, Hargreaves' team brings the ice into the "warm" room (a toasty –24° C). They slice off part of the core and pack it in a special box that will keep it frozen for up to three days. Then they ship it. "Of course there are FedEx horror stories," Hargreaves says.

Nearly everything at the lab is handmade and hand-engineered. For their latest and biggest project, Hargreaves and his colleagues designed a new system to efficiently collect and transport 3,400 meters of ice cores from the West Antarctic Ice Sheet Divide drilling project. The team flew from Denver to help gather the ice and, even in Antarctica, had to work in a refrigerator to keep temperatures cold enough.

Packed in 40-foot shipping containers with redundant refrigeration units, the cores made their way to McMurdo Station and then via ship to California. The final leg involved flatbed trucks to Denver. "I've never lost a core," Hargreaves says.

But with all the project's ice now safely on the shelves, there's not much storage room left. Hargreaves' next job is to figure how many more cores he can squeeze into his freezer. As the only federal repository for ice drilled by National Science Foundation–funded projects, the lab is, in essence, the nation's ice library. "If the ice melts, we're not going to go get it again," he says. — *Alexandra Witze*

Climate cores

Ice cores drilled from Earth's poles have shown scientists how the environment has changed over nearly the last million years — crucially, how atmospheric carbon dioxide levels rise and fall in concert with past temperatures. Here's a look at what some key ice-coring projects found:

GISP/GRIP, Greenland: From the late 1970s through the early 1990s, U.S. and European teams worked to drill down to bedrock beneath the Greenland ice sheet. Together the cores provide the longest continuous environmental record (more than 100,000 years) for the Northern Hemisphere. Chemical analyses have revealed evidence of human-caused changes to Earth's atmosphere as well as past volcanic eruptions and rapid climate change events.

Vostok, Antarctica: Russian scientists set a world record in 1998 by drilling to 3,623 meters beneath the Antarctic ice sheet. Drilling then halted for years as the team explored how it might safely penetrate deeper into the waters of the buried Lake Vostok — which it did successfully in February 2012. Studies of the deep core provided the first detailed record of how atmospheric chemistry changed over glacial cycles.

EPICA, Dome C, Antarctica: A European team drilled this core to a depth of 3,270 meters, finishing in 2004. The feat strengthened the Vostok findings and revealed a strong link between atmospheric carbon dioxide levels and temperatures through the last eight ice age cycles, back to 800,000 years ago.

FROM TOP: GIFFORD WONG/WAIS; JEFF KANIPE

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The train whistle blew. Time to go. One last kiss and I hopped onto the train. "I'll miss you every minute," she cried. "Don't you forget me!" I shouted back, "It's only New Jersey, sweetheart. I'll be home for supper."

Yes, we were ridiculous. But we were newlyweds. Some days, my morning commute felt like I was boarding a train to Siberia. Today, even after 33 years of marriage, we still have our ridiculous moments. We still can't stand to be apart. And she still wears that necklace.

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