Permafrost in Peril | Fluid Knots | Hitchhiking Black Hole

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ APRIL 6, 2013

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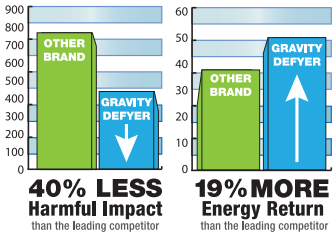

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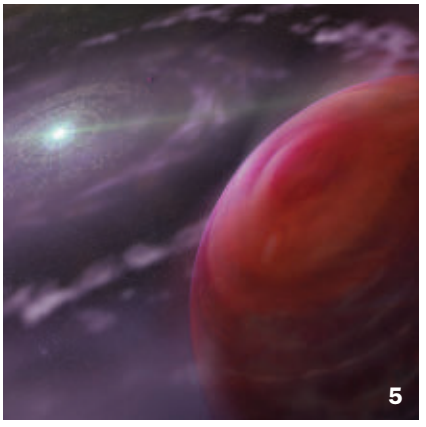

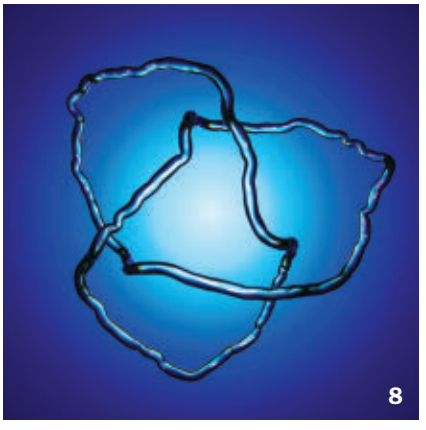

ScienceNews

In The News

Features

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COVER A glimpse into the summit crater of Antarctica's Mount Erebus reveals a cauldron of molten lava roiling at 1,000° Celsius. *Carsten Peter/National Geographic Stock*

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Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
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FROM THE EDITOR

The intrigue and reach of epigenetics grows

Cigarettes. Booze. Lunch meats. Stress. Pregnant women already have a long list of things they must avoid to keep their unborn babies healthy. Now, as Tina Hesman Saey reports on Page 18, there's evidence that a pack-a-day habit or other prenatal exposures may affect a mother's future grandchildren and even her great-grandchildren.

The legacy is due not to inherited changes in the genetic molecule DNA but to other chemical alterations that influence how genes behave. These non-DNA changes are called epigenetic, Greek for "above" or "over" genetics, and can come in many different forms. The field of epigenetics began as an effort to understand how cells — all carrying the same set of genes — specialize during development. But the field has grown and become utterly more intriguing. Today, it has implications for cell biology, evolution and medicine.

Epigenetic machinery has been found in every type of organism studied. Epigenetic modifications are dynamic, changing over a lifetime. They respond to the cellular environment — including exposures to high-fat diets, hormones, hormone-mimicking chemicals and stress. These changes can occur in the cells that give rise to sperm and eggs, too. Scientists had thought that at fertilization the epigenome is largely erased, leaving each generation with a relatively clean slate. But now it's clear that some epigenetic marks acquired during a lifetime can be passed down to future generations.

The idea that heritable changes can result from environmental effects and cellular experiences is a radical one for biologists, who rejected the Lamarckian model of evolution in favor of a gene-based, Darwinian view in the 1930s and '40s.

There's no doubt that epigenetics plays an important role in how the cell interprets the basic data stored in DNA. But how such interpretive notes can be inherited has been mysterious. Recent papers point to a molecule called piRNA, which directs the placement of one type of epigenetic mark at specific locations on the next generation's genome.

Still, many questions remain. Scientists haven't fully explored the links between epigenetic changes and specific medical conditions. Nor is it clear whether interventions could be used to prevent or cure epigenetic-related disease. One thing is certain: Avoiding behaviors like smoking that are known to harm your own health will help you and your offspring, directly or indirectly. — *Eva Emerson, Editor in Chief*

PHILIP CHANNING

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Say What?

Nares ***NAIR-ees***\ ***n.*** The openings of the nostrils. The nose poking out of a person's face is only the tip of the iceberg when it comes to odor perception. The real business of sniffing goes on behind the nose in the nasal cavity—a mazelike sac where incoming air gets funneled past olfactory receptors. Researchers in Germany and the United States used MRI scans to show that the size of one's nares correlates with the volume of the hidden cavern within. The findings, reported February 17 in *Physiology & Behavior*, suggest that people with large nares may have an olfactory advantage over people with more petite features. —*Jessica Shugart*

Science Past | FROM THE ISSUE OF APRIL 6, 1963

PATENTS OF THE WEEK — A new printing invention, electrostatic printing, is expected to have a major impact on the nation's second largest industry because good quality and inexpensive impressions can be made on virtually any material, from building bricks to fresh fruits and vegetables. In the new process dry ink particles instead of wet ink are screened onto the material to be printed. The particles are attracted to the object or surface by an electrically charged backing plate. The design or image to be printed forms the other electrode plate in the system. The ink particles are then fused permanently on the surface by heat or chemical treatment. The equipment involved is simple and lightweight compared with conventional printing presses.

Science Future

April 8–27
Join ornithologist Paul Sweet on birdwatching walks through New York City's Central Park during spring migration. See bit.ly/SFAMNHsweet

April 29
The National Academy of Sciences hosts a public symposium in Washington, D.C., to honor the society's 150th anniversary. See bit.ly/SFnas150

SN Online

www.sciencenews.org

ATOM & COSMOS
Curiosity finds minerals consistent with habitability. See "Life-friendly environment confirmed on Mars."

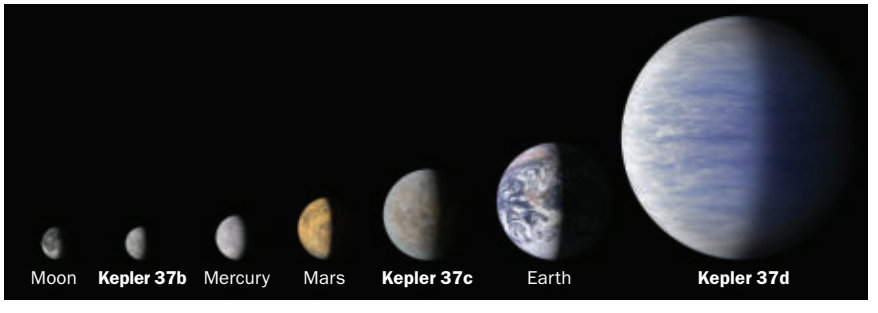
BODY & BRAIN
Scientists meld rat minds in "Rats do tasks while connected brain-to-brain."

CULTURE BEAKER
See Rachel Ehrenberg's column on website comments, "Trolls bad news for scientific discourse."

ON THE SCENE BLOG
Kids build plasma guns and more in "Intel Science Talent Search finalists show off their work."

The -est | SMALLEST EXOPLANET

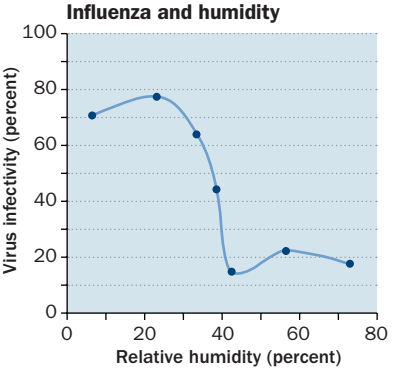
Mercury may be the runt of the solar system, but it still can pick on the newfound Kepler 37b, the smallest planet known. Scientists used NASA's Kepler space telescope to detect dimming caused when the exoplanet crosses in front of its star, about 215 light-years from Earth in the constellation Lyra. Most planets block several hundred parts per million of their star's light, but astronomers found Kepler 37b based on a dimming of just 22 parts per million—the telescope's most sensitive detection yet. The planet (illustrated below) is just 80 percent of Mercury's diameter and orbits its sun-sized star closely, the team reports February 20 in *Nature*, so it is probably a scorched world unsuitable for life. —*Andrew Grant*



Science Stats

DAMPING DOWN FLU

Cranking up the humidifier may help cut your risk of catching the flu. Researchers used mannequins that simulate coughing and breathing to study influenza transmission and found that particle-borne viruses remain infectious much longer in drier air.



SOURCE: J.D. NOTI *ET AL/PLOS ONE* 2013

CLOCKWISE FROM TOP: KGFOTO/ISTOCKPHOTO; JPL-CALTECH/NASA, CORNELL, MSSS; AMES, JPL-CALTECH/NASA

“It’s nice to look back in the past and see what’s already happened on the Earth, and that gives us some confidence about our future predictions.” —TED SCHUUR, PAGE 10

In the News

COURTESY OF DUNLAP INSTITUTE FOR ASTRONOMY & ASTROPHYSICS, MEDIAFARM

The planet HR 8799c (right foreground) is visible in this illustration, along with two planets nearer their parent star and the dusty disk from which they arose.

STORY ONE

Distant planets’ atmospheres come into view

Telescopes analyze gases on worlds light-years away

By Erin Wayman

Alien worlds have become a little less alien. Astronomers have gotten the most detailed look yet at the atmosphere of a planet outside the solar system.

The study is among the first to directly analyze the chemical makeup of an exoplanet. In the past, astronomers inferred the existence of exoplanets and their gases by looking for subtle changes in the light streaming from the planet’s star. Now, with improved instruments, a team led by Quinn Konopacky of the University of Toronto has detected light coming directly from a planet about 130 light-years away.

“It’s [data] I imagined we’d have in 10 years,” says Jonathan Fortney, a planetary scientist at the University of California, Santa Cruz.

The data have enough resolution to reveal not only the presence but also the abundance of carbon monoxide and water in the planet’s atmosphere, the team reports March 14 in *Science*. Such information could shed light on how the planet formed.

“This is the start of a great new era in exoplanet studies,” says Sara Seager, an astrophysicist at MIT.

In the new study, Konopacky and colleagues focused on the planet HR 8799c. Five to 10 times as massive as Jupiter, HR 8799c sits about eight times as far from its star as Jupiter does from the sun.

Because of that great distance, the astronomers could block the star’s glow and record infrared light from the planet using the Keck II 10-meter telescope on Hawaii’s Mauna Kea. Because different gases absorb and emit light in distinct ways, the team could identify carbon monoxide and water but found no methane, which scientists had thought might be present.

In another new study, posted March 11 at arXiv.org and accepted for publication in the *Astrophysical Journal*, researchers simultaneously collected infrared light

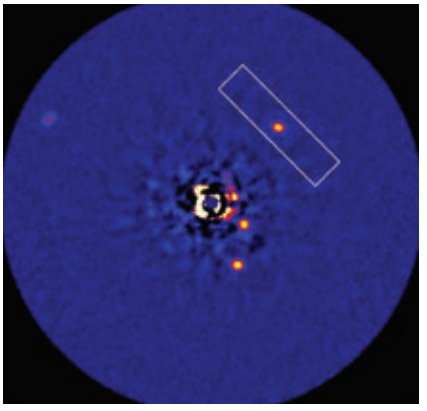
For the latest news, visit **www.sciencenews.org**

from the atmospheres of all four planets orbiting the star HR 8799 using the 200-inch Hale Telescope at Caltech's Palomar Observatory. A team led by Ben Oppenheimer, an astrophysicist at the American Museum of Natural History in New York City, found hints of ammonia, methane, carbon dioxide and acetylene in various planets' atmospheres. The chemistries of the planets diverge, Oppenheimer says. What's more, he says, "they're different from anything in our own solar system."

Although the teams looked at different wavelengths of light, which pick up different molecules, the two studies appear consistent, Oppenheimer says.

But by peering at just one planet, Konopacky's team obtained more detailed data that allowed the researchers to get a sense of how much carbon and oxygen is in HR 8799c's atmosphere.

Knowing the ratio of carbon to oxygen in the atmosphere may reveal how the planet formed, Konopacky says. Astronomers have two competing theories of how planets arise from the disk of gas and dust encircling a young star. In the gravitational instability model, some of the gas and dust suddenly clumps and collapses, simultaneously creating a planet's core and atmosphere. In this scenario, the chemical composition of a planet should match that of its star, she says.



The four known planets in the HR 8799 system appear as red or yellow dots in this infrared image from the Keck II telescope. The rectangle marks the area researchers observed in a detailed examination of the planet HR 8799c.

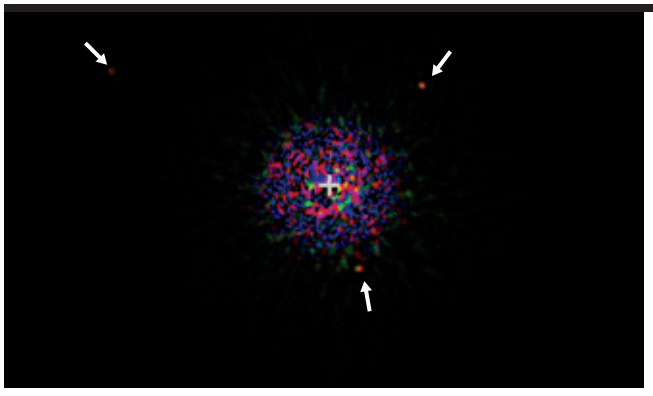
In the other model, known as core accretion, planet building is a two-step process. First, material from the disk accumulates into a core. Later, the core captures gases swirling in the disk to form an atmosphere. In this case, the carbon-to-oxygen ratio of the planet may differ from the star's because the accretion of cores may deplete the disk of certain elements, altering the chemical soup from which the atmosphere can later form.

Compared with its star, HR 8799c appears to have slightly more carbon relative to oxygen, suggesting the planet originated via core accretion. Konopacky and her colleagues surmise that when the disk around HR 8799 formed, water froze into particles of ice. The bits of ice collided to form the planet's core, leaving behind little water vapor, and therefore less oxygen, when the planet accumulated its atmosphere later on.

Other researchers are not convinced by this conclusion. "We don't really understand planetary formation enough to make a strong case," Fortney says. But the data from both new studies may help astronomers refine their simulations of planetary formation, Oppenheimer adds.

So far, astronomers have directly imaged planets around a few distant stars and researchers are poised to capture light from many more planets. For example, Oppenheimer and his colleagues are part of Project 1640, which is looking for Jupiter-sized planets around some 200 stars. Later this year, the Gemini Planet Imager, an instrument that will be mounted on a telescope in Chile, will begin a similar task, searching about 600 stars.

Telescopes will eventually image smaller, rocky worlds, says exoplanet scientist Mark Swain of the Jet Propulsion Laboratory in Pasadena, Calif. "Ultimately, with better instruments, people will be able to use these methods on Earthlike planets." ■



An early image of planets orbiting a star other than the sun, captured in 2008, depicts three of the four planets (arrows) around HR 8799. The star lies about 130 light-years away.

Back Story | DIRECT DETECTION

Exoplanets are usually seen only indirectly. They can be found by observing periodic dimming of a distant star at regular intervals (a sign of an orbiting planet's regular passage across the face of its sun) or by measuring small movements in a star caused by a planet's gravitational pull. Direct observation is much more difficult. The brightness of the planets orbiting HR 8799 made them among the first exoplanets to be imaged. Christian Marois of the Dominion Astrophysical Observatory in Victoria, British Columbia, and colleagues spotted three of the four HR 8799 planets in 2008 using the Gemini North and Keck II telescopes on Hawaii's Mauna Kea (*SN: 12/6/08, p. 5*), and came upon the fourth two years later while observing the system with the Keck II telescope (*SN Online: 12/3/10*).

BOTH: COURTESY OF C. MAROIS/NRC-HIA, W.M. KECK OBSERVATORY

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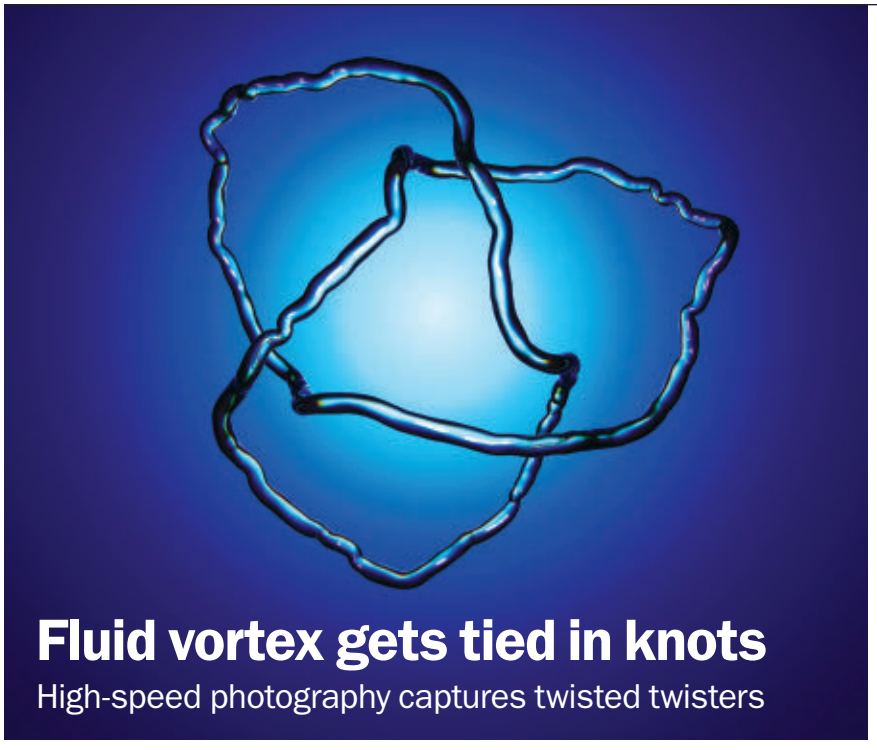

Physicists have created the first lab-made knotted vortex rings, as seen in this illustration and proposed by Lord Kelvin almost 150 years ago.

Fluid vortex gets tied in knots

High-speed photography captures twisted twisters

By Andrew Grant

Swirling rings of fluid have for the first time been tied in a knot. Physicists accomplished the feat with the help of some unlikely lab tools: a 3-D printer and YouTube videos of dolphins.

"It's a remarkable experiment," says Carlo Barenghi, a mathematician and physicist at Newcastle University in England. The creation of these knotted vortices in the lab, reported March 3 in *Nature Physics*, could help scientists understand the flow of plasma on the sun and the flow of air, blood and other fluids here on Earth, Barenghi says.

A vortex is a swirling mass of fluid, such as a tornado or a whirlpool in a cup of coffee after stirring in milk. Vortices can also bend and warp into various configurations; the most familiar example is a smoke ring, a twisted cylinder of circulating smoke particles.

In 1867, Scottish physicist Lord Kelvin went a step further and suggested that vortex rings could tie in knots. His idea didn't get much traction at first, but throughout the 20th century mathematicians and physicists offered evidence that knotted vortex loops could emerge in and affect the flow of various fluids and plasmas. In January astronomers spotted braided rings of plasma generated by the sun's magnetic field in the solar corona.

But scientists had no luck creating knotted vortices in the lab. The difficulty was twofold: The researchers had to generate the knots, which would be very small and disappear quickly, and then capture proof of their existence. Last year, University of Chicago physicists Dustin Kleckner and William Irvine set out to do both.

Kleckner and Irvine came up with the idea of a wing that drags through water. When a wing accelerates suddenly through a fluid (as a plane's wing does through air), two vortex rings form around it. The twist in the physicists' plan was to make a wing that was itself tied into a knot, which they hoped would knot up rings in its wake.

A knotted plastic wing like this one, created with a 3-D printer, allowed physicists to generate entangled vortex rings.

The difficulty was getting it built. "It's almost impossible to make an object like that in a machine shop," Irvine says. Fortunately, a colleague down the hall had a 3-D printer (*SN: 3/9/13, p. 20*) in his lab. Within a day, the printer spat out a knotted wing made of rigid plastic.

Then Kleckner and Irvine had to figure out how to detect any vortex knots their tied-up wing would generate. The scientists hit on an idea by watching a YouTube video of dolphins creating and manipulating vortex rings in a tank at an aquarium. The rings are clearly visible because the dolphins blow bubbles that get caught up in the core of the vortex. Kleckner and Irvine decided to mimic this feat by zapping the water with an electric current to produce scores of microbubbles.

The physicists finally tested their wing by coating it with bubbles and then rapidly dragging it through a tank of water. As a swarm of bubbles collected in the wing's wake, a high-speed camera shooting at 76,000 frames per second captured the movement of the bubbles in 3-D. When the researchers analyzed the shots, the results were unambiguous: The wing had generated knotted vortices. In the course of several tenths of a second, those entwined loops grew in size and then broke up into separate loops.

The next step, Kleckner says, is to study the structure and interaction of the knotted vortex loops and apply the findings to the flow of various fluids.

FROM TOP: D. KLECKNER AND W. IRVINE/UNIV. OF CHICAGO; ROBERT KOZLOFF

Life

"I'm not surprised you're finding a camel up there." —CHRISTINE JANIS

Craters may have nurtured early life

Cosmic crashes could have created hydrothermal havens

By Erin Wayman

Meteorites smacking into the early Earth could have created warm, watery environments favorable to primordial life. A new study of an impact crater in Finland suggests that such hydrothermal activity could have lasted up to 1.6 million years — as much as 100 times longer than theory suggested — providing plenty of time for life to emerge and spread.

Ancient impact craters on Mars were probably also home to hydrothermal activity, making them good places to search for signs of life, the team reports February 19 in *Geochimica et Cosmochimica Acta*.

Because modern hydrothermal systems house life's most ancient lineages, many biologists think that the first organisms arose in similar environments. Volcanic activity drives most hydrothermal systems today, such as the hot springs and geysers of Yellowstone. But when life evolved about 3.8 billion years ago, frequent pummeling of the planet was the largest source of hydrothermal activity.

Energy from such events melted rock and heated water circulating through the Earth's crust. These hydrothermal environments would have been cozy, protective habitats where life could have emerged, or at least gotten a foothold and further evolved.

"One of the big unknowns has been how long do these hydrothermal systems last," says Gordon Osinski, a planetary geologist at the University of Western Ontario in Canada. The roughly 250-kilometer-wide Sudbury crater in Canada hosted hydrothermal activity for a million years or longer after it formed about 1.85 billion years ago.

Smaller impacts, leaving behind holes 20 to 30 kilometers wide, are 10 times as common as Sudbury-sized craters. So these medium-sized impacts could have played a more important role than big ones in the origins of life, says study coauthor Martin Schmieder, a geologist at the University of Western Australia in Crawley. But theoretical calculations had indicated these craters would have cooled too quickly to sustain hydrothermal activity for more than a few tens of thousands of years — probably not long enough for life to have gotten its start.

Schmieder and coauthor Fred Jourdan of Curtin University in Perth, Australia, didn't intend to measure the cooling time of a medium-sized crater, but that's what happened when they dated Finland's 23-kilometer-wide Lappajärvi Crater. Using rocks from the crater, the pair determined that the impact occurred about 76.2 million years ago.

But grains of potassium-feldspar, which is one of the last minerals to crystallize when rock melted by an impact cools, were as much as 1.6 million years younger. The difference in age between the older rocks and the potassium-feldspar represents the period when the crater was hot enough to support a hydrothermal environment, Schmieder and Jourdan say.

Schmieder and Jourdan plan to look next at well-preserved craters in Germany or Australia, where they will also investigate properties that influence how long a crater takes to cool.

JULIUS CSOTONYI

Camel ancestors lived in Arctic

The desert's most iconic creature may be a snow lover at heart. Scientists have unearthed fossils of a giant camel (illustrated above) that roamed the Arctic more than 3 million years ago, when the region was warmer than today and blanketed by boreal forest. The discovery, reported March 5 in *Nature Communications*, suggests that modern camels descend from a cold-dwelling ancestor. A team led by paleobiologist Natalia Rybczynski of the Canadian Museum of Nature in Ottawa found roughly 30 fragments of a camel's lower leg bone on Ellesmere Island in the Canadian Arctic. Calculations indicate the beast stood 2.7 meters at its shoulders and weighed up to 900 kilograms. The researchers determined that the fragments belonged to a camel by comparing collagen proteins extracted from the bones to that of 37 modern mammal species. The dromedary camel was the best match. "I'm not surprised you're finding a camel up there," says Christine Janis, a paleobiologist at Brown University in Providence, R.I. Characteristics such as long legs for efficient walking and fat-storing humps may be adaptations to environments like the Arctic, where food occurs at distant intervals, she says. — *Erin Wayman*

Environment

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Hello warmth, bye permafrost

Expected climate change could thaw vast expanses

By Puneet Kollipara

A stalagmite's past may help reveal Earth's future. By studying Siberian cave formations as old as 500,000 years, researchers have found that even moderate climate warming in the past has set off significant thawing of permafrost.

If such extensive thawing of frozen soil occurred today, it could trigger a massive release of greenhouse gases, scientists report February 21 in *Science*. Permafrost locks in huge amounts of carbon that could be converted by melting into carbon dioxide and methane, boosting global warming.

During an era with average temperatures just 1.5 degrees Celsius warmer than they were at the beginning of the industrial era, permafrost melted in some areas that today are frozen yearround, the researchers report. This melting came with a change in temperature less than the 2 degrees that the United Nations has set as a target for averting catastrophic effects of warming.

"It's nice to look back in the past and see what's already happened on the Earth, and that gives us some confidence about our future predictions," says Ted Schuur of the University of Florida in Gainesville, who was not involved in the study.

Anton Vaks of the University of Oxford and an international team probed what happened to permafrost in warmer climates long ago by studying speleothems, ancient cave formations that include stalactites on cave ceilings and stalagmites on cave floors. These formations grow as mineral-laden water seeps into caves. In areas with permafrost, that happens only when the climate is warm enough to cause thawing, the researchers say.

Vaks and his team sampled speleothems from six caves along a path from northern Siberia south to the Gobi Desert. They dated layers going back 500,000 years by measuring the amounts of certain radioactive elements within the layers.

In nearly all of the warm periods, speleothem layers grew in areas that today have partial permafrost cover, the researchers found. During the warmest period some 400,000 years ago, the global average temperature was 1.5 degrees higher than in preindustrial times. Only during that period did speleothems grow in the cave farthest to the north.

That observation suggests that 1.5 degrees of warming was enough to thaw permafrost even in some areas that are fully covered today. And the finding implies the same could happen in the future, says George Kling of the University of Michigan in Ann Arbor.

Vladimir Romanovsky of the University of Alaska Fairbanks praises the study but warns against generalizing its findings to permafrost in other regions of the globe, noting that the method has some uncertainty. "Permafrost could be only one of the possible causes of growing or not growing of speleothems." Another possibility is that fractures in still-frozen permafrost could allow water to seep through, he says.

Another concern is that the method the researchers used might not detect partial thawing. If that had happened, water may not have reached caves, and speleothems would not have grown, Romanovsky says. But even partial thawing could change the climate, he warns, by turning previously locked-up carbon into greenhouse gases.

SMITHSONIAN TROPICAL RESEARCH INSTITUTE

Nutrients matter in tropics

Don't blame a lack of rain: A tropical forest of dry, bare-branched trees might reflect soil chock-full of phosphorus. In Panama's dry season, leafy woodlands stand next to forests of naked trees (shown). Scientists had thought that access to rainfall caused the growth patterns of different tree species. But when ecologist Richard Condit of the Smithsonian Tropical Research Institute in Panama City and his colleagues analyzed samples from 72 forest sites in Panama, they found that soil moisture levels between neighboring leafy and leafless species didn't differ much. Instead, phosphorus levels seem to drive the growth patterns, the researchers report February 25 in the *Proceedings of the National Academy of Sciences*. The leafy trees, Condit says, evolved to live in low-phosphorus soils. So the trees avoid investing phosphorus in building new leaves and instead hang onto their leaves throughout the dry season. Areas where phosphorus is abundant are dominated by trees that can afford to dump their leaves and grow new ones when the soil is wet. —*Meghan Rosen*

The Invention of the Year is Great News for your Ears

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Over the years, technology has made the way we live easier, safer and more convenient. In many cases, it's even made many products more affordable… (remember how much the first VCR used to cost?). Now, if you need some help in turning up the volume on the world around you, a new solution has been invented… it's called Perfect Choice HD™.

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Atom & Cosmos

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New home for runaway black hole

Galactic ejection may have created cosmic wanderer

By Andrew Grant

The most massive black hole ever measured may be an intergalactic hitchhiker that escaped from one galaxy before getting captured by another. If this scenario, laid out February 18 at arXiv.org, proves correct, it would be the first time astronomers have spotted a black hole that was expelled from its galactic home.

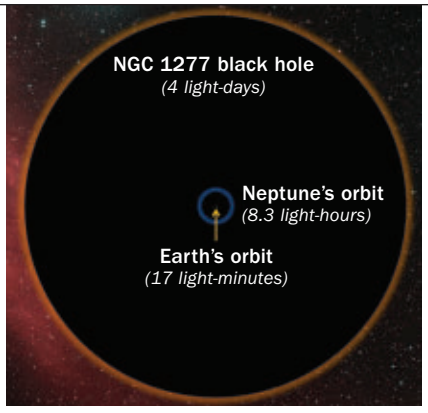
Simulations of galaxy mergers suggest that some supermassive black holes can be nomads: When the galaxies' black holes unite, they can emit an enormous surge of energy in one direction. That burst could rocket the newly formed black hole in the opposite direction.

Astronomers have scoured telescope images for signs of runaway black holes but have come up with only a few controversial possibilities. "We looked at a lot of objects and didn't find anything," says Erin Bonning, an astronomer at Quest University Canada in Squamish.

But last November, a study in *Nature* described a gargantuan black hole, 17 billion times the mass of the sun, at the center of a seemingly run-of-the-mill galaxy called NGC 1277 that is 250 million light-years away in the Perseus cluster. While a central black hole typically makes up about one-tenth of 1 percent of its host galaxy's mass, NGC 1277's black hole accounts for 14 percent of its mass. "That paper blew everyone's mind," Bonning says. "It's an extraordinary black hole in an ordinary galaxy."

Bonning and her colleague Gregory Shields of the University of Texas at Austin studied images of the Perseus cluster and calculated the gravitational interactions of astronomical objects, trying to determine whether this black hole could have been tossed from another galaxy and then snapped up by NGC 1277.

The key was finding a galaxy large enough to support a 17-billion-solar-mass black hole about 325,000 light-years away from NGC 1277. Bonning and Shields propose that this galaxy, NGC 1275, is the product of a merger of two galaxies whose black holes were each about 10 billion times the mass of the sun. When the galaxies united, energy released from the merger flung away the newly formed black hole.



The diameter of the supermassive black hole in the galaxy NGC 1277 — overlaid on the orbits of Neptune and Earth — is enormous.

Bonning and Shields suggest that the black hole spent a few billion years whizzing through intergalactic space at about 4.5 million kilometers per hour. Finally the black hole made a close pass to NGC 1277, and over hundreds of millions of years, the galaxy reeled it in to its center.

Avi Loeb, a theorist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., praises Bonning and Shields' creativity but notes that each of the steps that they describe does not occur frequently in the universe. "I would think that there are more likely ways of achieving the same result."

No vacancies around stars

Additional planets would throw off delicate balance

By Andrew Grant

Planetary systems in our galaxy are packed to the brim, according to a new study — throw in another orb and all hell will break loose. The study, posted February 28 at arXiv.org, argues that planetary systems around other stars share an evolutionary history similar to that of the solar system.

The orbits of the solar system's planets teeter near instability. Add another world, and the planets would pull each other into new, unstable orbits.

Scientists believe this local state of affairs is the result of a game of planetary pinball that occurred soon after the sun formed 4.5 billion years ago. After countless collisions, migrations and ejections, only the eight planets remained.

Astronomers Julia Fang and Jean-Luc Margot at UCLA simulated millions of faraway star systems, adjusting the spacing between planets based on the actual orbits of exoplanets discovered by NASA's Kepler space telescope.

The researchers then tacked on extra planets and ran the simulation forward in time. Around many stars, multiple worlds collided or a giant planet bumped a smaller one out of the system. Fang and Margot conclude that at least one-third of three-planet systems and 45 percent of four-planet systems are crammed.

Most of the planets that Kepler found orbit their stars closely, so the results may change when Kepler finds planets farther out. And Jack Lissauer, a space scientist at NASA Ames Research Center in Moffett Field, Calif., notes that other telescopes have found a few planets in long orbits around their stars; those systems may have room for extra worlds.

D. BENNINGFIELD, K. GEBHARDT, STARDATE

Transient ring encircles Earth

Two radiation belts temporarily became three

By Puneet Kollipara

For about four weeks in September, a third ring of energetic charged particles joined the two that float high above Earth's surface. The temporary ring may have formed in response to a solar shock wave that passed Earth, researchers report February 28 in *Science*.

The discovery could force scientists to revisit decades of ideas about the structure of the Van Allen belts, donut-shaped rings of radiation trapped in orbit by the planet's magnetic field. Those revisions could improve predictions of space weather and scientists' understanding of the space environment near Earth, resulting in better protection for manned and unmanned spacecraft that navigate those areas.

"It's a very important discovery," says Yuri Shprits of UCLA, who wasn't involved in the study. "Over half a century after the discovery of the radiation belts, this most important region of space where most of the satellites operate presents us with new puzzles."

Until the discovery, researchers thought the Van Allen belts always contained two zones of high-energy particles: an inner zone made mostly of protons and some electrons, and an outer zone dominated by electrons. A sparsely populated area separates the zones. The belts run from the top of the atmosphere, some 1,000 kilometers above Earth's surface, to as far as five or six Earth radii from the planet.

Disturbances that disrupt Earth's magnetic field can cause the outer zone to gain or lose particles. On August 30, NASA launched twin space probes to study the details of such disruptions and of the belts' composition.

Just days after the probes launched, researchers led by Daniel Baker of the University of Colorado Boulder watched a third ring grow between the two existing belts, and the outer ring expand. After a month, it disappeared, as did the outer zone, temporarily leaving only one ring. In the following months, the normal two-ring structure gradually returned.

A sun-produced shock wave that passed Earth in early September may have created the third ring, the researchers propose. Another shock wave came through in early October and may have obliterated the outer two rings.

The probes could help determine how often a third ring forms, Baker says.

Health & Illness

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Magnet ring offers heartburn relief

Device placed around esophagus prevents acid reflux

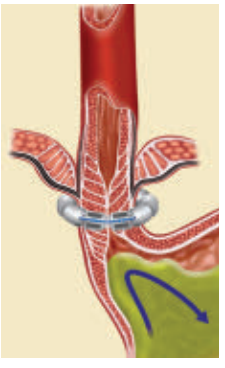
By Nathan Seppa

A small ring of magnets cinched around the bottom of the esophagus can prevent acid reflux in many people. Eighty-six of 100 patients with persistent reflux no longer needed heartburn medications one year after having the device surgically implanted, researchers report in the Feb. 21 *New England Journal of Medicine*.

"This is very encouraging," says Peter Kahrilas, a gastroenterologist at the Northwestern University School of Medicine in Chicago who wasn't part of the research. He says that for reflux disease, the magnet-laden ring is "the most promising device that has been introduced in a long time, if not ever."

Although the U.S. Food and Drug Administration approved the device for reflux in March 2012, scientists are still monitoring its long-term safety and effectiveness in patients with gastroesophageal reflux disease, or GERD. Chronic GERD can lead to esophageal scarring and a condition marked by abnormal cell growth called Barrett's esophagus, which increases the risk of an esophageal cancer called adenocarcinoma. In the United States, nearly 18,000 people each year develop some form of esophageal cancer.

Medicines to treat GERD aim to neutralize acid in the stomach or limit its production. But they don't address the anatomical problem at the core of acid reflux: a defective sphincter valve between the esophagus and the stomach that allows some of the stomach's acidic digestive juices to backflow into the esophagus.



A magnet-laden ring of titanium beads prevents acid reflux by contracting to prevent stomach contents from backing up into the esophagus.

The device is an expandable ring of titanium beads with magnetic cores that looks like a tiny bracelet. A surgeon clips it around the bottom of the esophagus. The ring of magnets pulls inward to cinch the tube closed but can expand to allow food to pass downward.

The high success rate in patients continued over three years, says study coauthor Robert Ganz, a gastroenterologist at the University of Minnesota in Minneapolis. The patients in the study who did continue to need heartburn medications decreased their doses.

But six patients experienced pain, vomiting or difficulty swallowing that led them to have the device removed. Two-thirds of the entire group reported some difficulty swallowing just after the ring was put in place, but this rate fell to 11 percent one year after surgery and 4 percent at three years.

Torax Medical of Shoreview, Minn., makes the device and markets it as LINX. Doctors at various hospitals have implanted a few hundred of the devices so far.

HIV eradicated in newborn

Only viral traces remain after prompt treatment

By Nathan Seppa

An infant born with HIV has cleared her body of the virus with the help of three medications started shortly after birth, scientists reported March 3 at the Conference on Retroviral and Opportunistic Infections in Atlanta.

On its face, the case looks like the first time an infant has ever wiped out the pathogen, as well as the first time drugs have cured a person. The virus was thwarted in the girl, now 2½ years old, with the help of more drugs than a newborn usually gets.

Virologist Deborah Persaud of Johns Hopkins University and her colleagues suggest that prompt use of triple-drug therapy knocked out HIV in the child by intercepting the virus before it could create reservoirs in the body that are unreachable by drugs.

The child's mother was unaware until giving birth that she was infected, so she hadn't taken anti-HIV drugs during pregnancy. This lack of prenatal antiretroviral care and positive tests for HIV in both mother and baby prompted Hannah Gay, a University of Mississippi pediatrician who supervised the treatment, to prescribe a therapeutic triple-drug therapy for the child as soon as possible, which turned out to be 30 hours after birth.

The baby's blood continued to test positive for HIV at days 7, 12 and 20. But on day 29 a test came back negative. The baby stayed on the regimen until she was 18 months old.

Several months later, the child was tested and found to be "functionally cured," a term signifying that doctors were unable to locate any replicating HIV in her body.

Mother-to-child HIV transmission has become uncommon in the United States, with perhaps 200 cases per year, thanks to preventive drug regimens during pregnancy and in newborns. It still occurs frequently elsewhere, with some 300,000 HIV-infected births every year.

"People are really quite intrigued by this report," says Daniel Kuritzkes, a virologist at Harvard Medical School.

TORAX MEDICAL

Genes & Cells

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Sperm fight flow to reach egg

Upstream swim gets male gametes to egg in men, mice

By Meghan Rosen

Mammalian sperm don't just go with the flow.

The little swimmers use head-on currents to guide themselves up fallopian tubes toward an egg, a new study suggests. Sex triggers fluids to spurt from the fallopian tubes, where tiny bristles called cilia sweep the fluid from the ovaries to the uterus. The moving fluid hands sperm a map to their target, researchers report in the March 18 *Current Biology*.

"I like this paper because it stirs up the field," says Susan Suarez, a reproductive biologist at Cornell University. Scientists had proposed two other ways sperm might find eggs: by sniffing out chemicals or by sensing temperature gradients.

Theories about mammalian sperm's chemical-sensing tactics first came from studying marine animals. Sea urchins squirt sperm into the ocean, where they chase down a trail of egg-secreted chemicals. But mammalian fertilization is more complicated, says Kiyoshi Miki of Boston Children's Hospital.

Female mammals have long, winding fallopian tubes, so a chemical trail there might fizzle out, Miki says. And no one has pinned down convincing sperm-luring biochemicals. Miki and David Clapham, also of Boston Children's Hospital, decided to look into the other proposed sperm navigation strategy: using temperature to find the egg.

When the scientists placed mouse or human sperm in a chamber with warm liquid on the bottom and cooler liquid on top, they noticed that the temperature gradient spurred tiny fluid currents. And the sperm cells in the dish consistently swam upstream, the researchers discovered. "It was very clever of them to notice the currents," Suarez says.

Miki and Clapham measured fluid secretion in dissected, living mouse fallopian tubes to see what currents sperm usually contend with. After animals mated, they found, fallopian tube juices got flowing.

The scientists mimicked the fluid flow in a culture dish by hooking up a tiny glass tube to a device called a micromanipulator and using it to slowly suck sperm into the tube. Then the researchers watched which way the cells moved. Nearly all the sperm swam away from the suction source.

"When we first saw this, it was very exciting," Miki says.

But the idea that sperm use currents to navigate was not exactly mainstream. Researchers reported this against-the-flow phenomenon in mammalian sperm back in 1872. Several scientists have since revisited the peculiar finding, but dismissed it as a laboratory quirk. In recent decades, however, scientists have built better tools for watching sperm move; Miki is convinced his results are real.

Miki and Clapham believe sperms' rotating tails drive their tendency to turn upstream. In culture dishes, even headless sperm — a tiny fraction of normal sperm populations — oriented against the fluid flow. But sperm that couldn't spin their tails didn't swim upstream.

"This mechanism of sperm guidance is important, no doubt about it," says biochemist Michael Eisenbach of the Weizmann Institute of Science in Rehovot, Israel. Still, he says, it may coexist with temperature- and chemical-guided strategies.

COURTESY OF CHRISTINE OESTERHELT

Alga benefits by borrowing

Life is hard in hot volcanic pools, like this one in Yellowstone National Park, laden with salt, acid, sulfur and toxic metals. But a red alga called *Galdieria sulphuraria* thrives in such environments with a little genetic help from some microbial buddies. The alga borrows at least 5 percent of its genes from bacteria and archaea that live in extreme conditions, Gerald Schönknecht of Oklahoma State University in Stillwater and his colleagues report in the March 8 *Science*. That amount of borrowing is unusual among eukaryotes, which tend to evolve new capabilities by copying old genes, with mutations gradually altering the function of redundant copies. By contrast, bacteria and archaea routinely swap genes among themselves. In its ancient past, *G. sulphuraria* snagged genes from bacteria and archaea that now help it cope with heat, salt and toxic metals, the researchers found by comparing the alga's genetic makeup with those of other species. —*Tina Hesman Saey*

Mind & Brain

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Human cells rev up mouse brains

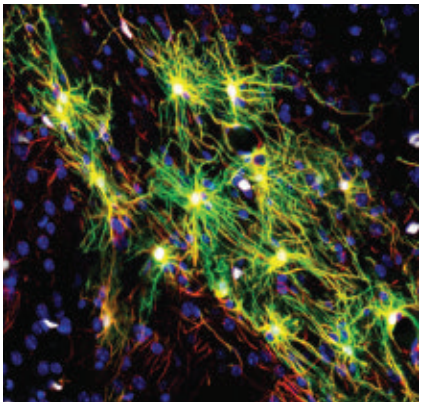
Transplanted neural support cells accelerate learning

By Tina Hesman Saey

Transplanting human brain cells into mice makes the mice smarter, a new study shows.

The smart-making brain cells are not the neurons most people think of as controlling thoughts. Instead, they are part of the supporting cast of brain cells known as glia (Greek for "glue"). The study, published March 7 in *Cell Stem Cell*, shows that glial cells, including a subset known as astrocytes, also influence memory formation. The finding could change scientists' view of how the brain works.

"It provides the first unequivocal evidence that astrocytes may well have been one of the evolutionary drivers of human capabilities," says neuroscientist Bruce Ransom of the University of Washington. "As completely outrageous as it sounds, I think the evidence is such now that we have to take that very seriously."



Mice with human astrocytes (large yellow-green cells with white nuclei) in their brains perform better on learning and memory tests than normal mice.

Researchers led by neurologist and stem cell biologist Steven Goldman and neurobiologist Maiken Nedergaard of the University of Rochester Medical Center in New York implanted into the brains of newborn mice cells called human glial progenitor cells. These are a type of stem cell poised to make several varieties of glia, including astrocytes.

Previously, the researchers had transplanted human glial progenitor cells into the brains of mice that had a genetic disorder mimicking multiple sclerosis. They noticed that the human cells had overwhelmed their mouse counterparts. The finding made the researchers wonder what effect human cells might have on otherwise normal mice.

So they tested human glial progenitor cells in normal mouse brains. By the time the mice were 6 months old, the human cells had pushed out the mouse progenitor cells and replaced many of the mouse astrocytes with human astrocytes.

In lab dish tests, human astrocytes communicated three times faster than mouse astrocytes did. And the human astrocytes helped forge stronger synapses between a mouse's neurons than the mouse's own astrocytes did.

The researchers also probed the animals' ability to learn that a certain sound portends a mild electric shock. Normal mice required several tries to pick up on the association between the sound and the shock. Mice with human astrocytes "pretty much picked up the association immediately and got more fearful," Goldman says.

The researchers can't yet rule out that undeveloped progenitor cells might also contribute. In any case, the results indicate that human cells not only aid in learning and memory, but do it better than their rodent counterparts do.

Mouse cells last longer in rat brains

Neurons relocated to longer-lived species double life span

By Meghan Rosen

Mouse neurons transplanted into rat brains lived as long as the rats did, surviving twice as long as an average mouse, researchers report February 25 in the *Proceedings of the National Academy of Sciences*.

The findings suggest that long lives might not mean deteriorating brains. "This could absolutely be true in other mammals — humans too," says study author Lorenzo Magrassi, a neurosurgeon at the University of Pavia in Italy.

One theory about aging holds that every species has a genetically determined life span and that all the cells in the body wear out and die at roughly the same time. For the neurons his team studied, Magrassi says, "We have shown that this simple idea is certainly not true."

Magrassi's team surgically transplanted neurons from embryonic mice with an average life span of 18 months into rats. The researchers waited as long as three years, until the animals were near death, to euthanize the rats and dissect their brains.

The transplanted mouse cells had linked up with the rat cells and developed into working neurons, though they did retain their characteristic small size. The mouse cells lived twice as long as they would have in a mouse brain, and they showed signs of aging similar to those of neighboring rat neurons.

Figuring out what helps the neurons survive could lead researchers to treatments for human diseases such as Parkinson's and Alzheimer's, Magrassi says.

The findings are "very promising," says Carmela Abraham, a neuroscientist at Boston University. "The question is: Can neurons live longer if we prolong our life span?" Magrassi's experiment, she says, suggests the answer is yes.

X. HAN *ET AL*./*CELL STEM CELL* 2013

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FROM Great Grandma TO You

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Epigenetic changes reach down through the generations

By Tina Hesman Saey

Like many women with parents of the *Mad Men* generation, Susan Murphy grew up in a household full of cigarette smoke. Both dad and mom smoked heavily, even while Murphy was still in her mother's womb.

"That explains a lot," Murphy quips, poking fun at herself.

But Murphy isn't worried about her own health. She's fine. Her children aren't, though. One boy died of cancer as a toddler. Another has autism. And her daughter has attention deficit disorder. Murphy knows the scientific evidence isn't in yet, but she still can't help wondering whether their fates might have been affected by her exposure to tobacco smoke before she was born.

Murphy, a researcher at Duke University, studies links between a mother's diet and chemical exposures during pregnancy with the child's later health. She and others have established that the womb is the antithesis of Las Vegas; what happens there not only doesn't stay there, it can influence a child's health for life.

Now, animal studies and a smattering of human data suggest such prenatal effects could reach farther down the family tree: The vices, virtues, inadvertent actions and accidental exposures of a pregnant mother may pose health consequences for her grandchildren and great-grandchildren, and perhaps even their offspring.

Scientists have long known that radiation or certain chemicals can cause typos in a developing fetus's genome — his or her genetic instruction book. Such mutations can get passed along to future generations in the DNA of sperm or egg cells. While exposure to sex hormones or a high-fat diet in the womb doesn't directly change or damage DNA, those sorts of exposures can induce scribblings in the genome's margins that can also be passed down.

The resulting health effects are not produced by altering DNA itself. Rather they stem from changes in chemical tags on DNA or its associated proteins, or to actions by RNA, another type of genetic molecule. All of these are exactly the types of changes that scientists have always assumed cannot be inherited. Their very name, epigenetic, literally means "over and above" or "beyond" genetics.

When these changes are inherited, scientists have found, the implications can be staggering. Part of your risk of disease may be determined by what your great-grandparents ate, not just the genes they passed on. Some researchers even believe that the long-lasting effects of these chemical marks helped shape human evolution.

Stuck for generations

Investigating how those marks travel to future generations is a new twist in the field of epigenetics. Originally, epigenetics researchers focused on the developmental processes that allow individual cells to specialize despite the fact that all the cells have the same DNA. It turned out that chemical tags that get stuck to DNA or to the proteins around which DNA is

wound can influence gene activity without altering the genes themselves.

Some of those chemical tags highlight passages in the genome, typically so that particular genes will be turned on. Other tags work more like a censor's black marker, redacting some genes so that they will be shut off. Chemically underscoring or crossing out different combinations of genes creates the various types of cells that populate the body.

Until fairly recently, scientists have thought that every new generation starts with its own freshly printed genome, devoid of epigenetic embellishments. That's because shortly after fertilization, vestiges of epigenetic tags hanging from the DNA of eggs and sperm are wiped away, leaving a clean slate. New marks are made as the embryo develops, and over the course of a lifetime some can change. But then scientists began to document cases in which inheritance of a particular trait did not follow the usual rules of genetics, hinting that at least some epigenetic marks may be carried on to new generations.

Michael Skinner was among the first to document that certain chemicals could produce health effects across multiple generations without altering DNA. Exposing a pregnant rat to chemicals that disrupt the action of sex hormones could produce fertility problems that lasted at least to her great-great-grandchildren's generation, his group reported in *Science* in 2005. Those problems were transmitted through the male line, apparently by way of chemical tags called methyl groups on DNA. (Many researchers study DNA methylation because it is more easily examined than other epigenetic tags, of which there are many.)

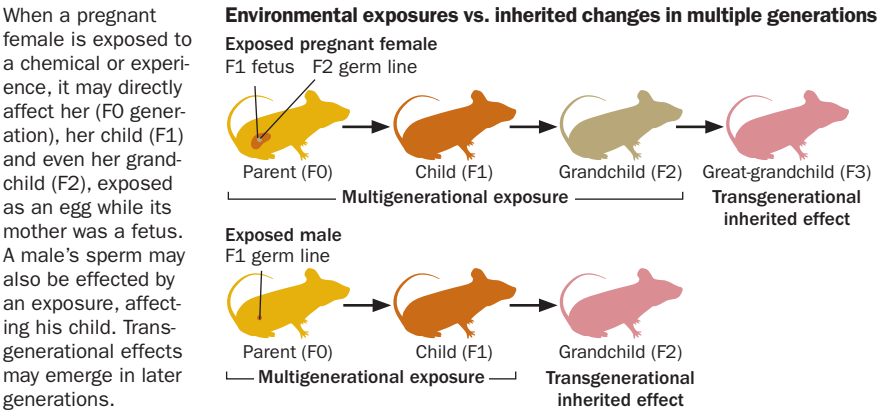
"At first everybody thought this was the greatest thing since sliced bread," recalls Skinner, of Washington State University in Pullman. "But then the implications started to sink in."

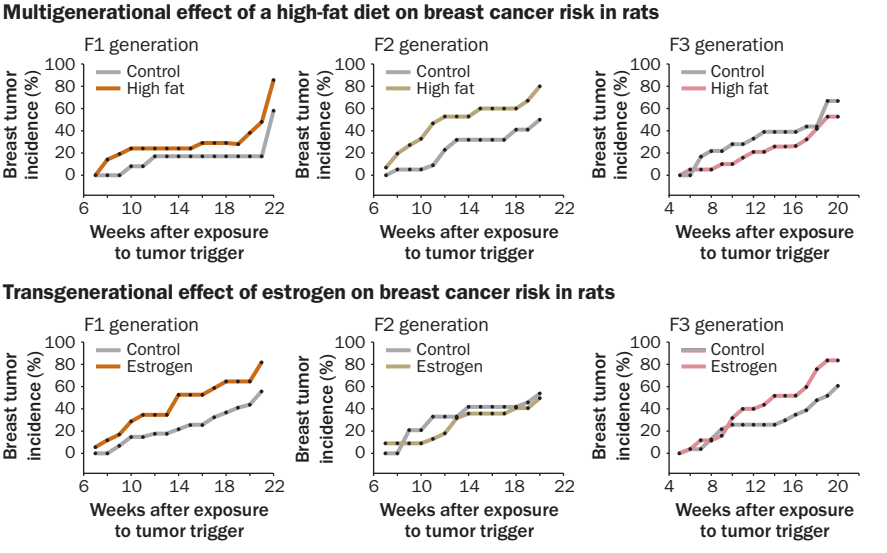
One implication is that epigenetic programming becomes permanent and gets passed along to future generations. Partly because it raises the specter of Lamarckian inheritance of acquired characteristics (think of the giraffe straining to reach high leaves and thus passing on longer necks to its offspring), the idea was not popular with many classical geneticists. To establish the idea that epigenetic marks can last generations, it was necessary to show that various chemicals and experiences could induce specific changes that had heritable health consequences.

Down the line Multiple generations may be affected by experiences during a pregnancy, either because several generations are exposed at the same time or because of a truly inherited, or transgenerational, effect. Epigenetics researchers have found both types of effects.

SOURCE, FROM TOP: M.K. SKINNER/*NATURE* 2010; S. DE ASSIS *ET AL*/*NATURE COMMUNICATIONS* 2012

When a pregnant female is exposed to a chemical or experience, it may directly affect her (F0 generation), her child (F1) and even her grandchild (F2), exposed as an egg while its mother was a fetus. A male's sperm may also be effected by an exposure, affecting his child. Transgenerational effects may emerge in later generations.





High-fat diets raised breast cancer risk in daughters (F1) and grand-daughters (F2) of pregnant rats. The elevated risk, linked to changes in DNA methylation, disappeared by the next generation (F3), indicating a multigenerational effect. Estrogen's ability to raise breast cancer risk persisted in great-granddaughters of exposed rats, indicating transgenerational inheritance.

Clues emerge

Evidence supporting that idea appeared in *Nature* in 2010. Rat fathers that ate a high-fat diet and became obese before mating passed along a propensity to become diabetic to their daughters (but not their sons), researchers in Australia reported.

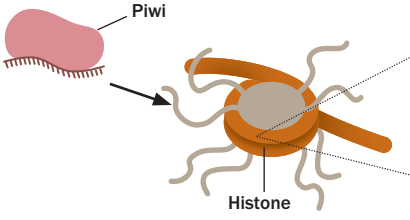
Something in the dads' high-fat diet apparently caused a change in methyl tags on DNA in the fathers' sperm that was then passed on to the daughters. It was direct evidence that diet or other environmental factors could influence epigenetic marks in sperm, escape the epigenetic reset at fertilization and affect the health of offspring.

In people, babies born to obese fathers had an altered epigenetic legacy, Murphy and her colleagues reported February 6

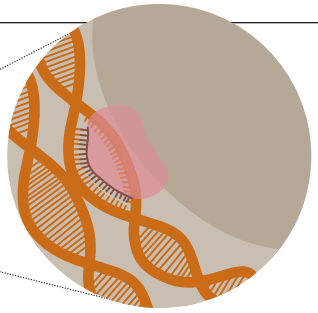
Epigenetic memory

New work points to a role for small RNA strands, called piRNAs, in directing the addition of certain epigenetic tags on the genome. While it's clear that piRNAs are important for passing epigenetic instructions from one generation to the next, many details about the process remain murky. Which piRNAs are made determines which genes are affected, but it's not clear yet how the cell decides which piRNAs to make.

1. A piRNA's sequence of chemical units specifies a location in the genome, like a mailing address on a letter.



2. A piRNA joins with the Piwi protein, and together they travel to a particular location on the DNA, which is spooled around histone proteins.



3. The piRNA-Piwi complex binds to a complementary strand of DNA.

in *BMC Medicine*. The children of 16 obese men had lower levels of methylation of the gene *IGF2* compared with the kids of normal-weight dads.

Murphy and others have shown that smoking and other prenatal encounters can coincide with changes in epigenetic tags. But she remains cautious about saying that epigenetic marks can really be inherited. Instead, the changes may result from an exposure that directly affects multiple generations. After all, a developing fetus experiences nearly the same things as its mother does. Female fetuses already have their lifetime supply of eggs, so those eggs — the pregnant mother's future grandchildren — are also directly affected by whatever mom encounters. Males don't start making sperm until puberty, but the germ cells that will give rise to sperm are present in male fetuses and may also be affected by the womb's environment.

So epigenetic changes observed in grandchildren might stem from conditions encountered by fetal germ cells. It's not until the great-grandchild generation that researchers can determine whether an epigenetic mark is truly inherited, because that is the first generation that had no contact with what the original pregnant mom encountered.

Few studies, even in animals, have followed epigenetic marks for that many generations, says Leena Hilakivi-Clarke, a breast cancer researcher at Georgetown University in Washington, D.C.

Hilakivi-Clarke's lab has studied the effects that hormones in the womb, such as estrogen and its chemical mimics, may have on breast cancer risk after menopause. Now her team is investigating breast cancer risks over multiple generations.

A legacy of cancer

Only about 10 percent of breast cancers that run in families can be linked to genetic mutations. While she was on maternity leave, Sonia de Assis, a researcher in Hilakivi-Clarke's lab, began to wonder if the other 90 percent of cases might be explained by epigenetic inheritance. She got the idea after reading one of Skinner's studies. It had shown that exposure to a fungicide could cause at least four generations of health problems in rodents.

Back in the lab, de Assis convinced Hilakivi-Clarke that they should study multiple generations of rats to see if DNA methylation patterns that had been linked to breast cancer risk could be passed to future generations. The team exposed pregnant mother rats to things that influence breast cancer risk in humans: high-fat diets or ethinyl estradiol, a synthetic estrogen used in some birth control pills.

> "I don't want to suggest that genetics and DNA is not important — it's just not the whole story."
>
> MICHAEL SKINNER

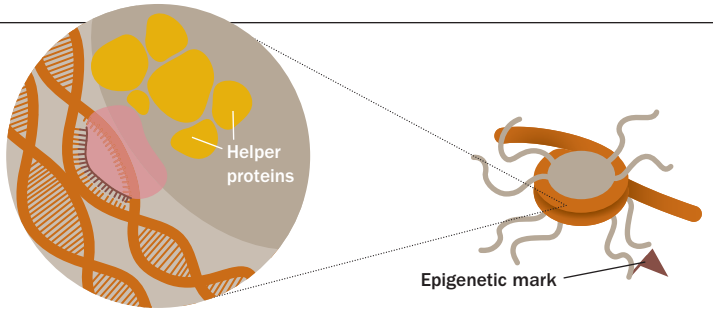
Pregnant rats on a high-fat diet had daughters and granddaughters that were more susceptible to developing mammary tumors when encountering a cancer-causing chemical later in life, the researchers reported last September in *Nature Communications*. But great-granddaughters were not at increased risk, indicating that when high-fat diets alter breast cancer susceptibility it is not a permanent, inherited change, says Hilakivi-Clarke.

Ethinyl estradiol, on the other hand, raised breast cancer susceptibility in the daughters, granddaughters and great-granddaughters of pregnant rats given the hormone in the last week of pregnancy (roughly equivalent to the last trimester in humans). In breast tissue, daughter rats exposed to the synthetic estrogen while in the womb had 214 genes with more methyl tags and 161 genes with fewer methyl tags than normal. That pattern persisted through the granddaughter on to the great-granddaughter generation, indicating that not only the risk of breast cancer but also the associated epigenetic marks could be inherited.

Estrogen isn't the only chemical that can pass its health effects down through generations. Researchers in Skinner's lab tested the effects of a variety of chemicals on ovarian health in rats. The team exposed pregnant rats to doses of chemicals people might encounter in everyday life. One was vinclozolin, the fungicide that gave de Assis the idea for her experiments. Among the others were various components of plastics, including bisphenol A; pesticides such as permethrin and the mosquito repellent DEET; dioxin; and jet fuel.

All of the chemicals studied led to an increase in ovary problems, including fewer eggs and more cysts, that lasted at least until the great-granddaughter generation, Skinner's team reported in May 2012 in *PLOS ONE*. The increase in ovarian disease was accompanied by persistent changes in DNA methylation

S. EGTS



4. The complex calls in an entourage of other proteins that actually create epigenetic marks.

5. A mark on the histone tail signals that a gene is to be shut down or turned on.

patterns in ovarian tissue.

Some of the treatments led to 100 percent of the great-granddaughters developing ovarian cysts. "There is no genetic mechanism that will give you that level of disease. None," says Skinner. "Some of our phenomena are so robust we couldn't explain it with genetics even if we wanted to."

Skinner thinks that epigenetics offers an organism a way to adjust the activity of genes rapidly in response to environmental cues. Epigenetic marks prepare future generations for the environment that they are likely to encounter, he contends. He even thinks that epigenetic changes may eventually become permanently inscribed in DNA, thus influencing the evolution of species. "I don't want to suggest that genetics and DNA is not important — it's just not the whole story," he says.

Flagged by RNA

Neither Skinner nor anyone else can yet explain exactly how epigenetic information gets passed to the next generation. But new clues are emerging from studies of worms and flies, and they point to a role for DNA's chemical cousin, RNA.

One of RNA's jobs may be to establish where and how densely epigenetic tags are placed. Geneticist Erik Miska and colleagues stumbled onto RNA's secret occupation while investigating an antiviral defense system in tiny, transparent worms called *C. elegans*. When viral genetic material infects a worm cell, an army of small bits of RNA attacks and neutralizes the threat. About 60 to 80 percent of offspring in each subsequent worm generation "remember" to shut off the viral genes or retain immunity to viruses. Miska's team traced this memory to small RNAs called piRNAs (pronounced "pie RNAs") found in germ cells.

When piRNAs trigger the shutdown of a gene, it's permanent, the researchers reported last July in *Cell*. "It is 100 percent efficient in all the offspring and it continues to act forever, which is very weird," says Miska, of the University of Cambridge in England. Forever, in this case, is at least 30 generations, as far out as his team looked.

Perhaps it should not be surprising that RNA can institute an everlasting change in gene activity. Plant geneticists have known for years that similar RNAs can permanently shut down genes, a process known as paramutation. Paramutation is the process that produces multicolored corn kernels, for instance. But it wasn't thought to take place in animals. Miska's data, and a 2012 *Nature* study showing that piRNAs can shut down genes in fruit flies, suggest that the little RNA snippets may be agents of enduring gene control in animals.

Miska's team discovered that piRNAs' takedown of certain genes is accompanied by another type of epigenetic mark, a methyl group stuck to a histone protein. Histones spool DNA so that it will fit inside cells, and also help control how active genes are. The histone mark linked to the piRNA-inactivated genes is known to dial back gene activity. In worms, that may be enough for permanent change.

Scientists are uncovering molecular details about how piRNAs put genes on lock-down. Because RNA is genetic material, it can match up to specific sequences of DNA letters. A cell may contain hundreds of thousands of piRNAs, each with a unique combination of 24 to 32 RNA units, or nucleotides, says Haifan Lin, a stem cell biologist at Yale University. The piRNA's sequence is like an address on a letter specifying where a protein called Piwi should recruit proteins that make epigenetic modifications, Lin and colleagues reported in the March 11 *Developmental Cell*. In the fruit flies Lin studies, as in worms, the modifier proteins stick methyl groups onto histones. But Lin thinks piRNAs may similarly direct DNA methylation enzymes in mammals, including humans.

Miska is impressed, and a bit troubled, that piRNAs seem to place a vise grip on genes. "This is something that is amazing, but I also find it very scary," he says.

Scary because epigenetic marks were long assumed to be malleable and respond to the environment. If the epigenetic programming gets stuck, an organism may find itself ill-adapted to the world around it. Some evidence suggests that addiction and mental illnesses may result (*SN: 5/24/08, p. 14*).

So far, Miska's team has not found a way to reverse piRNAs' grip. But the worms in his experiment are inbred. He thinks that mating with unrelated worms might help release the hold. Even in inbred worms, 20 to 40 percent of offspring can "forget" their epigenetic immunity to viruses. "There is a way out, which I find very comforting," Miska says.

If there really is a way out for the worms, it could mean that animals and people operating in a more natural environment have already discovered the escape hatch: mating with someone with different piRNAs.

No one knows how piRNAs might determine which epigenetic burdens trickle down through the generations. Even more is still unknown about what inherited epigenetic changes may mean for human health. Although lab experiments paint a rather worrisome picture, scientists emphasize that epigenetics may also cement positive changes. Even if your great-grandparents didn't have the healthiest of habits, following public health advice about exercising and eating a healthy diet may program beneficial epigenetic changes that are good for you and future generations. ■

Explore more

■ Richard Francis. *Epigenetics*. W.W. Norton & Co. 2011.

Erebus' lava lake churns beneath a cloud of gas and water vapor, yielding clues to the volcano's inner workings.

As Erebus lives and BREATHES

The Antarctica volcano's long-lived lava lake coughs up clues to the physiology of volcanoes

By Janet Raloff

MCMURDO STATION, ANTARCTICA — Even when the December sun beats down 24 hours a day, most of Antarctica remains cold, if not brutally frigid. With one dramatic exception. Wind-blown clouds of steam rise year-round from a lava lake atop Mount Erebus, the planet's southernmost active volcano.

This ice-covered cone belongs to a small chain of otherwise dormant peaks that make up Ross Island. Some 1,300 summer residents at the National Science Foundation's McMurdo research station 35 kilometers away can revel in the picture-postcard backdrop that Erebus offers. Few, however, have scaled the nearly 3,800-meter summit to peer into its churning pool of molten rock — a lake of lava roiling at roughly 1,000° Celsius.

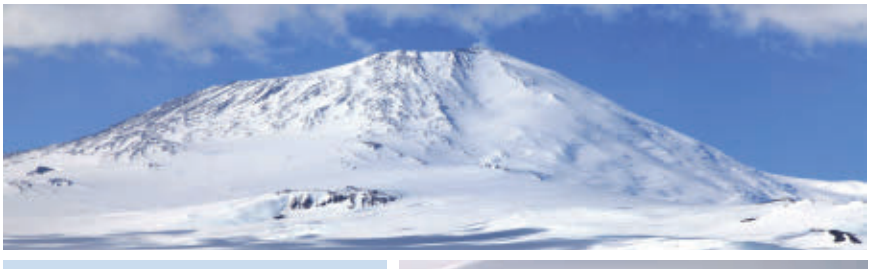
"This lava lake is a window into the volcano and its magma chamber," says volcanologist Philip Kyle of New Mexico Tech in Socorro. The magma chamber is the heart of a volcano; it controls and governs all eruptions. The lava in the lake rises up from inside a magma chamber somewhere deep below the primary crater on Erebus.

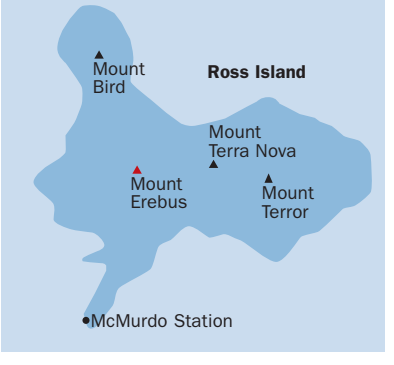
In most volcanoes, magma hides beneath a rocky cap. Only a few volcanoes, like Erebus, have lava lakes that have been open to the sky for decades, making them prime spots for the study of volcano behavior. And ironically, Kyle says, Erebus is perhaps the most accessible of such volcanoes — with the best logistical support thanks to transportation and other resources available through NSF at McMurdo. That's why Kyle — one of the most seasoned of Erebus watchers — has trekked to Antarctica annually for four decades.

Along with shifting teams of other researchers, Kyle collects the volcano's vital signs in an ongoing effort to gain clues to its inner workings — clues that might help scientists understand volcanoes elsewhere on the planet. With an ever evolving battery of physical and chemical tests, these Erebus observers have been probing the volcano's dynamic plumbing system beneath the magma chamber. Its conditions affect whether Erebus just exhales streams of carbon-rich gas or snorts out the occasional car-sized lava bomb.

To understand it all, Kyle and his colleagues focus on water vapor and other gases that bubble up through the magma.

Mountaintop lab Mount Erebus, Earth's southernmost active volcano and one of four moutains that form Ross Island, rises from Antarctica's Ross Sea. Researchers travel from McMurdo Station to a research base near the top of the volcano. From the rim they observe the lava lake below, measure its emissions and probe Erebus' plumbing system.





OPPOSITE PAGE: GEORGE STEINMETZ/CORBIS; THIS PAGE, CLOCKWISE FROM TOP: C. OPPENHEIMER; C. OPPENHEIMER; E. FELICIANO; RIDVAN EFE/SHUTTERSTOCK

Erebus' lava lake is open to the sky and easy to observe. From the rim, scientists can watch—and listen to—lava that has risen from the magma chamber.

Effectively Erebus' blood gases, these volatile chemicals rocket up from below Earth's crust. The bubbles' size and content offer valuable clues to their origin—and the volcano's stability.

Several years ago, Erebus watchers stumbled upon subtle cyclic variations in the gases emanating from the lava lake. The proportion of different gases changed in a pattern that repeated every 10 to 18 minutes. In sync with this oscillating gas chemistry, emerging data show, the lava lake's surface experiences a rhythmic 2- to 3-meter rise and fall. "In simple terms," Kyle concludes, "Erebus breathes. And it's the first time we've been able to see the breathing of a volcano. By watching this, we get a greater understanding of how all volcanoes work. That's the real bottom line."

Nelia Dunbar pokes a lava bomb freshly catapulted from the lake. Most lava bombs contain crystallized feldspar.

Listening to the inaudible

For scientists and the public alike, a big concern is whether an active volcano stands poised to begin a wholesale eruption or is merely suffering some geo-indigestion. So in 2000, Kyle invited one of his students, geophysicist Jeffrey Johnson, to set up a small network of microphones inside the rim to record the gastric churnings at Erebus.

Generated by the explosive release of gas at the lava lake's surface, the primary rumblings center around 1 hertz, below the threshold of human hearing. Their intensity depends on how big the breaking bubbles are and the pressure inside them. Now Johnson's microphones listen to the gurgling year-round, not just during that brief, relatively warm period when the summer sun shines day and night. And the infrasound ears aren't diminished by the pea-soup fog that often shrouds the lake.

As his initial data poured in, Johnson says, he was amazed at the infrasound's intensity. If audible, it would be booming at an ear-damaging 140 decibels, equivalent to gunshots or a jet engine at close range.

By knowing something about the depth and pressure at which the gas bubbles were born, Johnson began to back-calculate how big they had to be to trigger such booming infrasound. "We concluded we were recording the explosions of gas bubbles that were enormous—20 to 40 meters in diameter!" he says.

Johnson says he can still recall Phil Kyle telling him that bubbles that big didn't exist at Erebus. But a few years later, Kyle would have to apologize. A camera installed at Erebus to record nonstop video of the lake surface corroborated Johnson's calculations about the bubbles' extraordinary size.

Such megabubbles, known as slugs, probably fill the entire diameter of the conduit they ascend to reach the lake,

FROM TOP: CARSTEN PETER/NATIONAL GEOGRAPHIC STOCK; C. OPPENHEIMER

Johnson says. During some particularly active periods — as in 2005 and 2006, when Erebus was regularly flinging lava bombs up and over the crater rim — such slugs explode throughout the day for weeks or months. During the volcano's current relatively quiet phase, such gas slugs may break the lake's surface only once a week, says Johnson, now at Boise State University in Idaho.

By analyzing the bubble sizes and the gurgling rate of the lava lake, he and others are homing in on sources of the eruptive gases, how fast their bubbles rise, how much the bubbles coalesce during ascent and what the magma conduits must look like. There are still plenty of unanswered questions, Johnson says, "but infrasound is helping us better understand these systems."

Experimental detonations

Seismologists rely on a different set of ears to monitor Erebus.

Earthquakes have sometimes accompanied the volcano's more dramatic eruptive events, particularly in the late 1980s. So a year-round seismic monitoring system listens for signs of rattling on or below the volcano. Some Erebus watchers have begun using that technology to map the volcano's interior.

In 2007, Richard Aster and colleagues at New Mexico Tech "listened" to the seismic waves scattering through Erebus every time it erupted. Those eruptions tend to be mild and frequent — and generally consistent in size. "So we've got a repeating air gun–like seismic source right in the middle of this volcano," Aster says, "that's popping over and over."

Those data hinted at the location of the volcano's magma reservoir — below and to one side of the lava lake — and to other hot spots dotting the volcano's upper interior.

Daria Zandomeneghi, now a fellow at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, led a related Erebus mapping project while working with Kyle at New Mexico Tech. Her team planted explosive charges in 20-centimeter diameter ice holes at depths of 7 to 15 meters. A network of portable seismic sensors then recorded the shock waves generated by a sequence of 12 detonations.

"You might say we've been trying to CT scan Erebus by throwing 100 seismometers on top of it and then running around setting off explosions," says Kyle.

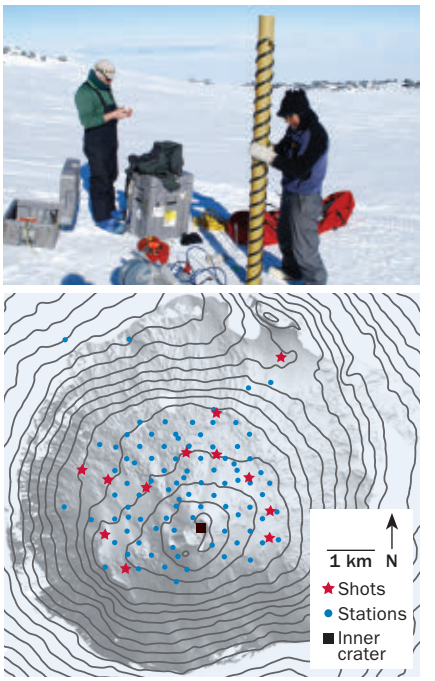
Unlike a medical CT scan, which uses X-rays, volcanic CT scanning analyzes how quickly vibrations zing through the mountain. Those passing through cool rock travel speedily; others slow as they encounter hot rock or conduits containing liquid magma. By knowing when the detonations occurred, the distance the ground-shaking waves traveled and the time it took them to reach each seismometer, the team could map regions of varying temperature. By combining that map with the seismic data from the volcano's eruptions, says Kyle, "We've been able to map the innards of Erebus."

But only roughly.

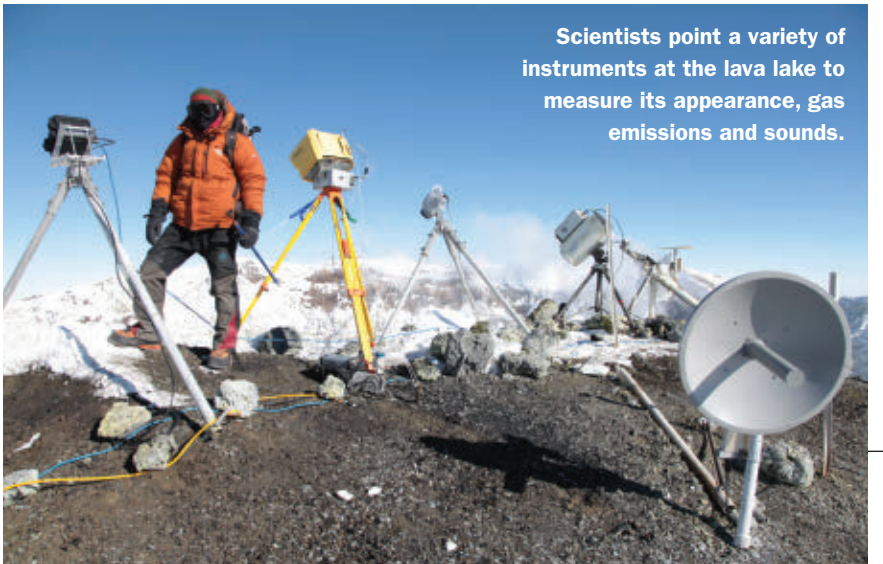
Merging the data identified just one common hot spot — probably the magma chamber — 500 meters below the surface and about 500 meters northwest of the lake, Zandomeneghi says. But the volcanic CT scans cannot establish the magma volume or identify the apparently small conduits between chamber and lake. "A feeding system obviously exists for the lava lake," she says. Her team's data indicate that it must consist of one or more narrow-diameter shafts.

The complicated structure of the system feeding the lake might explain how slight changes in the activation of feeder shafts can affect the frequency and location of eruptions, says Zandomeneghi.

The latest scanning findings will appear soon in the *Journal of Geophysical Research*.



Seismic evidence Scientists drill in order to plant an explosive charge. A topographical map shows 12 detonation sites and the locations of seismometers that record the shock waves generated by the explosions, which give clues to the density of materials within the volcano and aid in mapping its inner workings.



Scientists point a variety of instruments at the lava lake to measure its appearance, gas emissions and sounds.

An emerging portrait

Setting off explosions isn't necessary to glean clues to Erebus' source. A bit of sniffing will do, and Erebus' breath is unique. The dominant gas exhaled by most volcanoes is water vapor, Kyle notes, typically accounting for 60 to 90 percent of the total. Carbon dioxide,

TOP: JOHN WOOD (ABOVE), D. ZANDOMENEGHI *ET AL/ JOURNAL OF GEOPHYSICAL RESEARCH* (BELOW); C. OPPENHEIMER

the next biggest gas constituent, usually makes up 5 to 15 percent at volcanoes around the world. But Erebus emits a surprisingly high proportion of CO_2. Recent measurements now indicate that 90 percent of the volcano's normal gas output consists of a roughly equal mix of water vapor and CO_2, although the CO_2 varies a bit with time and how actively the volcano is erupting.

Another surprise: Carbon monoxide constitutes the third most prevalent gas in the volcano's releases. There's always a little CO in volcanic gases. But two years ago Kyle's team discovered unusually high amounts at Erebus.

All of this carbon may help explain why Erebus even exists, says geochemist Erik Hauri of the Carnegie Institution for Science in Washington, D.C. Volcanoes emerge when molten rock rises from below the Earth's crust. They tend to develop in places where tectonic plates collide or where one plate thins and fractures. But because copious carbon lowers the melting point of mantle rocks, Hauri explains, it allows regions of the deep Earth to melt when they otherwise wouldn't. "So you have these volcanoes, like Erebus, that sort of pop up in the middle of a plate," Hauri notes.

Carbon compounds are also among the least soluble gases in magma, so they will tend to bubble out. Those bubbles can enhance a magma's buoyancy.

Feldspar crystals mined from lava bombs contain clues to the composition of the volcano's magma.

The carbon-rich gases at Erebus might even help explain the volcano's puzzling low-level eruptive behavior, Hauri says. "It's kind of cooking all of the time."

That simmering is visible in the lake, where a roughly 30-meter-diameter stew of molten rock studded with crystals of the mineral feldspar churns away. The lake has been coughing out lava bombs containing these crystals for centuries. In his office at McMurdo, Kyle keeps a huge stash (above). He views them as mineral fingerprints of the maturation of the volcano's magma.

Although many magmas host microcrystals, Kyle notes, the crystals at Erebus are of phenomenal size, as long as 8.3 centimeters.

The feldspar and its glass inclusions form at different times and places during the magma's ascent. So analyzing the crystals' makeup provides further information about how the magma coursing through Erebus has been evolving.

Although magmas from many volcanoes erupt looking pretty much like a melted version of the original source rock, some magmas — like at Erebus — are more evolved. In fact, as volcanoes go, Erebus is fairly high on the geo-evolutionary ladder, observes volcanologist Clive Oppenheimer of the University of Cambridge in England.

As a volcano forms, high-pressure magma deep underground forces its way upward, making Earth's surface bulge. Eventually a stream of lava erupts out, its chemical recipe almost identical to that of the original magma. Over time, though, twists and turns can develop in the conduits channeling the magma upward. At Erebus, that process probably creates pockets that cause the magma to get temporarily hung up as it rises. During these pauses, certain gases may bubble out; others may catch up with the magma to enrich their concentration inside it. And various constituents of the magma may interact chemically during delays in its ascent.

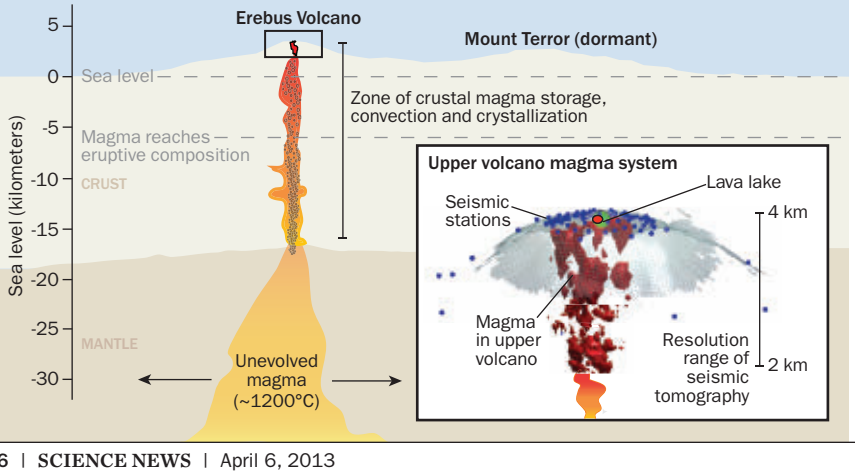
So the initial magma "may get stewed and brewed in the lower crust beneath the volcano," Oppenheimer says. By the time it erupts at Erebus, "you might have left 75 percent of the starting material behind. From that perspective, we'd call this magma quite evolved."

The type at Erebus is known as "phonolite." To understand how it morphed from a primitive liquid rock into this evolved state, Oppenheimer's team has been applying some forensic geochemistry to samples of the erupted rock and to gases bubbling from the lava lake.

The CO_2 measured by Oppenheimer and colleagues in belched gases indicates that Erebus is pumping carbon from more than 16 kilometers down, well within the mantle. Such deeply derived CO_2 will extract water from the molten rock. "This drying out is one way that magmas evolve," Oppenheimer explains.

This water extraction helps portions of the magma to crystallize, he says, trapping tiny quantities of molten

The rise of magma Molten rock begins its upward journey deep inside the mantle. As it rises through the crust it can change composition before finally reaching the upper volcano system (inset) and migrating to the magma chamber and lava lake, located 2 to 4 kilometers above sea level. SOURCE: R. ASTER AND P. KYLE/NEW MEXICO TECH, C. OPPENHEIMER/UNIV. OF CAMBRIDGE



FROM TOP: J. RALOFF; E. FELICIANO

rock, much as resin can trap insects in what will harden as amber. The crystal's trapped glassy bits amount to "fossilized bits of the magma chamber," Oppenheimer says. "We can see how much CO_2 and how much water is in those tiny inclusions and tell how deep the sample came from."

The Antarctic trade-off

There's no way to get around the weather in Antarctica. The field season at Erebus runs just the month of December, maybe a few weeks longer. Anyone who arrives much earlier or stays much later faces beastly cold and snowy conditions. And for half a year or more, there is too little light to fuel solar-powered equipment. It's frustrating, Oppenheimer notes, to realize how much energy is being radiated from the lava lake — "and we're not able to use any of it." And howling winds for months on end are brutal on unattended gear.

But there are pluses: It's easier to measure water vapor, crucial information for scientists, here than it is anywhere else in the world. "At many volcanoes water vapor represents more than 90 percent by weight of the gases expelled," notes Alain Burgisser at the University of Savoy in Bourget-du-Lac, France. But atmospheric moisture can mask the puffs of water vapor seeping from a volcano — except at Erebus, where the air is nearly bone dry.

The lava lake at Erebus also provides "remarkably fresh, clean sources" of vented gases and vapors that, at other sites, may have taken a torturous path through rock or water baths, morphing chemically or becoming diluted along the way. And Erebus' eruptions are predictably regular, another advantage for scientists. A lake at Hawaii's Kilauea volcano may be more thoroughly studied, but its varying eruption rates and intensity make understanding its ongoing activity more challenging.

Even Erebus' isolation offers benefits. Human settlements — in some cases major metropolitan areas — have developed in the foothills of many volcanoes around the world. No one would dare shake and rattle those peaks for fear of putting whole communities at risk, Kyle says. And he points out that civil unrest has postponed research at two other volcanoes with especially long-lived lava lakes — Erta Ale in Ethiopia and Mount Nyiragongo in the Democratic Republic of the Congo. At Erebus, Kyle says, scientists can work in relative safety, learning things that might translate to many other volcanoes.

Erebus is an "archetype volcano," says Oppenheimer — even if the window to its heart is easily accessible for only about a month each year. Ongoing study here is likely to increase understanding of what can be one of Earth's most powerful and unpredictable geologic events. ■

Explore more

- Mount Erebus Volcano Observatory: erebus.nmt.edu
- Global Volcanism Program: volcano.si.edu

Alive on Erebus?

Not all of the gases emanating from Erebus bubble out of its lava lake. The same magma chamber that feeds the lake also sends shafts of scalding magma up near the surface at various spots around the volcano's summit. At many sites, hot gas breaks through or melting ice can percolate down to hot rock before flashing to steam. In either case, the resulting hot gas can tunnel out room-sized enclosures beneath the ice (above). Among Antarctica's more magical — if ephemeral — environments, these warren-like ice caves may host life that dines on volcanic rock, scientists now suspect.

Any organisms would be microbial and very slow-living, says geochemist Hubert Staudigel (left) of the Scripps Institution of Oceanography in La Jolla, Calif. "When we look at volcanic glass — the stuff that forms when lava doesn't have enough time to cool and form crystals — we find micron-sized drill holes." Running up to 100 micrometers in length, he notes, these resemble holes that bacteria or fungi carve into rock at deep-sea vents and other mineral-rich sites.

To test the idea that germs ate the holes into the Erebus glass, Staudigel and his colleagues put out several polished mineral samples as bait, beginning four years ago. Preliminary data collected from some of the bait samples two years ago turned up signs of unidentified microbes, he says. While promising, that didn't prove the germs had come to dine.

This past December Staudigel's group retrieved additional bait samples. In coming months they will begin probing for signs that microbes have begun lunching on them. *—Janet Raloff*

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SSP president Elizabeth Marincola (right) with 2013 Intel STS winners (left to right) Adam Joseph Bowman, Jonah Kallenbach and Sara Volz.

Students honored for research

WASHINGTON — Sara Volz gasped in amazement when she heard her name called. The 17-year-old finalist had just been named the $100,000 grand-prize winner at the March 12 awards gala of the 2013 Intel Science Talent Search.

A high school student from Colorado Springs, Colo., Volz rushed across a stage in the National Building Museum's Great Hall. Decked out in a lavender satin dress, the teenager laughed and smiled as blue and white balloons rained down on the winners.

Volz's project, an experiment to pump up algal oil levels for use in biofuel, began in her bedroom. The teenager grew algae in 40 glass flasks underneath her loft bed, and used an herbicide to kill cells that dribbled out only tiny amounts of oil. Over multiple generations of algal growth, the protocol resulted in cells with naturally elevated levels of oil production.

Volz tended her algae garden almost every day, checking it regularly for evaporation and keeping it on strict light-dark cycles. "It's basically like having a pet," she joked. This fall, Volz plans to head to college at MIT.

Her winning research topped the projects of 39 other Intel STS finalists (*SN: 2/9/13, p. 14*). In total, the competition received 1,712 entries from 42 states, the District of Columbia, Guam and two U.S. schools overseas.

"SSP and Intel could not be prouder of the Intel Science Talent Search finalists of 2013," said Elizabeth Marincola, president of Society for Science & the Public and publisher of *Science News*.

At the ceremony, the Intel Foundation awarded a total of $630,000 to the 40 finalists of the Intel STS, a program of SSP first established in 1942. Intel began sponsoring the competition in 1998.

The Intel Foundation awarded second place and $75,000 to Jonah Kallenbach from Ambler, Pa. The 17-year-old figured out a way to better predict how different drugs latch onto proteins. His work could give researchers a new method for designing drugs that target specific molecules.

Third place and $50,000 went to Adam Joseph Bowman, 17, of Brentwood, Tenn., who constructed a plasma gun in his garage from parts he bought on eBay. He also designed an inexpensive fiber optics system to follow the plasma's movement. "I've always enjoyed building things," he said. Bowman has been refining his plasma gun since he was 14. — *Meghan Rosen*

Top 10 Winners

The 40 finalists in this year's Intel Science Talent Search received a total of $630,000 in awards for their research. The top 10 received $20,000 or more.

- **1st place** Sara Volz (pictured below), 17, Colorado Springs, Colo. $100,000 for research in algae-based biofuels.
- **2nd place** Jonah Kallenbach, 17, Ambler, Pa. $75,000 for work in drug-protein binding.
- **3rd place** Adam Joseph Bowman, 17, Brentwood, Tenn. $50,000 for designing and building an inexpensive, low-energy pulsed plasma device.
- **4th place** Hannah Kerner Larson, 18, Eugene, Ore. $40,000 for research on mathematical structures important in theoretical physics and computer science.
- **5th place** Peter Kraft, 17, of Munster, Ind. $30,000 for synthesis of 10 molecules known as coordination polymers, which could be useful in gas purification and hydrogen fuel storage.
- **6th place** Kensen Shi, 17, of College Station, Texas. $25,000 for an algorithm that helps robots navigate around obstacles.
- **7th place** Samuel Zbarsky, 17, of Rockville, Md. $25,000 for mathematical research that could improve the efficiency of computer networks.
- **8th place** Brittany Wenger, 18, of Sarasota, Fla. $20,000 for a computer program that analyzes breast biopsy samples.
- **9th place** Akshay Padmanabha, 16, of Collierville, Tenn. $20,000 for a method of detecting epileptic seizures.
- **10th place** Sahana Vasudevan, 16, of Palo Alto, Calif. $20,000 for a mathematics project that could lead to faster computer algorithms.

BOTH: CHRIS AYERS PHOTOGRAPHY/SSP

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The Kingdom of Rarities

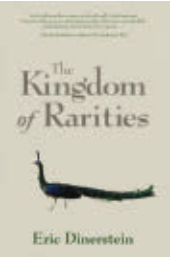
Eric Dinerstein

Armchair naturalists will delight in following Dinerstein as he treks the globe to find uncommon species and figure out why they are rare. Through field investigations and other research, this conservation biologist with the World Wildlife Fund comes to a rather startling conclusion: The majority of Earth's nonmicroscopic species are rare — and probably always have been.

Unlike the dandelions and starlings of the world, he points out, most species consist of small numbers of individuals or are found only in a few tiny bits of real estate. People often take the blame for making species rarer, and Dinerstein by no means exonerates humans. Thanks to overhunting and a general despoiling of the environment, many once-common species are at risk of vanishing. One prime example: the lowland rhinos of Nepal that Dinerstein studied for five years.

But many species are uncommon even in the absence of humans, as Dinerstein finds when he explores remote regions such as the upper Foja Mountains in New Guinea. In fact, he says, large numbers of rare plant and animal species have evolved all over the world to take advantage of highly specialized ecological niches.

Dinerstein's take-home message is that rare species have historically lived together in fairly stable harmony. Since people rely on the goods and services that wildlife provide, Dinerstein argues that it's time to take a lesson from Bhutan. The small Himalayan kingdom protects more of its land and native species than any other nation. What people elsewhere — especially in industrialized Western societies — should aspire to, he says, is Bhutan's compassion for the countless rare species with which we share our planet. — *Janet Raloff*



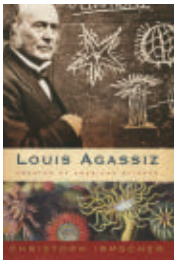
Island Press, 2013, 295 p., $29.95

Louis Agassiz: Creator of American Science

Christoph Irmscher

Swiss-born Louis Agassiz was the most famous naturalist in America in the mid-19th century. When he died in 1873, people across the United States mourned the loss of their favorite scientist.

Today, Agassiz is largely forgotten outside academia. After reading his biography, it's not hard to understand why people may have wanted to forget him. Agassiz was something of a scoundrel — an arrogant idea stealer who left his family when he immigrated to North America. He also rejected Darwin's theory of natural selection, instead believing in the fixity of species created by God.



Yet Agassiz had his saving graces and deserves to be remembered, argues Irmscher, an English professor. Agassiz spent much of his career as a Harvard professor studying marine fossils. He encouraged people to send him specimens, igniting a national interest in natural history. While studying the Swiss Alps, Agassiz determined that glaciers had been more extensive in the past. His theory of ice ages was not entirely his own, though; many of his collaborators felt he took credit for their ideas.

Agassiz's side in these scuffles seems lost to history. He rarely wrote of his innermost thoughts, so Irmscher is left telling Agassiz's story mostly through disgruntled colleagues. For balance, the author quotes Agassiz's close friends, who portray him as a charismatic man who strongly believed in the importance of science to society.

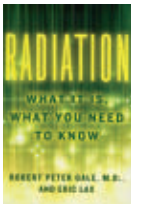
In the end, it's Agassiz's mix of good and bad, right and wrong, that makes his life an interesting read. — *Erin Wayman*

Houghton Mifflin Harcourt, 2013, 434 p., $35

Alien Life Imagined

Mark Brake

See how humans' fascination with the possibility of extraterrestrial life has evolved over the centuries. *Cambridge Univ., 2013, 276 p., $45*



Radiation

Robert Peter Gale and Eric Lax

A medical doctor and a writer team up to dispel misconceptions about radioactivity and explain the risks of everyday exposures. *Knopf, 2013, 270 p., $26.95*

Friendfluence

Carlin Flora

Citing studies on evolution and psychology, this exploration of the nature of friendship shows the importance of making and keeping friends. *Doubleday, 2013, 288 p., $25.95*

Antarctica

Gabrielle Walker

A science writer takes readers on a journey to the bottom of the Earth through first-hand accounts of her travels with scientists. *Houghton Mifflin Harcourt, 2013, 388 p., $27*

The Enlightenment Vision

Stuart Jordan

A physicist reviews the Enlightenment of the 17th and 18th centuries — considered the "rise of reason" — and the progression of scientific knowledge since. *Prometheus, 2013, 295 p., $26*

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Get a grip

The article "Pruney fingers get better grip" (*SN: 2/9/13, p. 11*) indicated that skin wrinkling in response to extended exposure to water was the result of constricting blood vessels. I was waiting to read about the possibility that this was the body's response to prevent heat loss. Water has a high heat capacity, and therefore I might expect that blood vessel constriction is to minimize heat transfer from the body to the water. Perhaps the wrinkling is a secondary, albeit advantageous, effect.
Jim Marrone, Pinole, Calif.

Cat controversy

As a conservation biologist, I am wary of claims extrapolated from a survey of previous studies ("Cats claim billions of bird and small mammal victims annually," *SN: 2/23/13, p. 14*) — studies which themselves are often incomplete and/or estimate data because gathering accurate numbers in the field is difficult. If the best that the *Nature Communications* paper can report is that North American feral cats kill between 952 million and 3.1 billion birds per year, somebody needs to get back in the field.
Alice Cascorbi, Portland, Ore.

My opinion: Feral cats, or domestic cats that are allowed to roam outside, are introduced vermin just as are Burmese pythons in the Everglades or brown tree snakes on island bird sanctuaries, and should be eliminated in the same way. (No doubt this will provoke plenty of posturing, irrational outrage from toxoplasmotic "cat lovers.")
Steve Palmer, online comment

I cannot help but wonder how the estimated deaths of birds caused by domestic cats compared with the death of birds through human development — high-rise cities, neat tidy suburbs, paving, deforestation and agriculture.
Evelyn Haskins, online comment

Squeeze on cancer

Regarding "Pressure keeps cancer in check" (*SN: 1/26/13, p. 8*), how do you put pressure on a single cell? And does the researcher believe the pressure from exercise may have the same effect?
Joe Lucier, via e-mail

The researchers built a special apparatus to supply short pulses of pressure to cells from all sides at once. They used many cells, not just one — important because the pressure caused the cells to cozy up to each other and reestablish communications. Exercise or massage doesn't apply the same type of pressure and probably won't do the same thing. Once scientists identify the molecular events turned on by pressure, they may be able to trigger those events chemically, such as with a chemotherapy drug. — Tina Hesman Saey

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The Science Life

For more of The Science Life, visit People at **www.sciencenews.org/people**

Geneticist Joseph Pickrell posted his DNA sequence and some identifying tags, shown here, to a blog about personal genetic data.

A genetic exhibitionist

Harvard geneticist Joseph Pickrell is part of a new generation of scientists talking about their data not just over the lab bench, but in conversations online. Pickrell uses the Internet to open himself, his research and his thoughts about others' work to public scrutiny.

Pickrell (below) analyzes genetic data from people living today to reconstruct ancient evolutionary relationships. But he wouldn't expect his research subjects to make their genetic secrets public if he wasn't willing to do so himself. "I feel pretty strongly that genetic data isn't scary," he says.

To prove it, Pickrell and other scientists have posted their personal genetic data on Genomes Unzipped, a blog commenting on the personal genomics industry. Most of the information comes from companies, such as 23andMe and Lumigenix, that analyze people's DNA for a fee.

Pickrell learned from his data that he carries a genetic variant that doubles his risk of Alzheimer's disease. "It's not great news," he says, but "it's better to know than to not know."

Another blogger uncovered Ashkenazi Jewish ancestry in Pickrell's genetic background. It turns out that one of Pickrell's great-grandparents was a Jew who immigrated to the United States from Poland in the early 1900s. Pickrell learned that the family had swept that under the rug for fear of discrimination.

It's not just his DNA that Pickrell shares with the world. He has posted drafts of some of his research papers on preprint servers such as arXiv.org and advocates the use of such online forums so that other scientists can point out weaknesses before a study is published. On the blog Haldane's Sieve, Pickrell comments on papers that he finds at arXiv.org. His blogs and tweets are extensions of the sorts of conversations scientists have at conferences, he says. "It's the fun part of what we do."

Pickrell does not have his own laboratory — he's now a postdoctoral researcher in David Reich's lab at Harvard — but he has already built a following among more experienced scientists. Even on the outrageous Internet, Pickrell says, "you get taken seriously if you say serious things." — *Tina Hesman Saey*

Tracing the dog family tree

Geneticist Joseph Pickrell uses DNA to decipher how groups of organisms are related evolutionarily. His work has delved into the family trees of humans and, recently, dogs. Pickrell and his colleague Jonathan Pritchard of the University of Chicago discovered that an ancient African breed called the basenji (above) got about 25 percent of its genes from gray wolves. In comparison, wolves contribute about 9 percent to boxers' ancestry. Chinese shar-peis, in turn, trace about 9 percent of their genetic makeup to boxers. His work illustrates that pure breeds aren't so "pure," with considerable mixing between breeds after domestication.

CLOCKWISE FROM TOP: STEPHEN EGTS, DATA FROM 23ANDME; HIKUTA/ISTOCKPHOTO; COURTESY OF J. PICKRELL

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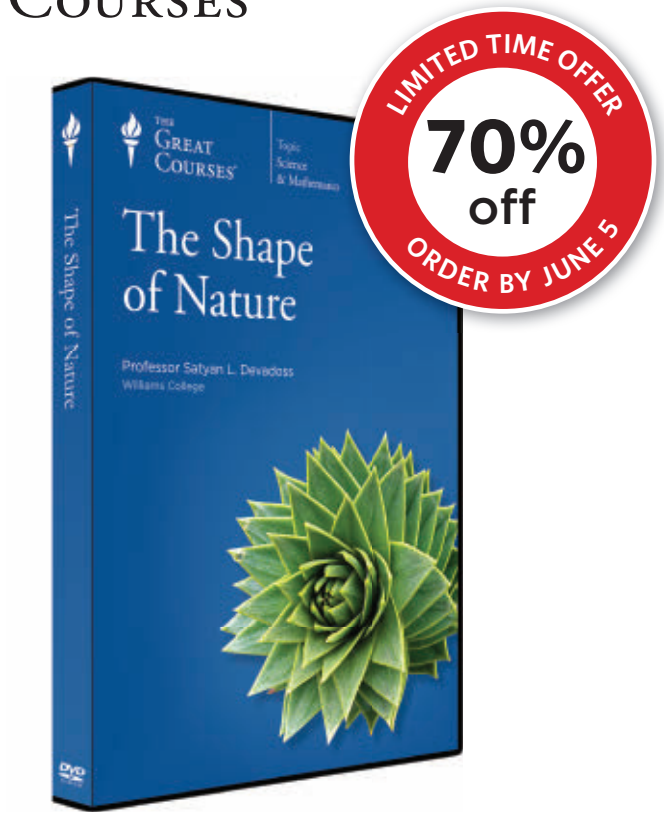

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Perfection from the laboratory. We won't bore you with the details of the ingenious process, but it involves the use of rare minerals heated to an incredibly high temperature of nearly 5000˚F. This can only be accomplished inside some very expensive equipment. After cutting and polishing, scientists finally created a faultless marvel that's optically brighter and clearer, with more flashes of color. According to the book *Jewelry and Gems–the Buying Guide* the technique used in Diamond*Aura* offers, *"The best diamond simulation to date, and even some jewelers have mistaken these stones for mined diamonds."*

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	Mined Flawless Diamond	Diamond*Aura* Compares to:
Hardness	Cuts Glass	**Cuts Glass**
Cut (58 facets)	Brilliant	**Brilliant**
Color	"D" Colorless	**Colorless**
Clarity	"IF" Clear	**Clear**
Dispersion/Fire	0.044	**0.066**
4 ctw pendant	$96,000+	**$129**

The 4 Cs. Our gemologists have broken the code to create an impeccable beauty with even more fire than mined diamonds. Diamond*Aura* are hard enough to cut glass and are so clear and white that they rival a "D Flawless" diamond in terms of color and clarity. Our Diamond*Aura* jewelry retains every important specification: color, clarity, cut, and carat weight. In purely scientific measurement terms, ***the fire is actually superior to that of a diamond***. Fire is the dispersion of white light into a rainbow of color. A team of cutters and polishers artistically execute each of the symmetrically brilliant cuts to maximize light reflection and refraction.

Buying naturally mined diamonds can be a dangerous journey. Prices are high and often fixed, quality is subjective and the origins of the stones may be in doubt. Do you really want to worry about that? Or do you just want a look that is spectacular?

The *Omni Pendant* is for that love of a lifetime. If you're looking for the most fire, carat weight, brilliance and clarity for a magnificent price, the 4-carat, 5-stone Diamond*Aura Omni Pendant* is set in fine .925 sterling silver finished in luxurious gold. Today it can be yours for only $129.00! And to make the magic even more tempting, we'll include the 18" gold-finished, sterling silver chain ($59 value) as well as the 1 ctw Diamond*Aura* gold-finished, sterling silver stud earrings ($99 value) ABSOLUTELY FREE!

4 ctw of scintillating Diamond*Aura* enlarged to show details.

Receive these 1 ctw $99 Diamond*Aura* stud earrings finished in luxurious gold ABSOLUTELY FREE!

Read details below.

Your satisfaction is 100% guaranteed. Take a closer look at the *Omni Pendant* and experience the sparkle for yourself. If you don't fall in love, just send it back within 30 days for a complete refund of your purchase price.

Exclusive—Not Available in Stores

Diamond*Aura*® Omni Pendant (4 ctw) **$129** + S&P

Includes Diamond*Aura*® stud earrings and gold-finished chain – a total value of $287 – with pendant purchase!

Call now to take advantage of this fantastic offer.

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