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# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ SEPTEMBER 24, 2011

Beer's Patagonian Roots

Mate's Early Stress Kills

Ice Man's Last Meal

## Background check

Cancer treatment gets personal with genetics

# Greek God Invents FREE Love

*Inspired by a mythological romance, this stunning 170-carat amethyst bead necklace is yours for the taking!*

She was Amethyst, a maiden devoted to virtue. He was Dionysus, the notorious Greek god of intoxication and revelry. He loved her, but she wanted to wait for someone more suitable. He was a god, used to getting what he wanted. The chase was on. But once Diana saw that Amethyst was serious about keeping her heart pure, the goddess transformed her into a statue of perfect stone. Dionysus stopped partying for a moment and wept. He spilled his wine and infused the statue with the rich violet color we now know as amethyst.

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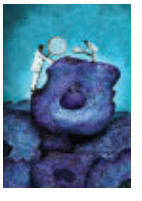

**COVER** By studying the genetic profiles of individual patients' tumors, scientists may be able to better direct cancer treatment.
*Michael Morgenstern*

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FROM THE EDITOR

# When wishing upon a star, be careful what you wish

When astronomers wish upon a star, their dream seldom comes true. That's because they always wish a nearby star would explode, and that rarely happens.

Last month, though, a star in the not-so-far-away galaxy M101 gave some astronomers their wish, as it brightened from a tiny speck in the cosmos into a brilliant cosmic lightbulb. Supernova PTF 11kly was spotted August 24, perhaps only 12 hours after the initiation of the explosion, as Nadia Drake reports in this issue (Page 5).

That's by Earth-based clocks, of course. From an intergalactic perspective, the explosion occurred 21 million years ago; it took light that long to reach Earth from M101 (aka the Pinwheel Galaxy), 21 million light-years away. For supernovas, that's actually pretty darn close — in recent decades only one other supernova, in the Large Magellanic Cloud (a satellite galaxy to the Milky Way), has blown up closer.

Astronomers are even more excited about this new one, though, because its progenitor star was a white dwarf. When white dwarfs explode (a category of supernova designated as type 1a), their brightness (along with the timing of their brightening and subsequent dimming) provides excellent clues to their distances. Consequently they make good cosmic yardsticks (excuse me, parsec sticks) to help scientists gauge the dimensions of the heavens. Studying type 1a supernovas has provided compelling evidence that the universe is expanding at an ever faster rate.

PTF 11kly's proximity does not necessarily make the case for cosmic acceleration any stronger. That conclusion rests on viewing supernovas at much greater distances. But by being so nearby, PTF 11kly offers astronomers a superior specimen for detailed study, a chance to understand the inner workings of type 1a's much more precisely.

It may be that the ensuing improved understanding will confirm evidence from earlier supernovas and bolster astronomers' current beliefs about the universe's behavior. On the other hand, up-close-and-personal scrutiny of this supernova may reveal oddities that someday invalidate the faith astronomers have placed in type 1a parsec sticks. If so, the standard picture of modern cosmology may crack into a more complicated puzzle. Which only goes to show that astronomers, like everybody else, should be careful what they wish for.

*—Tom Siegfried, Editor in Chief*



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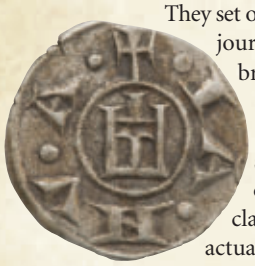

They set out on a legendary journey. They brought back a historic artifact, one of two to survive to this day that lays claim to being the actual Holy Grail.

What the Crusaders found is a stunning glass goblet.

It resides today in the main cathedral in the powerful Italian city-state of Genoa.

The Crusaders acquired what is arguably the most coveted object in history not by means of a bloody battle or political intrigue.

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The same 900-year-old fine silver coins used to pay the Crusaders.

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We don't know where, precisely, the glass goblet in Genoa was found. Nor how much ransom was paid in Silver Crusader coins. We do know that in the 1100s, these fine silver coins were struck in Genoa.

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## Say What?

**gyrochronology** *jai-roh-kron-AH-lo-gee*\ *n.* The measurement of a star's age by clocking its spin rate. Usually researchers can date stars only by looking at them in a cluster and finding ones that have reached a distinctive point in their evolution. But most stars also spin more slowly as they age, like a top spinning on a table, Søren Meibom of the Harvard-Smithsonian Center for Astrophysics reported May 23 at the American Astronomical Society meeting in Boston. The finding could help astronomers estimate the ages of solo stars—which are thought to be more likely to host planets (as illustrated above)—using the stars' color and rotation rate. —*Camille M. Carlisle*

## Science Past | FROM THE ISSUE OF SEPTEMBER 23, 1961

ALGAE COULD PROVIDE OXYGEN FOR SPACEMAN — Minute plant life that form the common green scum found on the surface of stagnant ponds and in river beds, *Chlorella*


algae, assisted by the sun, may provide the future man in space with the oxygen essential to maintain life. A new gas exchange device operating on the principle of photosynthesis was designed and demonstrated by Lt. Col. John B. Fulton of the U.S. Air Force Arctic Aeromedical Laboratory, Fairbanks, Alaska. The algae using the energy of the sun convert the carbon dioxide exhaled by the astronaut into oxygen which is breathed in and exhaled again as carbon dioxide, the process being repeated indefinitely.

## How Bizarre

Single prairie voles are more likely than partnered voles to succumb to drug addiction. Social bonds are thought to protect against addiction in people, too, but how that works physiologically has been a mystery. Now researchers led by Zuoxin Wang of Florida State University in Tallahassee report that male voles in a monogamous relationship eschew amphetamine, while single males find it strongly rewarding. In both groups, amphetamine causes nerve cells to release the feel-good messenger dopamine. But in partnered voles, other nerve cells don't scoop up this dopamine as well, the team notes in the June 1 *Journal of Neuroscience*. —*Laura Sanders*

## Science Future

**October 1**
Afraid of the dark? The Boston Museum of Science's "In the Dark" exhibit shows the wonders of caves, the deep ocean and more. Visit www.mos.org

**October 9–15**
Earth Science Week explores "Our Ever-Changing Earth" with events and activities around the world. Learn what's near you at www.earthsciweek.org

**October 14–21**
The Imagine Science Film Festival in New York City brings science to the big screen. Visit imaginesciencefilms.com for detailed listings.

## SN Online

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**ATOM & COSMOS**
Japan's Hayabusa spacecraft has returned to Earth with the first-ever scrapings taken from an asteroid. Find out what the specks of dust reveal in "Asteroid sample nails meteorite source."

**LIFE**
A young elephant shows off its ability to have an "aha" moment by finding a way to reach fruit just out of reach. Learn more and see a video of the problem solver in action in "Young elephant struck by idea."

**HUMANS**
Human ancestors may have picked up genes that impart an immune system boost by canoodling with Neandertals and other hominid cousins long ago. Read more in "Beneficial liaisons."

## Science Stats | SHUTTLE ROUNDUP

The space shuttles flew 135 missions starting with *Columbia* in April 1981 and ending with *Atlantis* on July 21.

Total miles traveled:
**542,398,878**
Equal to 21,156 orbits around Earth

Total time in space:
**1,332 days, 20 hours, 1 minute, 34 seconds**

Total number of individuals flown:
**355**

SOURCE: NASA

CLOCKWISE FROM TOP LEFT: DAVID A. AGUILAR/HARVARD-SMITHSONIAN CFA; ISAS, JAXA; GRAPHIC: MAUREEN ARNSON; BRUCE S. CUSHING/VISUALS UNLIMITED

“The amazing thing for me is, that supernova exploded 21 million years ago.... And we just happened to open up the telescope on that Wednesday night, and in came the photons.” —MARK SULLIVAN

# In the News



STORY ONE

## Astronomers celebrate as star goes boom in neighborhood

### Supernova bursts into view in nearby Pinwheel Galaxy

**By Nadia Drake**

Many people appreciate a good light show, but probably not as much as the astronomers who recently spied a rare cosmological treat.

On August 24 at 03:59 Universal time, telescopes at the Palomar Observatory in southern California captured a white dwarf star just 21 million light-years away—the next state over, astronomically—as it went supernova, exploding in a blaze of light. Scientists involved in the Palomar Transient Factory sky survey raced to record the dwarf’s early death throes.

“We think we found it probably 12 hours after it exploded,” says astronomer Mark Sullivan of the University of Oxford in England. “The amazing thing for me is, that supernova exploded 21 million years ago. It’s taken light 21 million years to arrive. And we just happened to open up the telescope on that Wednesday night, and in came the photons.”

Located in the Pinwheel Galaxy (officially labeled M101), the new supernova is the type that astronomers designate as 1a. Seeing a type 1a supernova so soon after birth and so close by is a rarity.

NASA, ESA

**The Pinwheel Galaxy (technical name, M101) is one of the most picturesque in the cosmos and now also one of the most popular among astronomers, who raced to observe the brightening of a supernova that appeared there on August 24.**

“Saying it’s ‘once in a generation’ is very true,” says astronomer Peter Nugent of Lawrence Berkeley National Laboratory. In the last four decades, Nugent notes, astronomers know of only three supernovas that have gone off at this distance or closer—and just one, observed in 1972, was a type 1a. Only supernova 1987a, a peculiar type 2, or core-collapse, supernova was detected as soon after exploding.

“It’s like watching popcorn pop—you don’t know which kernel will go next,” says astrophysicist Adam Riess of Johns Hopkins University in Baltimore.

On August 27, the Hubble Space Telescope swiveled to stare at the new stellar outburst, nestled near a kink in the Big Dipper’s handle. The brightening supernova, called PTF 11kly, was expected to reach peak luminosity during the second week of September, when even a good pair of binoculars could reveal the object to the casual observer on a dark night.

Type 1a supernovas occur after a white dwarf star gains weight, probably from eating material shed by a companion star. When the tiny, Earth-sized white dwarf exceeds about 1.4 times the mass

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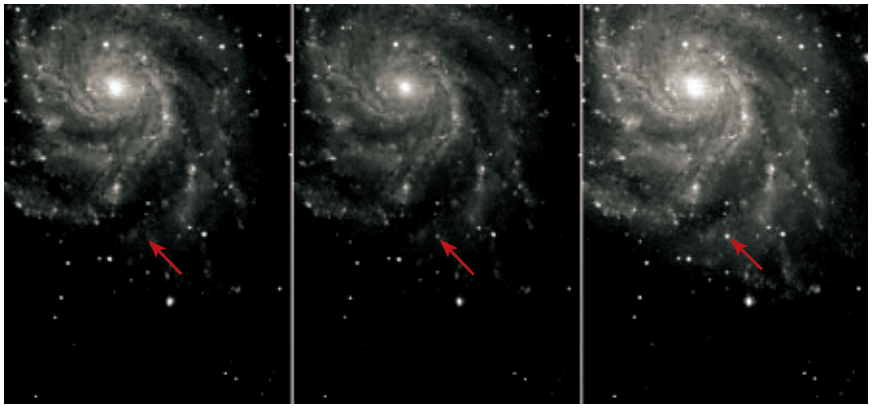


**Astronomers detected supernova PTF 11kly (location marked by arrow) growing brighter (above, from left, on August 23, 24 and 25 Universal time), in the Pinwheel Galaxy. Caused by thermonuclear reactions inside white dwarfs, type 1a supernovas are used by scientists to measure the expanding universe.**

of the sun, a runaway thermonuclear reaction ignites and the star violently combusts, producing a bright cosmic pockmark.

Because the starting mass of type 1a supernovas is so uniform, these explosions reach predictable peak brightnesses. Astronomers can therefore use the brightnesses to measure relative extragalactic distances and the universe's expansion rate.

For 80 years, scientists have known that the universe is growing. In 1998, evidence from type 1a supernova measurements suggested that the rate of the expansion is accelerating.

Since then, further data from supernovas and other observations have supported that conclusion; astronomers now attribute the quickening expansion to "dark energy," a mysterious, repulsive force thought to make up more than 70 percent of the mass-energy content of the universe.

"This class of supernova is the kind of object that showed us that there was dark energy, and is one of the best tools we have for measuring the expansion rate of the universe," Riess says.

Riess is planning on using Hubble telescope observations of M101 to learn more about Cepheid variable stars, also important cosmic mile-markers, but only for measuring shorter distances than those accessible with faraway supernovas. Hubble will continue to peer at M101 through October, recording data about both the supernova and the Cepheids. Since the Pinwheel Galaxy is so close by, astronomers can take detailed measurements of both Cepheids and the supernova and combine them to nail down "true" distances.

"A galaxy like this is sort of like the Rosetta Stone," Riess says. "It provides the translation between the two — it calibrates the supernova using the Cepheids."

Catching a type 1a explosion so early will help astronomers understand more about the parent white dwarf star's composition and may reveal details about how supernovas evolve in different galaxies, or with different starting ingredients.

It's possible that brightness varies with the parent star's composition, or the type of galaxy it explodes in. But Riess says major fluctuations are unlikely, and that studying any such variations would help scientists better understand the expanding universe.

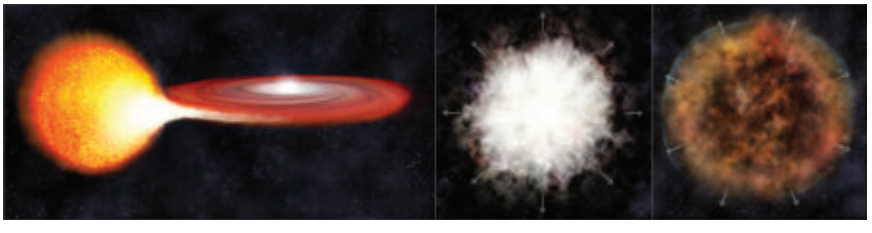
"We're actually going to measure it more precisely and more accurately, and that would help us understand dark energy," Riess says.

Scientists are looking through archival Hubble telescope images, hoping to spot the now-destroyed white dwarf and any companion star that may have fed it until it burst. Researchers will continue to observe the object for years, until only the dregs remain.

Of course, it's all dust and gas now, since astronomers are glimpsing a 21-million-year-old event.

By now, "it's probably evacuated out a little hole in the gas," Nugent says. "All of its material has been flung off. It's perhaps started the process of collapsing to form new stars, depending on the local environment, and you have blobs of things like calcium and silicon and iron flying around." ■

## Back Story | WHITE DWARF'S DEMISE



A stellar explosion observed last month, designated PTF 11kly, is what astronomers call a type 1a supernova. Supernovas of this type occur after a white dwarf star, typically not much heavier than the sun, adds enough material to exceed about 1.4 times the sun's mass. One likely scenario for acquiring the extra mass is siphoning it from a nearby star (left). Once the mass limit is exceeded, the white dwarf ignites in a thermonuclear explosion (center), leaving behind nothing but debris (right).

TOP: PETER NUGENT, PALOMAR TRANSIENT FACTORY; BOTTOM: M. WEISS/CXC/NASA

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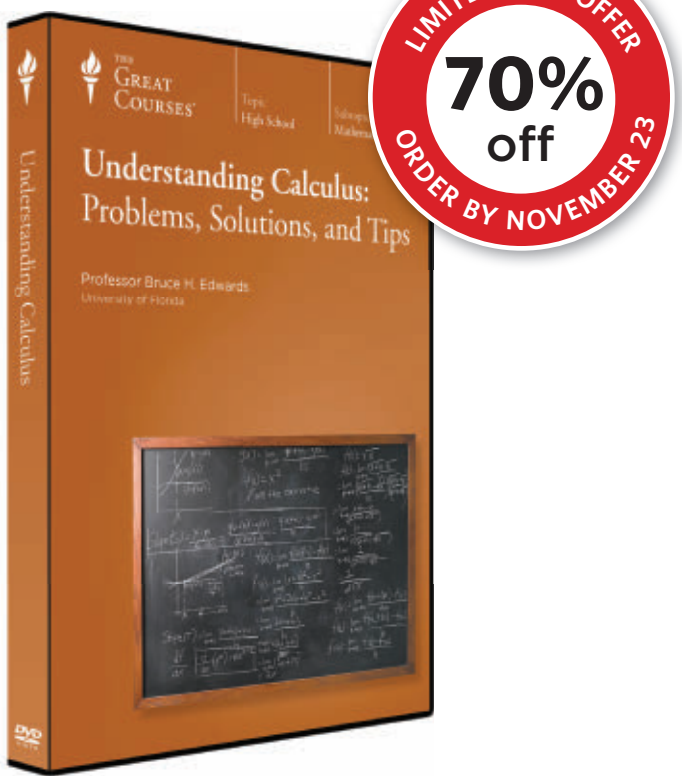


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# Humans

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## For his last meal, Iceman ate goat

### Stomach contents reveal new details about murder victim

**By Alexandra Witze**

Outside of the Nancy Grace show, few people have had their final hours as poked, prodded and scrutinized as much as Ötzi, the "Iceman" who died high in the Italian Alps 5,300 years ago.

Hikers discovered his frozen, mummified body in 1991. Two decades later, scientists have a good idea of what happened to Ötzi: Fleeing pursuers, he retreated to the mountains only to be shot in the back with an arrow. But even today, the Iceman is still giving up surprises.

New, more detailed radiological images of the mummy have revealed his stomach for the first time and shown that he didn't die hungry. Within an hour of his murder, Ötzi ate a big meal mostly of the wild goat called ibex, reports a team led by Albert Zink, head of the Institute for Mummies and the Iceman in Bolzano, Italy.

"We now think that he must have felt quite safe, because otherwise he wouldn't have had this big meal," Zink says. "This was a really big surprise." The work was published online August 17 in the *Journal of Archaeological Science*.

The Iceman may have eaten meat fairly regularly, the scientists suggest; the new scans also uncovered three gallstones, a sign that his diet could have been richer in animal products than researchers thought. And newfound signs of heavy strain in Ötzi's knees may mean he walked a lot in mountainous terrain — as opposed to being a valley dweller who wandered up high just before his death.

In life, Ötzi was a brown-eyed, long-haired man in his mid-40s who stood 5 feet 3 inches tall, average height for the Copper Age. In death, he became one of the world's best-preserved mummies, thanks to the ice that encased him soon after his murder. When climbers found Ötzi sticking out of a retreating glacier in September 1991, scientists rushed his body into a climate- and humidity-controlled cell so he wouldn't thaw.

Until now, the closest researchers had gotten to Ötzi's last meal was samples from his colon. It contained the remains of several meals, including the meat of red deer and ibex along with vegetables and grains such as einkorn, a local wheat.

But in 2005 Zink's team took more detailed X-ray computed tomography images, revealing the long-sought stomach. After death, many of the Iceman's organs shrank and moved from their original locations, and nobody had recognized the stomach because it had shifted into the upper abdomen, Zink says.

In November, the researchers pulled some of Ötzi's stomach contents out through an incision in the abdominal wall. Preliminary DNA analysis of the fatty tissue shows it came from an ibex.

"What we have found is that he consumed an omnivorous diet," says Klaus Oeggl, a paleobotanist at the University of Innsbruck in Austria who is analyzing the nonmeat parts of the stomach contents. The Iceman's last several meals contained a mix of meat, vegetables and grains, with more meat in his final meal.

To Zink, a full stomach suggests that Ötzi wasn't actively fleeing his pursuers just before he died. Oeggl, however, speculates that the Iceman could have gotten a head start on those chasing him, then sat down for a break before an enemy surprised and shot him.

Once the arrow hit Ötzi, scientists reported in 2007, it tore open an artery and sent him into fatal hemorrhagic shock. He died on the spot. Ötzi also received a deep laceration on his right hand several days before he died.

Other evidence supports the theory that the Iceman had been under stress. In his last 33 hours, Ötzi moved from up near the timberline to down among the trees and then up again to the ice, as shown by pollen grains from various alpine plant species lodged in his body.

In October, Iceman scientists will gather in Bolzano for a 20th anniversary symposium, which may include a report on the first complete analysis of the Iceman's DNA, which has been finished but not yet published.

**Two decades after the Iceman's discovery, scientists have only just found the stomach of the 5,300-year-old mummy. Many of his internal organs have shrunk and moved from their original positions.**

SOUTH TYROL MUSEUM OF ARCHAEOLOGY

"Experiencing personal growth from going through tough times doesn't mean you're doing well." —WILBUR SCOTT

# Support troops feel stress of war

## In Iraq and Afghanistan, no one works 'behind the lines'

**By Bruce Bower**

Soldiers fighting at the tip of the spear — the leading edge of combat — confront bloodshed, suffering and dying. But the success of those soldiers' operations depends on a huge network of service and support personnel who themselves face considerable and often overlooked war stress, says military sociologist Wilbur Scott of the U.S. Air Force Academy in Colorado Springs.

After returning from deployment, National Guard combat service personnel — including clerks, truck drivers, medics and supply officers — displayed slightly less emotional resilience and described more stress while overseas and after returning home than their comrades engaged in combat, Scott reported August 20. Service personnel cited deployment stress triggered by exposure to danger, life-threatening situations and death.

Their responses reflect the changed nature of warfare, Scott suggested. In Iraq and Afghanistan, counterinsurgency efforts have replaced conventional warfare. Combat soldiers not only fight and kill but establish relationships with local officials, head local building projects and encourage trust in local governments. Service personnel work in the midst of these operations, where they can encounter guerilla attacks or roadside bombs.

Poor coping upon returning from National Guard deployment — whether among former service personnel or combat troops — usually involved excessive alcohol drinking, abuse of prescription drugs and carrying a gun for protection, Scott said. Such findings underscore the need to provide programs that ease veterans back into civilian life, commented military sociologist Bradford Booth of ICF International, a consulting firm in Fairfax, Va.

Scott and his colleagues surveyed 1,460 Army National Guard soldiers, including 969 deployed solely to war zones in Afghanistan or Iraq. Whether combat or service personnel, soldiers returning from war zones were most likely to report having grappled with and found some meaning in their military experiences. Yet those who served in war zones also reported the most symptoms of posttraumatic stress disorder and the worst difficulties readjusting to civilian life.

"Experiencing personal growth from going through tough times doesn't mean you're doing well," Scott said.

# Recession alters parenting style

## Mothers with gene variant became more aggressive

**By Bruce Bower**

Recent economic woes in the United States may have triggered a temporary upturn in the use of harsh parenting methods by mothers carrying a particular gene variant.

Mothers who inherited either one or two copies of a particular form of the dopamine D2 receptor gene, dubbed *DRD2*, cited sharp rises in spanking, yelling and other aggressive parenting methods for six to seven months after the onset of the economic recession in December 2007, sociologist Dohoon Lee of New York University reported August 22.

Hard-line child-rearing approaches then declined for a few months and remained stable until a second drop to prerecession levels started around June 2009, the research showed.

Mothers who didn't inherit the gene variant displayed no upsurge in aggressive parenting styles after the recession started, Lee and his colleagues found.

As the recession progressed, mothers with the crucial *DRD2* variant apparently adjusted enough to tougher economic times to allow for a return to prerecession parenting practices, Lee proposes.

Economic uncertainty may prompt harsh parenting in genetically predisposed individuals as much as economic hardship and poverty do, Lee said.

His findings reveal one potential genetic pathway by which large-scale economic developments affect child-rearing styles, remarked sociologist Yang Yang of the University of North Carolina at Chapel Hill. She said that further research is needed to confirm that mothers who treated their kids more harshly in response to the recession gradually adjusted to new economic realities and thus became less aggressive parents.

The same *DRD2* gene variant that Lee and colleagues linked to harsher parenting during the recession has previously been tied to a propensity for violence, alcoholism, attention-deficit/hyperactivity disorder and several other psychiatric conditions. Still, other research questions whether any link exists between *DRD2* and mental ailments.

Lee's team analyzed survey responses obtained monthly from August 2007 to February 2010 from 4,898 mothers whose children were around age 9. Participants lived in any of 20 U.S. cities. DNA had been obtained earlier from mothers in a parenting and child development study.

Carriers of genes such as the *DRD2* variant may blossom in positive environments and wither in negative environments (*SN Online: 4/6/11*), commented sociologist Ronald Simons of the University of Georgia in Athens. It remains to be seen whether mothers who reacted more punitively after the recession began will show a spike in warm parenting methods when flush economic times return. ■

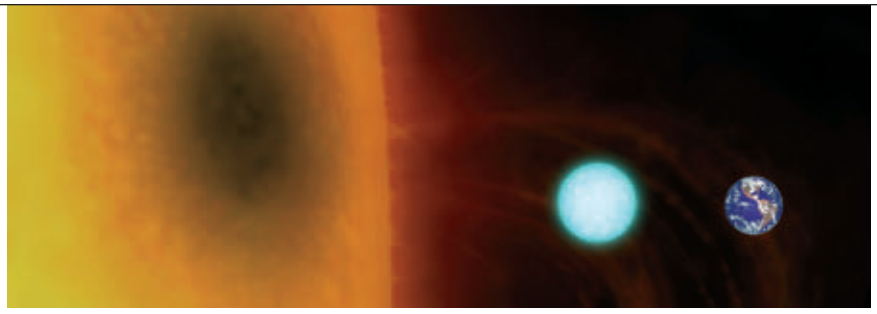
# Atom & Cosmos

For longer versions of these and other Atom & Cosmos stories, visit **www.sciencenews.org**

## For white dwarfs, Earths for dinner

### Lots of rocky debris pollutes dead stars' atmospheres

**By Nadia Drake**



**Roughly Earth-sized (right)—but with the mass of the sun (left)—a white dwarf (center) shreds and munches anything that gets too close. Astronomers have identified chemical signatures of Earthlike worlds smearing the tiny stars' atmospheres.**

Astronomers studying the atmospheres of planet-munching white dwarf stars have found that some stellar meals include the same ingredients as Earth.

Remains of rocky bodies that once circled the white dwarfs pepper the gas envelopes around the dead stars. The ratios of elements in the remains—called "pollution," since it mars a star's pristine atmosphere—tell astronomers what the digested bodies were made of.

"We think that most of these systems that show pollution must in some way approximate ours," says astronomer John Debes of NASA's Goddard Space Flight Center in Greenbelt, Md. "This is the first hint that despite all the oddball planetary systems we see, some of them must be more like our own."

Using the Keck I telescope in Hawaii, Ben Zuckerman of UCLA and colleagues found that each of two polluted white dwarf stars snarfed at least 10 quadrillion metric tons of rocky dust. White dwarf PG1225-079 has a mix of magnesium, iron and nickel in ratios resembling Earth's; white dwarf HS2253+8023 munched material containing more than 85 percent oxygen, magnesium, silicon and iron—very much like Earth, the team reports online August 7 at arXiv.org and in an upcoming *Astrophysical Journal*.

"This means that planetlike rocky material is forming at Earthlike distances or temperatures from these stars," says Zuckerman. He notes that it's still unclear whether the material is from a planet, planetlike bodies or an asteroid.

For years, astronomers thought the dwarfs were simply catching dust during their interstellar travels. Now, scientists think the debris signals ancient orbiting planetary systems. Zuckerman says that 25 to 30 percent of white dwarfs have orbital systems containing both large planets and smaller rocky bodies. After a dwarf forms, Jupiter-mass planets can perturb the orbits of smaller bodies and bounce them toward the star.

White dwarfs are about the size of Earth but as massive as the sun. They mark the final stage of stellar evolution for most stars in the Milky Way. But before reaching that stage, stars puff up into red giants, a process that can rearrange an orbiting planetary system.

## Galactic bull's-eye

Hoag's Object, shown at left, is a galaxy made up of a golden central sphere of stars surrounded by a much bigger star-studded hula hoop. When Arthur Hoag discovered the object in 1950, he thought the ring was the image of a distant galaxy smeared into a circular halo by the gravity of the dense central orb. Not until 1987 did researchers confirm that the orb and ring were part of the same galaxy. Now, using ground- and space-based observations, Israeli and Russian astronomers propose that the object's core formed first—at least 10 billion years ago. Soon after, the core skirted itself with a disk of hydrogen gas that it pulled from surrounding material. The disk's spiral pattern could be caused by rotation of the core if the central cluster isn't quite spherical. That setup would also explain ongoing star formation that dots the ring with young, massive stars. The object could be a good test bed for understanding how important gas-snatching is in already formed galaxies, the astronomers report in an upcoming *Monthly Notices of the Royal Astronomical Society*. —*Camille M. Carlisle*

FROM TOP: MARK GARLICK/PHOTO RESEARCHERS, INC.; NASA, HUBBLE HERITAGE TEAM/STSCI/AURA

**330** exoplanets | Discovered up to end of 2008

**269** exoplanets | Discovered 2009–Sept. 6, 2011

## NEWS BRIEFS

### Earth not so special

Recent observations have burst the idea that the Earth occupies a special spot in a gigantic cosmic bubble. The work counters proposals to explain the apparently accelerating expansion of the universe without a mysterious force known as dark energy. Such proposals reject the Copernican principle, which holds that the Earth occupies a typical location in the cosmos. If instead Earth occupies a sparsely populated bubble, galaxies within it would zip away rapidly, pulled by the gravity of the denser stuff outside, mimicking an accelerating cosmic expansion. But such galactic motion should leave imprints in microwave radiation from the Big Bang. Telescopes in Chile and Antarctica find no such evidence, astrophysicists from China and the United States report in the July 22 *Physical Review Letters*. —*Devin Powell*

### Pulsar's diamond planet

Astronomers have discovered the densest exoplanet yet—they call it a diamond planet—orbiting a whirling pulsar. Though the first exoplanet system found circles one of these spinning stellar cores, no other pulsar planets have been spotted since. The new exoplanet is comparable in mass to Jupiter but 20 times denser, an international team reports online August 25 in *Science*. The planet may be made of carbon and oxygen instead of the hydrogen and helium that are found in run-of-the-mill gas giants; it could be an über-lightweight dead star called a white dwarf that became a planet when its mass was stolen by the pulsar. —*Camille M. Carlisle*

### Earthy exoplanets

Scientists have created rap sheets for six planets beyond the solar system, orbiting three distant stars. One star hosts a system with three super-Earth planets, heavier than Earth but lighter than gas giants. Another harbors a 3.6-Earth-mass planet within its habitable zone, scientists from Europe report online August 17 at arXiv.org. That planet, HD 85512b, described in a second paper at arXiv.org, could be habitable if clouds cover more than half its surface. —*Nadia Drake*

Science & Society

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# Middle school science smarts

## First class of Broadcom MASTERS finalists named

**By Devin Powell**

Thirty talented sixth-, seventh- and eighth-graders have raised the bar for the question, "Are you smarter than a middle schooler?" These science-minded youngsters have advanced to the final round of a new national competition, the first ever Broadcom Math, Applied Science, Technology and Engineering for Rising Stars program, or MASTERS event.

Finalists were chosen for their original research projects, which covered a range of scientific topics — from the cognitive benefits of yoga to the physics that gives light to LEDs. Following last year's *Deepwater Horizon* oil spill, one student in Texas tested how oil and chemicals that disperse oil impact algae. Another used a computer simulation to investigate dark matter's influence on rotating galaxies.

In October the selected students will travel to Washington, D.C., where they will present their projects to the public, meet members of Congress and vie for prizes in team challenges.

"Middle school is the time when a boy or girl first develops independent desires and interests," says Paula Golden, executive director of Broadcom Foundation and director of community affairs for Broadcom Corp. "Engaging in a science or engineering project at this age may well ignite a passion that will inspire a middle schooler to stay with math and science."

The 2011 Broadcom MASTERS is sponsored by the Broadcom Foundation and Society for Science & the Public, which publishes *Science News*. Past finalists of another competition administered by SSP — the Intel Science Talent Search for high school seniors — have gone on to win Nobel Prizes, among other accolades.

"In addition to launching science careers, SSP's competitions motivate students to view the world through a scientific lens, essential for the navigation of issues that affect everyone in today's complex global society," says Elizabeth Marincola, president of SSP and publisher of *Science News*.

In its first year, the Broadcom MASTERS program received 1,476 entries from students who were nominated by SSP-affiliated local science fairs in 45 states, Washington, D.C., and Puerto Rico. A panel of scientists and engineers whittled the applicants down to 300 semifinalists.

Judges have now selected 30 finalists and one alternate. Each winner's school will receive $1,000 from the Broadcom Foundation. A single overall winner, to be announced at an October 4 awards ceremony, will receive the top prize, a $25,000 educational award presented by the Samueli Foundation, a private foundation based in Corona Del Mar, Calif. ■

### THE FINALISTS

ARIZONA **Meagen Bethel,** Tucson, Doolen Middle School

CALIFORNIA **Namrata Balasingam,** San Jose, Challenger School, Strawberry Park; **Braeden Benedict*,** Rancho Palos Verdes, Saint John Fisher Parish School; **Daniel Feeny,** Woodside, Woodside Elementary School; **Crystal Poole,** San Diego, Thurgood Marshall Middle School

FLORIDA **Maria Elena Grimmett,** Jupiter, The Weiss School; **Nikhil Patel,** Geneva, Sanford Middle School

HAWAII **Robert Heckman,** Kailua, Kailua Intermediate School; **Jordan Kamimura,** Hilo, Hilo Intermediate School

MASSACHUSETTS **Nathan Han**, Boston, Jackson Mann K–8 School; **Emily Sarkisian,** Mansfield, St. Mary's Catholic School

MINNESOTA **Roshini Asirvatham,** Rochester, Friedell Middle School; **Carolyn Jons,** Eden Prairie, Central Middle School

NORTH CAROLINA **Justin Barber,** Raleigh, St. Timothy's School; **Andrew Blonsky**, Chapel Hill, Price Creek Independent School; **Chad Campbell,** Hampstead, Topsail Middle School

NEW MEXICO **Coleman Kendrick,** Los Alamos, Los Alamos Middle School

OHIO **Kyle Davis,** Sunbury, Big Walnut Middle School; **Jennifer Markley,** Westerville, Walnut Springs Middle School; **Samantha Rowland,** Tipp City, Tippecanoe Middle School

OREGON **Valerie Ding,** Portland, Summa North at Meadow Park Middle School; **Anirudh Jain,** Portland, Summa North at Meadow Park Middle School; **Mahita Tovinkere,** Portland, Stoller Middle School

PENNSYLVANIA **Benjamin Hylak,** West Grove, Sacred Heart School

PUERTO RICO **Adriana Monzon,** Guaynabo, Academia del Perpetuo Socorro

SOUTH CAROLINA **William White,** Hilton Head, Hilton Head Preparatory School

TEXAS **Ria Chhabra,** Plano, Renner Middle School; **Alicia D'Souza,** Plano, C.M. Rice Middle School; **Lauren Hall,** Corpus Christi, School of Science and Technology; **I-Chun Lin,** Plano, Schimelpfenig Middle School

WASHINGTON **Katherine Landoni,** Sequim, Sequim Middle School

**Elected not to compete.*
*Finalists are listed by state, name, hometown and school.*

**43 thousand** | Number of transnational corporations analyzed in new study

**40 percent** | Monetary value of corporations studied owned by just 147 companies

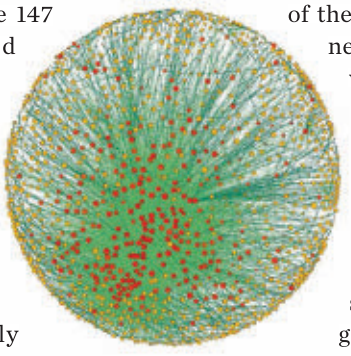
# Financial world dominated by a few

## ‘Superentity’ controls more than one-third of global wealth

**By Rachel Ehrenberg**

Conventional wisdom says a few sticky, fat fingers control a disproportionate slice of the world economy’s pie. A new analysis suggests that the conventional wisdom is right on the money.

Diagramming relationships among more than 43,000 corporations reveals a tightly linked core of top economic actors. In 2007, a mere 147 companies controlled nearly 40 percent of the monetary value of all transnational corporations, researchers report online July 28 at arXiv.org.



**A central core of extremely powerful actors (red dots) dominates international corporate finance, a new mathematical analysis finds.**

S. VITALI *ET AL*/ARXIV.ORG 2011

“This is empirical evidence of what’s been understood anecdotally for years,” says information theorist Brandy Aven of Carnegie Mellon in Pittsburgh.

The analysis is a first effort to document the international web of relationships among companies and to examine who owns shares — and how many — in whom. Tapping into the financial information database Orbis, scientists from ETH Zurich in Switzerland examined transnational companies, which they defined as having at least 10 percent of their holdings in more than one country. Then the team looked at upstream and downstream connections, yielding a network of 600,508 economic actors connected through more than a million ownership ties.

This network takes on a bowtie shape, with a large number of diffuse actors in the wings and a few major players tangled up in the tie’s knot. So while it’s true that ownership of publicly held corporations is broadly distributed, says complex systems scientist James Glattfelder, a coauthor of the new work, “take a step back and it’s all flowing into the same few hands.”

While any man on the street may have predicted this outcome, the economic literature portrays markets as so dynamic that they lack hot spots of control, Glattfelder says.

Researchers aren’t sure what to make of the core’s interconnectedness. It could expose the whole network to risk. “Imagine a disease spreading,” says Aven. “If you have a high school where everyone’s sleeping together and one person gets syphilis, then everyone gets syphilis.”

But on the flip side, she notes, interconnectedness can lead to better self-policing and positive behaviors, such as fair labor practices.

And even though the status of many players has changed drastically since 2007 (now-defunct Lehman Brothers is a key element of the core), the study shows that ownership is becoming increasingly concentrated and transnational, says Gerald Davis of the University of Michigan.

Ownership can be difficult to study internationally because holding shares in a mutual fund doesn’t necessarily mean the same thing in the U.S. as it does in China. And even within a single country, ownership can be hard to tease out, says economist Matthew Jackson of Stanford University. For example, when an individual invests in a mutual fund or even purchases shares through an institution like Merrill Lynch, the firm is often still the official owner of the assets.

## NEWS BRIEFS

### Psychling dynamics

Although cyclist Alberto Contador won the 2009 Tour de France, he was criticized for defecting from his teammates and sprinting ahead when tactics demanded patience. New research suggests that criticism was on the mark. When strong riders break away from their companions, it helps the defector but hurts the team, researchers report in an upcoming issue of *Complexity*. University of Colorado Boulder scientists and a sports psychologist developed a bike racing model incorporating variables such as cooperation, defection, speed, distance and effort. The model nicely captures real racing dynamics: below-average riders fare better as defectors, above-average riders as cooperators and when a strong rider does defect, it harms the team. —*Rachel Ehrenberg*

### Traveling germs

Homebodies don’t rack up the same miles as frequent fliers, but most models of how infectious diseases spread treat all travelers the same. A new model takes these differences into account. The research, published online August 8 in *Physical Review X,* suggests that most models vastly overestimate a disease’s spread. And the frequency of long trips isn’t the only factor influencing whether a disease hops to another continent. The durations of those trips is crucial as well, reports the team from the Max Planck Institute for Dynamics and Self-organization, the University of Göttingen in Germany, and Northwestern University.
—*Rachel Ehrenberg*

# Life

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## Early stress can be contagious

### Rough chickhood for zebra finch shortens partner's life

**By Susan Milius**

Among the regrettable things one might catch from a long-term mating partner, add the life-shortening effects of stress in childhood.

Chickhood stress is bad for zebra finches. Nestlings dosed with stress hormones tend to die earlier in adulthood even if they enjoy plentiful food and predator-free lab quarters after maturity.

And so do those unfortunate nestlings' future mates, a new study finds. Zebra finches, which form strong pair bonds, somehow transmit their risk of stress-shortened life span to their partners.

"It's like giving them a disease," says evolutionary ecologist Pat Monaghan of the University of Glasgow in Scotland.

Working out the effects of early stress over a lifetime requires lab experiments, because most natural exposures to stress usually continue into adulthood. So Monaghan and her colleagues administered stress hormones to chicks for about half of their month or so as nestlings and then gauged the long-term effects on the treated birds and their mates.

After three years, about 20 percent of finches stressed with hormone doses as nestlings had died — and so had about the same proportion of their mates who had enjoyed tranquil chickhoods. In contrast, only about 5 percent of finches with happy childhoods who were mated to other easy-childhood birds died in that time.

**Even if zebra finches look healthy, if one in a pair had a stressful time as a chick, both face a higher risk of a shortened life span, a new study has found.**

The shorter life spans for survivors of early stress aren't a surprise, but the transmission to partners is, says Jonathan Seckl of the University of Edinburgh, who studies stress hormones. "If this was true in humans, such folks should carry a health warning," he says.

Worst off were birds from rough backgrounds mated to each other: About 40 percent of them were dead in three years, the researchers report online August 17 in *Proceedings of the Royal Society B*.

The effect that Monaghan and colleagues have demonstrated "illustrates just how much your partner can affect your own health, even in very subtle ways," says Simon Griffith of Macquarie University in Sydney. Shortening the partner's life didn't seem to come from having to work harder to make up for a mate that wouldn't or couldn't put in its own effort, but from some less direct effect.

"If these data can be applied to humans at all," says Michael Romero of Tufts University in Medford, Mass., "the take-home lesson would be to choose your mate well so that your mate can help decrease — somewhat — the number of stressors that life throws at you."

## Big fish return to no-fishing zone

### Gulf of California park a model for overharvested areas

**By Janet Raloff**

Within 14 years of a national marine park in Mexico's Gulf of California closing its borders to fishing, the total mass of its denizens more than quintupled, a new study finds. Over the same period the share of top predators — sentinels of a healthy ecosystem — also soared. Both trends countered those for fish in unprotected regions of the Gulf.

"People who object to marine protected areas, especially to strong protection like here, often say there is no proof that they work," says Elliott Norse of the Marine Conservation Institute in Bellevue, Wash., who was not involved in the new study. "Well, this is the proof."

The 71-square-kilometer Cabo Pulmo National Marine Park sits close to where the Gulf of California opens into the Pacific. Since 1995, 35 percent of the park's waters have been off-limits to fishing, but local communities informally extended the no-take zone to the rest of the park, says Octavio Aburto-Oropeza of the Scripps Institution of Oceanography in La Jolla, Calif. He and his colleagues report their survey of the reef's fish populations August 12 in *PLoS ONE*.

Fishers typically first target the biggest individuals among meaty predators such as giant groupers and snappers. Absent in 1999, such big fish — some a meter or more long — again inhabit Cabo Pulmo, Aburto-Oropeza says.

**A grouper (*Mycteroperca jordani*) is among the large predators that have returned to Cabo Pulmo National Marine Park after a fishing ban.**

Sharks remain virtually absent. Owing to heavy exploitation for the fin trade and slow rates of reproduction, this family of predators remains rare inside Cabo Pulmo and out, Aburto-Oropeza says.

FROM TOP: © JUNIORS BILDARCHIV/ALAMY; O. ABURTO-OROPEZA/ILCP

Body & Brain

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# Flu response may depend on genes

## Different activity patterns accompany severe, mild reactions

**By Tina Hesman Saey**

The difference between staying well and suffering days of misery from the flu depends on which of two contradictory ways the immune system reacts to the infection.

One strong reaction releases inflammatory chemicals leading to sickness, researchers report online August 25 in *PLoS Genetics*. An equally strong but opposite reaction produces anti-inflammatory compounds and fights off the flu without producing symptoms.

Alfred Hero and colleagues infected 17 volunteers with a strain of seasonal flu called H3N2/Wisconsin. Nine of the volunteers got sick. Some of the others reported feeling under the weather, but had no clinically discernible symptoms. The researchers drew blood before the flu inoculation and every eight hours for five days after the initial infection. The team then examined the activity of about 22,000 genes in each blood sample.

"The persistent patterns that came out of this were striking to say the least," says Hero, a computer scientist and electrical engineer at the University of Michigan Medical School.

Gene activity patterns could predict how sick people would get up to 36 hours before symptoms peaked, the researchers found. Those who got sick activated immune chemicals that trigger inflammation and stress responses.

"In asymptomatic people the immune response is just as active, but dramatically different in nature," Hero says. People who stayed well not only repressed the stress response, but also activated anti-inflammation and antioxidant genes.

"This is really exciting data," says Octavio Ramilo of Nationwide Children's Hospital in Columbus, Ohio. The study illustrates that analyzing gene activity may help doctors determine which patients are most in danger of getting seriously ill. But this study hasn't put the entire story together yet, he says. Researchers still need to determine whether the different responses depend upon the person's genetic makeup, properties of the virus or other factors. And the people in the study may react differently to other flu strains or even to the same one under different circumstances.

The technology may one day help doctors identify which viruses are infecting babies with fevers and predict which infants will end up in intensive care.

## Genes & Cells

For more Genes & Cells stories, visit **www.sciencenews.org**

# Lager's mystery ingredient found

## Ancestor of cold-brewed beer yeast turns up in Patagonia

**By Tina Hesman Saey**

Lager beers got their start in Bavaria, but it was a little South American spice that really kicked things off.

Scientists have known for decades that a hybrid species of yeast, *Saccharomyces pastorianus*, is the microbe that ferments lagers. It's also well known that one parent of *S. pastorianus* is the common baking and brewing yeast *S. cerevisiae*. But the other parent of lager yeast has eluded scientists, who have scoured Europe and North America looking for it.

Turns out they were looking in the wrong hemisphere. Researchers led by Chris Todd Hittinger of the University of Wisconsin–Madison and Diego Libkind of the Argentinean National Council for Scientific and Technical Research in Bariloche have tracked the missing wild parent of lager yeast to the beech forests of Patagonia. The researchers report the capture of the newly discovered yeast, dubbed *S. eubayanus*, in the Aug. 30 *Proceedings of the National Academy of Sciences*.

"I got chills reading it, I was so excited," says Barbara Dunn, a comparative geneticist at Stanford who has been on the trail of the wild yeast herself. "It is incredibly surprising that it is from Patagonia."

Libkind found *S. eubayanus* in galls — pale peach balloonlike structures resulting from fungal infections — on Patagonian beech trees. The galls, full of sugar, house *S. eubayanus* and another wild yeast that ferment the sugars. It's generally chilly in Patagonia, just the way lager yeast like it. Lagers are brewed at 4° to 9° Celsius (39° to 48° Fahrenheit).

The *S. cerevisiae* yeast used for making ales, wines and other alcoholic beverages don't like the cold, preferring temperatures of about 15° to 25° C (59° to 77° F). So when Germans started brewing beers in winter to avoid summertime contaminants such as molds and bacteria that skunk beer, the chillier brewing conditions would have favored the creation of a hybrid lager yeast based on *S. cerevisiae* and a cold-loving relative, says evolutionary biologist Antonis Rokas of Vanderbilt University in Nashville.

**Galls — growths resulting from a fungal infection — on beech trees in northern Patagonia contain a wild yeast that gave rise to a hybrid yeast used in beer.**

The researchers aren't sure how *S. eubayanus* got to Bavaria; perhaps by hitching a ride on beechwood or barrels made of beech, or on fruit or in the belly of a fruit fly. However it got to Europe, when *S. eubayanus* arrived it found a ready-made niche and a partner to merge with in breweries, Rokas speculates.

Knowing the identity of the wild parent may help scientists learn how the lager hybrids formed and how domestication genetically changed the yeast, Rokas says. Brewers may also be able to create new hybrid strains that can be tailored for modern brewing practices.

# Butterfly masters disguise

The tasty *Heliconius numata* butterfly (right column) evades predators by copying the wing patterns of a foul-tasting species, *Melinaea mneme* (left column). *H. numata*, also known as the passion-vine butterfly, has to get the pattern exactly right or a sharp-eyed bird will spot the fake and gobble it up. Born mimics, members of the species lock in wing patterns with flipped-around bits of DNA, Richard ffrench-Constant of the University of Exeter in England and colleagues report online August 14 in *Nature*. The flipped DNA causes six or more genes — on a section of a chromosome important in setting wing patterns in butterflies and peppered moths — to be inherited as a single unit, a supergene. Different versions of the supergene allow *H. numata* to adopt seven different wing patterns reminiscent of several bad-tasting species. Other *Heliconius* butterflies mimic only one nonpalatable species. Researchers aren't sure if other butterfly species use DNA flipping to determine their patterns. — *Tina Hesman Saey*

FROM TOP: D. LIBKIND; © MATHIEU JORON

# Molecules

**1.3 million** Number of fires in the United States in 2009

**3 thousand** U.S. civilian deaths from fire in 2009

**$12.5 billion** U.S. property loss from fires in 2009

## Panda poop may hold biofuel key

### Gut microbes break down tough bamboo efficiently

**By Alexandra Witze**

Two giant pandas in the Memphis Zoo have dropped researchers a gift. Studies of the pandas' poop show that their gut microbes break down bamboo efficiently — a trick that humans could co-opt to turn woody plant material into alternative energy sources.

"We're taking refuse — panda poop and the microbes that live there — and trying to break down another form of refuse," says Ashli Brown, a biochemist at Mississippi State University. Brown described her team's results on August 29.

Pandas eat bamboo almost exclusively but don't have multichambered stomachs like cows to aid digestion. The team discovered 12 species of waste-digesting bacteria in the zoo pandas' feces, including at least one never before seen in pandas. The scientists are now trying to extract the enzymes these bacteria use to chew up plants. Preliminary work suggests the bacteria are at least as efficient at digestion as ones found in the guts of wood-chomping termites, Brown says.

Once isolated, the enzymes could be produced in the lab and possibly used to speed up the complicated, expensive process of turning the tough, fibrous plant material known as cellulose into biofuel.

**Bamboo breaks down quickly in pandas' gastrointestinal tracts thanks to powerful microbes that digest it, a study shows.**

## Building a greener flame retardant

### Nanolayer approach incorporates renewable material

**By Janet Raloff**

Materials scientists in Texas have developed flexible coatings mere billionths of a meter thick that keep cotton clothing from going up in flames and plastic foam from melting. Unlike the widely used but potentially toxic flame retardants they've been designed to replace, these nanocoatings appear relatively safe, their designers say.

Researchers from Texas A&M University in College Station described their team's new technologies August 31.

Because fabric fibers are so thin, "being able to fire-retard them is a big deal," observes chemist Charles Wilkie of Marquette University in Milwaukee, a fire-retardant specialist not involved with the study. "So I'm encouraged. The new work is impressive."

The Texas team, led by Jaime Grunlan, has been seeking safer alternatives to brominated fire retardants, some of which have been banned over concerns about their potential toxic effects. The researchers tested alternating layers of garden-variety clay and an inexpensive waste material: chitosan, a natural compound extracted from shrimp and lobster shells.

Untreated plastic foam, such as the type used in furniture, held over a propane torch flame for 10 seconds quickly ignited, melted and burned up. But after applying 10 dual layers of clay and chitosan to an identical piece of foam, the 10-second flame created a thin veneer of char but left the interior unscathed.

The new formulation proved disappointing on cotton fabric, Grunlan says. So the team turned to materials that intumesce — undergo a foaming chemical reaction — at high temperatures. In the construction industry, millimeter-thick intumescent coatings on steel girders protect a skyscraper's skeleton. Grunlan's group scaled the technology down to nanometer-thick alternating layers of the compounds, polysodium phosphate and poly-allylamine.

When cotton fabric that had been treated with 10 alternating layers of each chemical was exposed to a flame for 10 seconds, the fabric blackened but didn't burn up, Grunlan says. The only sign of damage was localized, minor charring where the flame had touched the fabric. Details of the fabric experiments were published September 8 in *Advanced Materials*.

**Four pieces of cotton were exposed to a flame for 10 seconds. The untreated piece (left) burned up. The other three were coated with (from left) 5, 10 or 20 alternating layers of each of two flame retardant compounds. More layers offered better protection.**

FROM TOP A. WITZE; Y.-C. LI *ET AL/ADVANCED MATERIALS* 2011/WILEY-VCH VERLAG

MICHAEL MORGENSTERN

# Tumor tell-all

## Unraveling complex genetic stories in cancer cells may lead to personalized treatment

**By Tina Hesman Saey**

Tumors are ugly. But the staff at Massachusetts General Hospital takes a snapshot of almost every one that crosses the doorstep.

These snapshots are not photographs, but are rather whole rap sheets on the genetic deformities that twist normal cells into cancerous ones. In a laboratory tucked within the labyrinth of corridors connecting the hospital's many buildings, researchers punch tiny cores no bigger than a grain of rice from tumor samples. Those cores are handed off to robots and tested for 110 mutations that commonly strike 15 genes important in cancer.

Across the country, doctors at the Oregon Health & Science University in Portland use another method for testing tumors. The staff there looks for 643 different mutations in 52 genes in solid tumors, such as those of lung and colon cancer, and screens blood or bone marrow from leukemia patients for 370 mutations across 31 genes. Though the tests don't reveal everything that has gone wrong to lead to a patient's tumor, they may point to mistakes that drive the cancer. "They're the original 'stomp on the gas pedal' type of mutations," says Christopher Corless, a pathologist who directs the tests at Oregon.

Efforts under way at these two cancer centers are creating some of the first ripples in what many scientists predict will be a growing wave of genetic testing of tumors. Traditionally doctors order tests to see if just one of a small handful of genes is broken, and such tests have been used widely for the treatment of only breast cancer and a few other cancer types. But that piecemeal approach is giving way to more comprehensive probes of cancer's molecular workings.

Big cancer centers and clinical labs at university-affiliated hospitals around the country are now adopting tumor-testing programs similar to those in Massachusetts and Oregon. Even though the wave has yet to swell outside of academic centers to smaller community hospitals and doctors' offices, some clinicians are already finding troublemaker genes and drugs that can counteract them. Scientists are taking the process many steps further in the lab, deciphering a tumor's complete genetic instruction book. Having such information, at least in the case of one man with a rare cancer, has helped uncover unexpected cancer drivers and tailor patient care.

Such comprehensive testing is beginning to change the way many doctors and researchers think about cancer. Soon tumors may be diagnosed and treated much like an infectious disease. Just as identifying the bacteria or virus responsible for an infection helps doctors prescribe the right medication, finding the mutations behind a tumor could lead to treatments that target and knock out cancer cells while sparing healthy ones.

Where a quick-and-easy cure isn't possible, cancer could be transformed into something akin to chronic infections like HIV or hepatitis C. "We're trying to convert all of cancer to what we did for HIV," says David Ryan, an oncologist at Massachusetts General Hospital, in Boston. With cancer, "You hear this constant, 'I'm going to beat it, I'm going to beat it, I'm going to beat it.' Well, HIV never goes away. You still have to take the medicines, but you can live with it."

## Live (longer) with it

Pharmaceutical companies have a couple of success stories that suggest Ryan's vision may not be far-fetched. A drug called Gleevec has extended by years the lives of people with one form of leukemia. That drug stops the cancer-promoting action of specific proteins that help tell a cell when to grow and divide.

Some cancer-causing mutations switch these proteins, known as tyrosine kinases, to a permanent "on" position, like the accelerator pedal in a car getting stuck to the floor. Gleevec helps pull back on the throttle, slowing or stopping the cancer's growth. Other drugs (erlotinib, gefitinib, cetuximab) block the action of a tyrosine kinase called the epidermal growth factor receptor or EGFR, which turns on cell growth programs. Genetic mutations that keep the protein permanently active or that cause too much of it to be produced can lead to lung cancer.

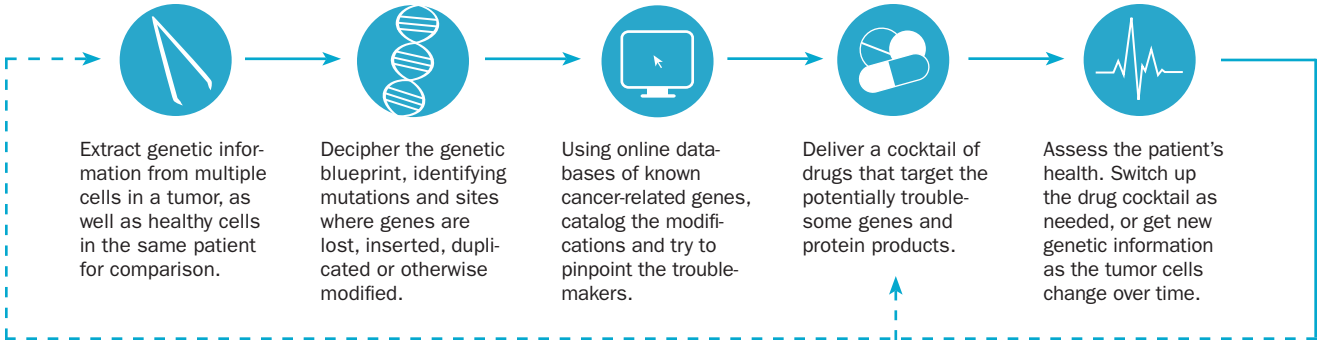
Despite these signs that targeting specific genes and their products can help fight cancer, only about 5 percent of all cancer patients have benefited from genetic testing thus far, estimates Daniel Haber, a cancer geneticist at Mass General who counts the development of erlotinib as the happiest experience of his research career. Yet the number of beneficiaries may be about to grow.

Researchers have recently learned that between 40 and 60 percent of melanomas and 7 to 8 percent of all cancers have accelerator-sticking mutations in a gene called *BRAF* that codes for another growth-control molecule. The most common of the mutations changes one link in the amino acid chain that makes up the BRAF protein, a switch from valine to glutamic acid.

A study published in the *New England Journal of Medicine* last year showed that an experimental drug known as vemurafenib could melt away many melanoma tumors that had spread throughout the body by inhibiting the activity of the mutant BRAF protein. The drug, now approved by the U.S. Food and Drug Administration, has stopped tumor growth for more than seven months in patients with the mutation, extending their lives.

Other drugs are buying cancer patients even more time. Drugs that combat EGFR abnormalities have given lung cancer patients as long as 30 months from diagnosis. Standard chemotherapy typically offers only 12 months, says William Pao, director of personalized cancer medicine at the Vanderbilt-Ingram Cancer Center in Nashville.

**Tumor testing dreams** Though some patients do benefit from drugs that target specific cancer-causing mutations, in most cases a tumor's underlying mutations are unknown. Someday, researchers hope, comprehensive genetic tumor testing (steps depicted below) will become cheap and fast enough to influence patient care, providing every cancer sufferer with personalized treatment.




E. FELICIANO

"That's a big difference if they want to see their kid graduate or another baby being born," Pao says.

## A case of cancer

"Magical" drugs like these are still wishful thinking for most patients, though, says John Iafrate, a molecular pathologist at Mass General and a pioneer of the hospital's tumor snapshot program. The search for anticancer medications that pinpoint specific genetic defects reminds him of the early days of antiretroviral therapy for HIV. Attacking one tumor process may not be enough to completely eliminate the cancer, he says, just as the antiretroviral drug AZT wasn't able to control HIV infections on its own.

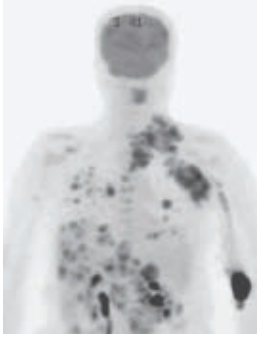
To leap forward, scientists have to find out what makes each person's cancer tick, so they can go after it with the right drug combination. Iafrate and others are testing a few dozen genes known to be important in many different cancers. But that approach offers limited information — and in some cases can even mislead doctors.

That's what happened in the case of a 78-year-old man with a very rare tumor on his tongue. Doctors treating the British Columbia man had his tumor tested for a small number of mutations, finding that the tumor cells made twice as much EGFR protein as normal cells do. A drug prescribed to combat the change proved futile; the cancer spread to the man's lungs.

At that point, the clinicians decided they needed help. They turned to Steven Jones and his team at Canada's Michael Smith Genome Sciences Centre at the British Columbia Cancer Agency in Vancouver. Jones' team deciphered the complete genetic blueprint of one of the lung tumors. In a study published last year in *Genome Biology*, the researchers described the genetic mess: 7,629 genes were duplicated, triplicated or more; at least four chromosomes were missing huge chunks of DNA; and four genes contained mutations that would alter protein products. Also, 1,078 genes had higher-than-normal activity, while 1,986 others were less active than normal.

Compiling the data turned out to be the easy part. Figuring out which of these myriad abnormalities were responsible for the man's cancer required "quite a lot of computational gymnastics," Jones says. "There is no computer program that you just put your data in and it spits out what's causing the problem."

Before treatment



After treatment

**A drug targeting a common mutation in patients with spreading melanoma reduced tumor presence (darkness in chest and abdomen) within 15 days.**

It took "15 people in a room scratching our heads and consulting the literature" to conclude that a gene called *RET* and its cronies were probably driving the tumor's runaway growth, Jones says. *RET* produces a protein that helps cells decide when it is time to grow and differentiate. Other mutations in known cancer genes probably goaded further growth and made the tumors immune to the first drug.

With that info, the doctors put the man on a drug that inhibits the RET protein and other growth-promoting proteins. After about a month of treatment, the lung tumors had shrunk by 22 percent. But after four months on the drug, the tumors began to grow again, so doctors tried two other drugs. Those drugs bought the man another three months before the cancer started progressing yet again.

Researchers examined the genetic blueprints of the treatment-resistant cancer and found nine new mutations that weren't in the original tumor or the man's normal DNA. And other bits of DNA continued to be added and lost as well. Jones and colleagues speculate that only a carefully concocted cocktail of drugs could have stopped the cancer, which ultimately led to the man's death.

## Too little, too late

The case highlights how having a tumor's complete genetic profile — what scientists call a genome sequence — can change patient care. But the study is also an exception. Most studies catalog a tumor's genetic changes long after it has been removed from the body, when it is far too late to influence treatment, says Elaine Mardis, a genome scientist at Washington University School of Medicine in St. Louis.

Genome sequences aren't often used during early treatment because it can take months to prepare samples, compile the genetic blueprints and then analyze the results. In a study published in the April 20 *Journal of the American Medical Association*, Mardis and her colleagues showed that they could find the source of a patient's leukemia in just seven weeks, a short enough time to affect treatment.

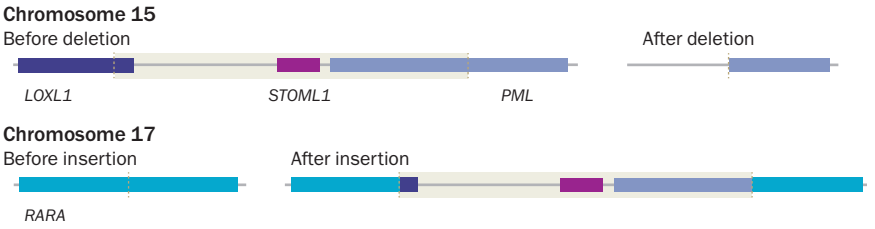
Still, Pao says clinical tests shouldn't take much longer than a week or two. And besides costing valuable time, the bill for a complete genetic blueprint can be substantial. Some companies estimate that it costs $5,000 to $6,000 to assemble a tumor's whole genome.

Mark Boguski, a pathologist at Harvard Medical School, thinks it's a bargain. "If I had cancer and $10,000, I'd have two choices: Take a cruise and check off my bucket list, or get my genome sequenced," he says. "I'd get my genome sequenced, no question."

But there are additional costs in the bioinformatics. Cancer databases that might help in interpreting genetic details usually don't present information in clinically useful ways, Pao says. Even for a doctor who has a patient's cancer genome in hand and knows all

K.T. FLAHERTY *ET AL*/*NEJM* 2010

**Power of the blueprint** A recent genetic study identified a segment of chromosome 15 that had relocated to chromosome 17 in a patient with a difficult-to-diagnose case of leukemia. The change, which affected the cancer-related *RARA* gene (bright blue), was not visible via a microscope.




SOURCE: J.S. WELCH *ET AL*/*JAMA* 2011

the mutations, it is incredibly hard to extract meaning from the alphabet soup of genetic errors. Pao and his Vanderbilt colleagues have built a new database that may help doctors decide which of the many mutations in a cancer cell are important, and which drugs to prescribe.

Right now, every time scientists compile a person's genetic information, they have to sift through a mountain of data to find the changes that are driving that person's cancer. "Every case is a research project," Boguski says.

## Spotting the drivers

Jerry Shay, a cell biologist at the University of Texas Southwestern Medical Center at Dallas, once wondered whether churning out reams of genetic data was even worthwhile.

"I started this thinking that we'd show most of this stuff was rubbish, and we were wasting money sequencing cancer genomes," he says. "I'm a complete turnaround."

Shay's original problem with most cancer genome studies was that they came up with exhaustive lists of all the ways that cancer cells are messed up and then somebody had to make a rather subjective decision about which of those abnormalities was important. Instead of guessing, he and his colleagues decided to ask colon cancer cells.

Previous studies had estimated that 151 genes play a role in colon cancer. Only eight to 15 were thought to really drive the tumor — causing its out-of-control growth. The vast majority of mutations were thought to have happened incidentally and were like passengers on a runaway bus.

Shay's team grew cells from the lining of the colon in lab dishes and then introduced mutations in two genes frequently involved in cancer, *p53* and *KRAS*. But cells with mutations in either of those genes grew fairly normally, the researchers reported in the July *Cancer Research*. Then the researchers used a genetic trick to start knocking out each of the 151 genes one by one from colon cells that already carried either the *p53* or *KRAS* abnormalities.

Instead of a bus with a few drivers and lots of passengers, Shay's team found that 65 of the presumed passengers were anything but backseat drivers. Those mutations had a hand either directly on the wheel or were involved in biological processes with genes that did, encouraging the colon cells to grow like tumors. Of those, 49 sparked cancerlike behavior when paired with either *p53* or *KRAS* mutations.

If the study were a Dr. Seuss book about colon cells, it might be called "Oh, the Places You'll Go Wrong!" There could be 50 to 100 paths that lead a colon cell to cancer, not just eight to 15 as other researchers had thought, Shay says.

"The idea that cancer cells accumulate a lot of incidental mutations that don't mean much is not well-founded," he says. "It's just not as simple as we'd like to think."

Finding so many genes steering cancer could be good news for treatment. Right now, there is no way to stop *KRAS* once it has run amok. But the right drugs might persuade a codriver to hit the brakes, Shay suggests. He says more tests are needed to determine if other cancers also have many drivers.

## Personal touch

After compiling genetic blueprints of more than 400 tumors from 20 different types of cancer, Mardis and her colleagues have discovered that genome sequences can point to more than just a cancer's driving mutations.

One thing Mardis and her collaborators have learned is that tumors are not monolithic entities. They contain many groups of cells, some with mutations that might render them immune to chemotherapy or targeted drugs. Even if such cells make up only 10 percent or less of a tumor, they could still cause the tumor to spread or cause a recurrence at the original tumor site. Mardis wants to determine just how many cells' DNA needs to be thoroughly looked at to identify all the problem mutations.

"We're not going to learn that information until we just go ahead and do it," she says.

Moving genetic testing forward may also one day help reveal whether precancerous cells are going to turn into cancer, saving some people from unnecessary surgery while allowing others to shut down cancer before a tumor revs up. "People don't really understand just how personalized cancer care is going to become," Mardis says.

The personal touch is still on the horizon, though. Despite decades of openly declared war on cancer, researchers are still in the early phase of learning about the genetics behind the disease.

When it comes to cancer, says Ryan, doctors are in the same position they were in when he started working in 1988 at Columbia College of Physicians and Surgeons in New York City. "HIV was rampant. Every night I was on call we'd admit 10 people, and seven to eight of them had HIV." Once the protease inhibitors came out in the mid-1990s, the university hospital no longer needed a floor for AIDS and tuberculosis. "It's gone," he says. "That's what we want for cancer." ■

## Explore more

- Explore the Vanderbilt-Ingram cancer database at mycancergenome.org

# LAST words

## Tevatron's data may have more to say, even after the atom smasher shuts down

**By Devin Powell**

REIDAR HAHN/FERMILAB

The most powerful atom smasher in the United States will soon smash no more.

Known as the Tevatron, this 6.3-kilometer subterranean ring was once the biggest, baddest physics machine in the world. For 26 years it has been slamming together bits of matter and antimatter moving at nearly the speed of light. These violent collisions spit out new particles never before seen by humankind, revealing some of nature's deepest secrets.

Yet for all its past achievements, the Tevatron's time has come. Facing a tight budget, the U.S. Department of Energy will shutter the aged machine on September 30 (*SN: 2/12/11, p. 5*).

A more powerful machine will continue the task of probing the universe at ever-smaller scales: the Large Hadron Collider, or LHC, at CERN near Geneva.

"Other people have had to turn off their colliders for the same reason that we're having to turn ours off now: There's a bigger, better game in town," says Steve Holmes of the Fermi National Accelerator Laboratory in Batavia, Ill., the preeminent particle physics lab in the United States and home to the Tevatron.

But even after the Tevatron has been embalmed, its liquid helium lifeblood drained away, the work won't be done. Some Fermilab scientists will spend months, others years, digging through the pile of information left behind: about a million billion recorded collisions between protons and their antimatter counterparts, antiprotons.

"Now that we're stopping taking data, we can concentrate all of our energy on updating our analyses," say Giovanni Punzi, a spokesman for the Tevatron's Collider Detector at Fermilab, or CDF, and a physicist at the University of Pisa and the National Institute of Nuclear Physics in Italy.

Some scientists believe the condemned machine still has something to say about the Higgs boson. This particle, whose existence would confirm the mechanism thought to give mass to other particles, has never been caught in action. With the LHC now the uncontested front-runner for this discovery, the Tevatron may still be able to help by narrowing the search, playing Horatio to the LHC's Hamlet.

Peculiar sightings reported by Fermilab scientists over the last few years will also be investigated, anomalies difficult to explain with the laws of nature as they are currently understood. If confirmed, such oddities could hint at new and exotic physics.

Sheer manpower may ultimately limit what can be found; every day, more physicists switch to other projects, including heading to the LHC. But extracting every last bit of science from the remaining data could add a final postscript to the Tevatron's legacy.

### Higgs hunt

Every collision recorded at the Tevatron during its lifetime has the potential to surprise. Each smashup between a proton and an antiproton can create

additional particles that break down into spectacular showers of debris. Two detectors at distant points along the Tevatron ring, CDF and another called DZero, record the energies and trajectories of these pieces of subatomic flotsam.

Working backward from this debris can reveal ephemeral particles that don't live long enough to be seen directly. One such particle is the Higgs. No one really knows what the Higgs looks like, but the most popular version would break down into a pair of quarks, fundamental particles that make up larger entities such as protons and neutrons. The pair of quarks expected from the Higgs — a bottom quark and its antimatter partner — would in turn decay into jets of still other particles visible to the Tevatron.

As with Bigfoot, though, one snapshot isn't enough to claim discovery. Despite upgrades over the years, the Tevatron hasn't produced enough collisions to definitively rule out statistical flukes, random fluctuations that could mimic the Higgs.

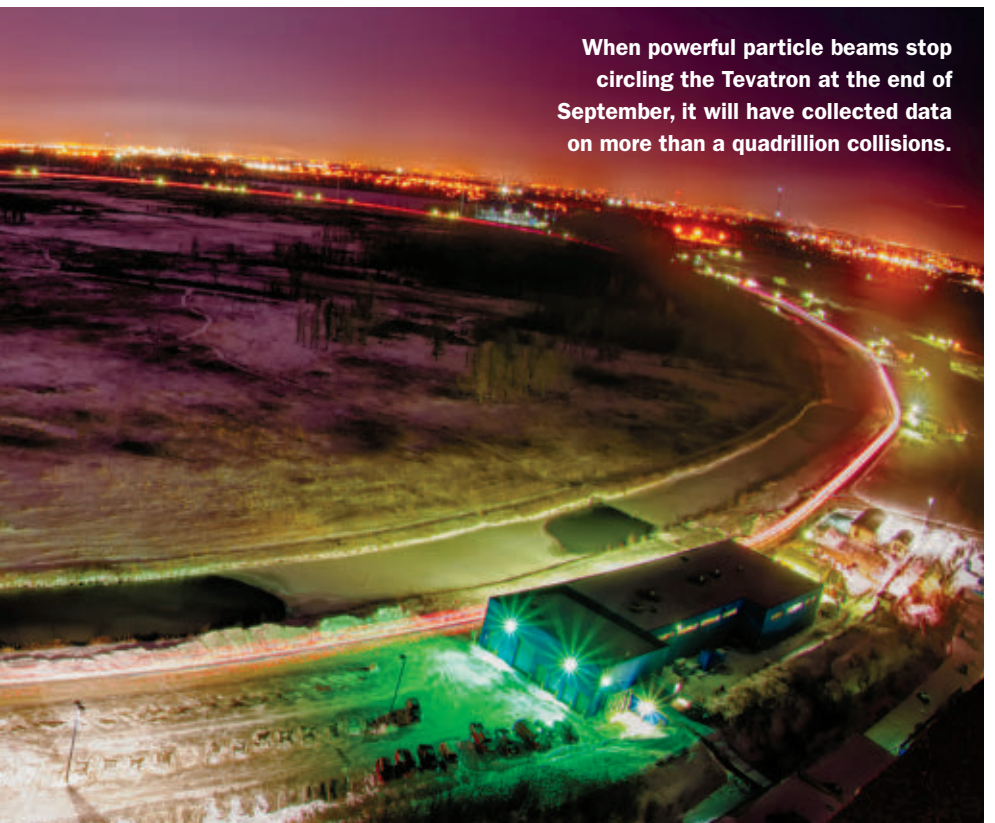
"Discovering the Higgs boson has always been a really long shot for the Tevatron," says Chris Quigg, a theoretical physicist at Fermilab.

With the details of the Higgs still unknown, the Tevatron could help rule out some possible masses for the particle, though. Statistically speaking, it's easier to show what isn't than to show what is.

In July the Tevatron eliminated a sizable swath of possible masses. Previous work had put the mass of the Higgs particle somewhere between 114 billion and 185 billion electron volts, or GeV. (Particle physicists measure mass in energy, relying on Einstein's $E=mc^2$.) The new analysis, which included about 80 percent of the total data expected to be collected before shutdown in September, ruled out 156 to 177 GeV with 95 percent confidence.

Still newer results from the LHC have given the Higgs even less space in which to hide. If the Higgs is the version most physicists expect, it should have a mass less than 145 GeV, researchers reported in August in Mumbai at a high-energy physics meeting.

Whether the Tevatron can winnow away more of the remaining range with its full dataset remains to be seen. Both the LHC and the Tevatron have spotted the faintest hints of something Higgs-like below about 145 GeV. If either the Tevatron or the LHC's data rule out this region, more exotic versions of the Higgs will need to be considered.



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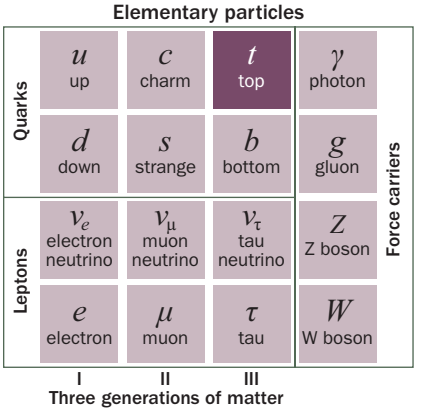
**When powerful particle beams stop circling the Tevatron at the end of September, it will have collected data on more than a quadrillion collisions.**




**For more than a quarter century, the Tevatron has probed the standard model's particles (shown); the top quark was discovered at the Tevatron in 1995.**

"We expect to complete our Higgs analysis by March," says Fermilab's Rob Roser.

## Standard model defender

The Higgs is only one piece of a much larger puzzle called the standard model of particle physics. Stitched together in the 1970s from earlier theories, this modestly named cornerstone of modern physics uses 16 elementary particles to explain most of the clockwork that keeps the universe ticking, with the notable exception of gravity.

Throughout its long history, the Tevatron has risen to defend the standard model again and again. The collider discovered a host of particles predicted by the model — both a fundamental particle and larger ones built of the fundamental units — filling in the blanks of subatomic family trees. Some of these particles still haven't been seen anywhere else: certain baryons — composite particles made of three quarks — for instance (*SN: 9/27/08, p. 7*; *SN: 8/27/11, p. 14*).

"The Tevatron really helped to establish how good the standard model is," says physicist Frank Wilczek of MIT, who won a Nobel Prize for his contributions to the model. "It's much better than we anticipated in the early days."

In 1995 the Tevatron discovered the top quark, the last of the standard model's six quarks to be spotted. Physicists had expected to find the particle after

a 1977 Fermilab experiment turned up evidence for the bottom quark, a particle that needed a partner. But machines built specifically to search for that partner — the TRISTAN detector in Japan, for instance — were striking out. The problem, scientists began to realize, was the top quark's bizarre mass. It weighs almost as much as an entire atom of gold.

"The top quark turned out to be much heavier than we originally thought," says Meenakshi Narain, a particle physicist at Brown University in Providence, R.I., who helped discover it.

Such a heavy particle could be created only by the high-energy collisions of the Tevatron, which reach almost 2 trillion electron volts. That's about twice the energy due to motion of a flying mosquito in an area a trillionth as big. Only Fermilab physicists have measured the mass of this particular quark, a measurement repeated with ever-greater precision over the years.

Adding more numbers to the right of a decimal point may not sound as sexy as discovering a new particle. But knowing these masses precisely helps to calibrate the mathematical machinery of the standard model, which doesn't predict the masses of particles by itself. Tevatron measurements of the heaviness of the top quark and another particle called the W boson provided an important indirect limit on the Higgs mass, before those indirect measurements were trumped by the LHC's latest data.

The Tevatron's unflagging support of the standard model, though, has also been a source of great disappointment. Physicists need something beyond this framework, something that can explain why the Higgs, if discovered, has the mass it does. Extra dimensions beyond the four that people experience as space and time have been proposed, as has a new kind of symmetry hidden in the universe.

Many had hoped that the Tevatron would reveal signs of this "supersymmetry," one of the most popular extensions of the standard model. According to supersymmetry, every particle has a shadowy twin that differs in a quantum property called spin.

But no evidence of these extra particles has turned up. If such particles exist, they probably have high masses and can be produced only in the higher-energy collisions possible at the LHC.

"There are all these unrealized hopes," says Michael Peskin, a theoretical physicist at SLAC National Accelerator Laboratory in Menlo Park, Calif. "They didn't find any new interactions beyond the interactions included in the standard model."

## Hand-wringing hints

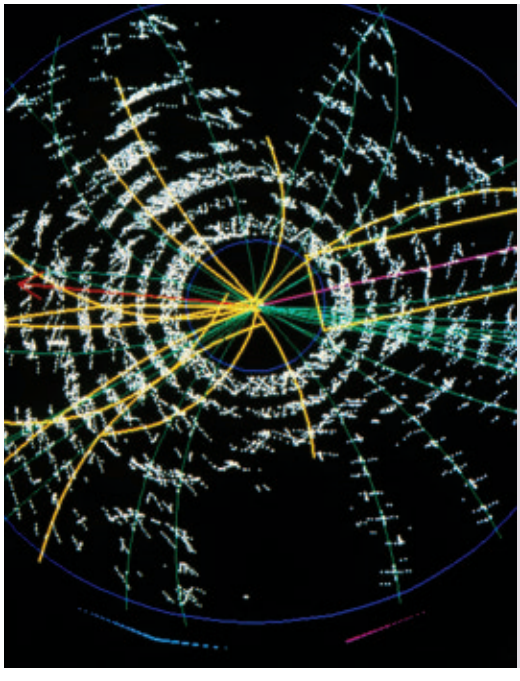
While it's true that no Tevatron claims of physics beyond the standard model have been verified, some strange but inconclusive anomalies have popped up in the collider's final years. These hints, some of which have already been challenged by other measurements at the Tevatron and elsewhere, have physicists wringing their hands and pulling their hair.

The Tevatron isn't the first particle collider to tantalize scientists at the end of its days. In 2000, the Large Electron-Positron Collider at CERN found a strange signal in its data just before its shutdown. This blip at about 115 GeV was in the right range to be the Higgs, some argued. But the odds of a fluke were too high to claim a discovery, and the mysterious signal hasn't been substantiated.

Fermilab physicists hope to fare better as they analyze their remaining data.

"When Columbus started his journey, he didn't know he would discover America," says Dmitri Denisov, a spokesman for DZero. "We're just going and seeing what we can find."

In 2008 CDF spotted pairs of particles behaving badly. Top quarks created



FERMILAB/PHOTO RESEARCHERS, INC.

## TeV legacy

The Fermi National Accelerator Laboratory, home to the Tevatron, has hosted a number of important discoveries over several decades.

**December 1966**
Weston, Ill., selected as the site for the new National Accelerator Laboratory

**March 1972**
First proton beam with energies at 200 GeV, the target energy, circles the main ring

**May 1974**
NAL becomes Fermilab, named for Enrico Fermi

**June 1977**
Discovery of the bottom quark

**July 1979**
U.S. Department of Energy signs off on the building of a superconducting accelerator, later called the Tevatron

**October 1985**
First collisions of protons and antiprotons observed at the Tevatron's Collider Detector at Fermilab, with energy of 1.6 TeV

**March 1995**
Discovery of the top quark (particle tracks shown) reported by both detectors

**March 1999**
Direct observation of CP violation in neutral kaons, suggesting not all particles and their antiparticles behave symmetrically

**July 2000**
First direct observation of the tau neutrino, the third neutrino type

**June 2009**
Observation of the Omega-sub-b baryon, an exotic and much heavier cousin of the proton

**July 2011**
Discovery of the neutral Xi-sub-b particle furthers scientific understanding of how quarks form other matter particles

in proton-antiproton collisions tended to move in the direction of the protons. Antitop quarks, the antimatter version of the top quark, generally moved back the other way.

A later look with more CDF data, about half of what will be collected by the end of September, only strengthened the statistics, and DZero has also reported this unexpected preference. The anomaly is too strong to square with the predictions of quantum chromodynamics, one of the theories rolled into the standard model.

A bookie taking bets that the CDF asymmetry is a fluke could post odds just shy of one in a thousand — about a "three sigma" result, in the language of physicists. That's not good enough to say anything for sure, but it has stirred up some excitement.

"I find this forward-backward asymmetry tantalizing because both experiments saw it," says Christopher Hill, a theoretical physicist at Fermilab.

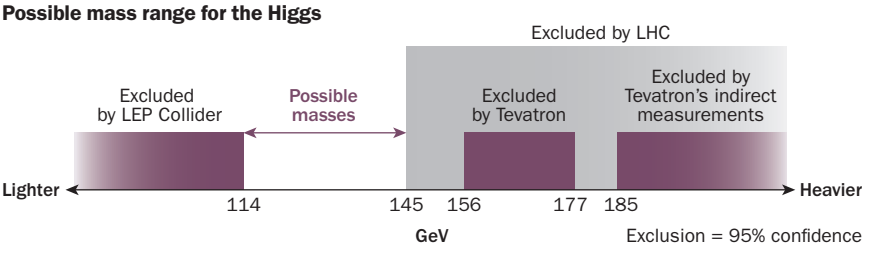
Hill has an explanation for this unusual behavior, worked out in full mathematical detail by Harvard physicist Matthew Schwartz and colleagues in a paper posted online June 15 at arXiv.org. Two top quarks might behave like a pair of electrons in a superconductor, a material with no resistance to the flow of electricity. A new particle could unite the pair, which, in this theory, play the role of the Higgs by explaining the origin of mass.

Then again, adding in the full dataset could also wipe out this anomaly.

"We can't make any claim yet, but we should have a more definitive look at this thing by next summer," says Dan Amidei, a member of the CDF team and a physicist at the University of Michigan in Ann Arbor. "My greatest worry is not that it goes away with more data, but that it remains a hint and we never know what it was."

Other curiosities on the table include jets of particles with energies between 120 and 160 GeV, which could be the remnants of a new, unexplained particle (not the Higgs). CDF saw the jets, but DZero didn't. DZero, meanwhile, has uncovered an unexplained preference for the production of the matter version of the muon — an overweight cousin of the electron — over the antimatter version. This tricky measurement hasn't been repeated by the CDF team.

**Higgs in hiding** Though the Tevatron is out of the running to discover the Higgs boson, analyses of the atom smasher's remaining data may further limit this elusive particle's potential mass. Recent findings at the Large Hadron Collider suggest the Higgs mass is below 145 GeV.




Convincing the wider physics community that these oddities are real will be difficult. The LHC has already begun to investigate them; early results, presented in July at a meeting in Grenoble, France, contain no signs of anything out of the ordinary, contradicting the Tevatron results.

"I think they're embarrassing rubbish," says Wilczek, who favors supersymmetry as an extension of the standard model. "You really have to do contortions to make these things consistent with what we know, and I find it hard to believe that Mother Nature has such poor taste."

## Future frontiers

Even though the LHC is currently running at half its intended strength, that international machine will soon be the sole collider pushing the high-energy frontier in search of never-before-seen particles. No one else can compete with its collisions.

Without its famed atom smasher, Fermilab is shifting its focus to other areas, including the activities of already discovered particles. Next year, the lab will shut down temporarily to transplant some of the Tevatron's bits and pieces into other experiments and to upgrade its accelerator complex for a new generation of experiments that require intense beams packed with tremendous numbers of particles, just not at such high energies.

Beams that once fed the Tevatron will be reconfigured to churn out muons for projects including Muon g-2. By examining the strange behavior of muons in magnetic fields, this project could point to certain versions of supersymmetry.

Other particles called neutrinos, loners that barely interact with the rest of matter, will become a centerpiece of particle physics in the United States, as well as in France, China and Japan. NOvA, an experiment under construction at Fermilab, will shoot beams of these particles 810 kilometers underground to a mine near the United States' border with Canada. Understanding how neutrinos change from one kind to another during this trip could help to solve one of the biggest puzzles in physics: why the universe contains vastly more matter than antimatter.

Other big questions still remain for particle physicists at Fermilab and other institutions in the United States and around the world. Physicists don't understand what the universe looked like in its first moments, for instance. No single theory has convincingly united gravity with nature's other forces. And no one knows what dark matter and dark energy are, even though such invisible stuff appears to make up more than 95 percent of the universe's mass-energy.

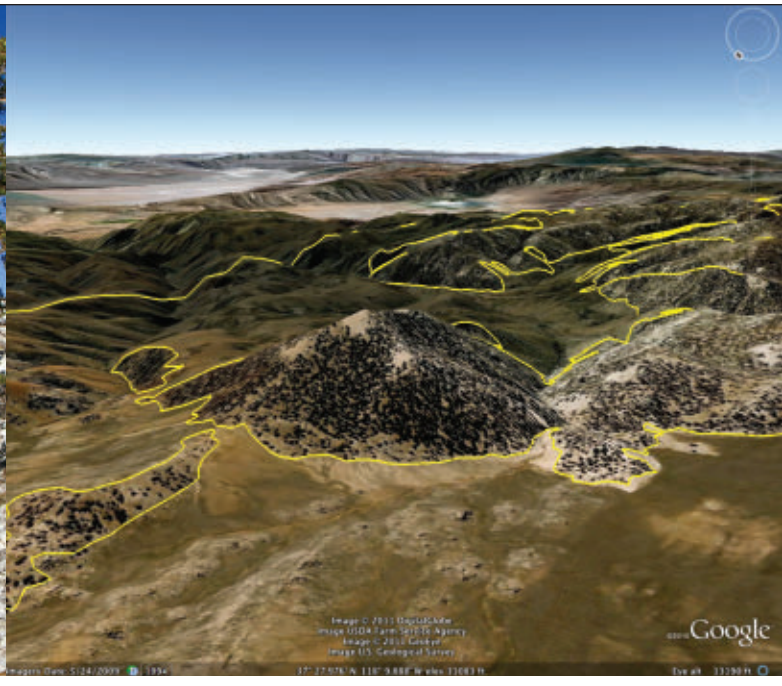
In the coming decades, a host of projects will tackle these big questions from different angles. With all its strength, even the LHC isn't expected to have the final word. Already, scientists are planning for the next biggest, baddest physics machine. ■

## Explore more

- For info on proposed future colliders: arxiv.org/abs/0909.3240

T. DUBÉ

# Science from on High




## Google Earth gives researchers new access

By Rachel Ehrenberg

If Christopher Columbus wanted to travel the globe today, he wouldn't need three ships and the financial backing of royalty — an Internet connection would do the trick. With Google Earth's three-dimensional interactive view of the planet, Columbus could sail to the New World from the comfort of his living room (after checking out an overhead view of his house in Genoa).

By combining satellite imagery, aerial photography and geographic data, Google Earth provides views of planet Earth — and its moon and Mars — that were once available only to the well-funded and tech-savvy. And while the computer program offers unprecedented virtual trips to places many would never be able to visit, such as the Colosseum and the Galápagos Islands, Google Earth isn't just a tool for voyeuristic global tourists. The technology is changing the way scientists conduct research.

Some are using the tool for good old scientific discovery, à la Lewis and Clark, who documented much of the wildlife of the American West. Ecologist Adelia Barber, for example, scouts the rugged and largely inaccessible terrain of California's White Mountains seeking the long-lived bristlecone pine. Barber, of the University of California, Santa Cruz, has found that Google Earth's resolution of that swatch of the globe is good enough for her to tell a bristlecone forest from a stand of piñon pine, greatly simplifying her efforts to map and study bristlecones.

Marine ecologist Elizabeth Madin is taking this bird's-eye view to the seas. After a colleague mentioned seeing halos of bare sand around sections of coral reef on Google Earth, Madin, a postdoctoral fellow at the University of Technology, Sydney, immediately suspected that small critters munching swaths of seaweed formed the rings. Madin checked out the lagoons of Australia's Great Barrier Reef with the program and was astounded that the little nibbles of fish and sea urchins might have such a visible effect.

"These are really small-scale interactions and yet they have really large-scale effects that you can actually see from space," Madin says. "It's cool."

Subsequent trips to the reef confirmed that the barren rings were what are called "grazing halos," relatively safe zones into which the grazers dare venture from the reef's shelter. Further looking via Google Earth revealed no such halos in a heavily fished section of a reef off Jakarta.

In areas where overfishing has cleared out top predators, small grazers dine where they like, leaving no obvious footprint, Madin and her colleagues reported online June 14 in *Scientific Reports*. Google Earth might be a good tool for remotely monitoring interactions between predators and prey in all kinds of environments, Madin says. She can imagine scientists probing such relationships high in the Rockies, where the reintroduction of wolves is shifting elk populations, thus altering the distribution of plants on which elk graze.

Getting to reefs often involves hiring a boat and a crew of scuba divers, which can cost tens of thousands of dollars, Madin says. Likewise, high mountain habitats can be hard to reach. But surveying from space may provide scientists like her with a "first cut," saving time and money.

"At this stage we're really using it like a telescope," she says. While Google Earth surveys won't replace on-the-ground work, they could be harnessed for conservation management, says Madin, especially in areas with limited staff and funding.

**With Google Earth's overhead view, ecologist Adelia Barber can generate maps of California's White Mountains that highlight regions (yellow outline) where bristlecones (far left) might grow.**

## An eye on the wild

Zoologist Iain Douglas-Hamilton, founder of Kenya-based Save the Elephants, is doing just that.

Shortly after Google Earth was released in 2005, Douglas-Hamilton brought his tracking data from GPS collars on African elephants to Google and asked for help integrating the data with the program. Today, the tagged elephants' whereabouts are streamed onto Google Earth's satellite maps. This visual data, which the scientists can access from anywhere in the world, provides details about the when, where and why of elephant movement. Working with Google Earth has offered new insights into elephant ranges and roadways, for example, shedding light on favorite watering holes, the value of protected corridors of land and who is interacting with whom.

"It provides a really nice overview of what an elephant's been up to," says Jake Wall, a graduate student at the University of British Columbia in Vancouver who is working with Save the Elephants.

More recently, the team has used the program to spot potential poaching. If a young and healthy elephant stops moving or suddenly moves a very long distance — both red flags that the animal has been killed — Douglas-Hamilton's team can send a detailed history of that elephant to local wildlife officials.

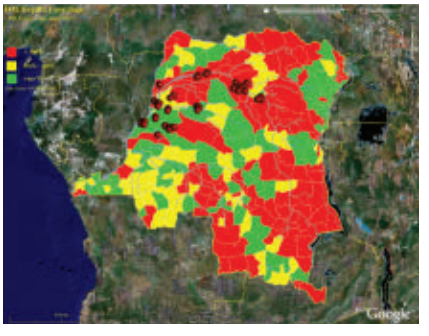
Google Earth is all about visuals, not analysis, Wall notes. He compares it to Microsoft PowerPoint, which makes data pretty and digestible, as opposed to Excel, which does the actual number crunching. Yet visual tools in the right hands can have great power, providing a universal language that crosses scientific disciplines. Public health officials recently harnessed Google Earth to guide an entire vaccination program after more than 50 people acquired polio during an outbreak in the Congo.

"I had my GPS device and I started putting in coordinates of reported cases," says Raoul Kamadjeu of the U.S. Centers for Disease Control and Prevention's global immunizations division in Atlanta. When he saw the data expressed all at once on the computer screen, Kamadjeu realized that the outbreak was tracking along the Congo River.

With Google Earth, which provided much better geographic data than available handmade maps, Kamadjeu and his colleagues could estimate how long it would take and how many staff members were needed to vaccinate every young child living along a particular stretch of the river. The program allowed the design of a speedy and effective campaign that vaccinated many people who had previously been missed, he reported in the *International Journal of Health Geographics* in 2009. This "river strategy" continues to be helpful in fighting polio in the region today.

## Caller corrections

Back in the lab, Google Earth can help scientists out in another way — as they try to test their hypotheses. The National Oceanic and Atmospheric Administration's National Severe Storms Laboratory in Norman, Okla., collects high-resolution radar and satellite data that are fed into algorithms used for storm warnings and forecasting. One test of these predictions is voluntary reports by citizens who call to say, "Hey, it's hailing here," says Valliappa Lakshmanan, of the NOAA lab and the University of Oklahoma. But in sparsely populated areas, the lab might get just one data point from a citizen caller.



**By mapping the locations of recent polio outbreaks (dots) in the Congo along with vaccination data (colors), researchers could better understand how the disease spreads.**

Now the lab integrates prediction data with Google Earth as part of an ongoing project called the Severe Hazards Analysis and Verification Experiment, or SHAVE. Phone number data sets are overlaid on a map of a region, and University of Oklahoma students are called upon to contact people in areas where storms were predicted, gathering location-specific data on when storms started, how big the hailstones are or how much a stream is overflowing its banks.

After applying this system to flash flood predictions throughout the United States in the summer of 2008, the team found that only 133 of the 417 severe events reported to SHAVE occurred within areas designated by the traditional approach.

This find suggests that the traditional algorithms aren't capturing the full spatial extent of flash flooding, researchers from the NOAA lab and the University of Oklahoma reported in the *Journal of Hydrology* in November. Now the researchers can refine their algorithms to better predict which environments are most vulnerable to flash flooding, Lakshmanan says.

For all the help that Google Earth gives to researchers at NOAA and elsewhere, scientists are helping Google Earth too, uploading a wealth of data now easily available to the public. Users can access the U.S. Geological Survey's earthquake data to see where and how big each recorded quake rumbles, look up local ant species or follow a shark as it swims the Pacific.

Students can even explore the American West. But gone are the clunky graphics of the game *Oregon Trail*; the experience of today's kids approaches the richness of Lewis and Clark's original journey. ■

## Explore more

- To see how scientific and other organizations are using Google Earth: earth.google.com/outreach/showcase.html

### Sex on Six Legs: Lessons on Life, Love and Language from the Insect World

*Marlene Zuk*

People are more afraid of insects than of death, or so says a survey that Zuk cites a bit skeptically. (Heights and public speaking are supposedly scarier than both.) Surveys aside, bugs certainly have a PR problem, and Zuk is out to win friends for them.

Her wry, amiable volume makes a case for appreciating the wonders and weirdnesses of the most numerous of animals. As she puts it, an insect-of-the-month calendar might not have to repeat a species for well over 80,000 years. The book thus falls into the paradoxical tradition of the why-not-to-hate-bugs book that appeals especially to people who already love them. An earlier classic of this microgenre, May Berenbaum's *Bugs in the System*, has amused insect enthusiasts since 1996, and Zuk, a behavioral ecologist, focuses on more recent research.

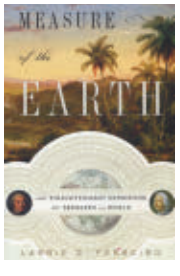
Despite the title, which depending on personal tastes can be a plus or a minus for a commuter read, the book gives clear accounts of a wide range of research beyond sex: insect personalities, wasp facial recognition, fruit flies artificially bred for intelligence, slave-making ants, hitchhiking blister beetles and much more. One of the more unusual sections is the first, the obligatory chapter on why anybody should care about insects. Along with the expected discussions of ecological importance and value for humankind, Zuk articulates the emotional appeal of humans' six-legged neighbors. They give people "the ability to glimpse another world," a spot-on phrase for one of their charms. As Zuk asks, "Who needs to be able to see dead people when you can see live insects?" —*Susan Milius*


*Houghton Mifflin Harcourt, 2011, 272 p., $25*

### Measure of the Earth: The Enlightenment Expedition That Reshaped Our World

*Larrie D. Ferreiro*

Barely two centuries after Columbus found that the world wasn't flat, scientists set out to establish whether it was really round. The question required comparing the distance between degrees of latitude in Europe — which had been measured — with that distance in the Arctic or at the equator.



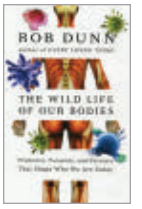

In his latest book, Ferreiro gives life to three French scientists and their 1736 geodesic mission to the equator. Astronomer Louis Godin, mathematician Pierre Bouguer and geographer Charles Marie de La Condamine offer a snapshot of another time.

The scientists traveled to a plateau near Quito in South America. There they surveyed a 215-mile line and used it to calculate giant imaginary triangles using geometry, trigonometry, a device called a quadrant, star sightings and land distance measurements. Triangulating nearby peaks of the Andes with points on the ground, they found that one degree of latitude was shorter at the equator than in Europe. In other words, the Earth bulges at the equator.

At times the story can bog down in detail, but surprises make up for it. The mission was the first large international scientific expedition attempted and led to the discoveries of rubber and cinchona bark — the source of quinine — and the naming of Ecuador.

Not until 1743, after the calculations were complete, did the scientists realize they had also determined Earth's size. La Condamine found out belatedly; he was on the first scientific expedition down the Amazon. Another time indeed. —*Nathan Seppa*

*Basic Books, 2011, 337 p., $28*

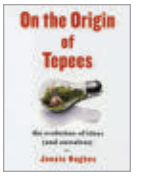



**The Wild Life of Our Bodies**
*Rob Dunn*
A biologist explores how "clean living" has made people sicker in some ways. *Harper, 2011, 290 p., $26.99*


**Virtual Water**
*Tony Allan*
Learn why it takes 140 liters of water to make a cup of coffee in this exploration of the water use hidden in everyday life. *I.B. Tauris, 2011, 368 p., $18*


**Among African Apes**
*Martha M. Robbins and Christophe Boesch, eds.*
Tales and photos from primate researchers give readers a vivid look into the lives of apes. *Univ. of California Press, 2011, 182 p., $29.95*


**Future Science**
*Max Brockman, ed.*
Essays by 19 young scientists explore how science will answer questions ranging from nature versus nurture to understanding infinity. *Vintage Books, 2011, 247 p., $15.95*




**On the Origin of Tepees**
*Jonnie Hughes*
An entertaining tour of the American West shows how ideas spread through the cultural landscape. *Free Press, 2011, 302 p., $25*

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## New light on sunshine vitamin

Regarding the article "The power of D" (*SN: 7/16/11, p. 22*), I was very surprised that there was no mention of the positive effects of this vitamin on the debilitating effects of depression. I have lived in northern latitudes between upstate New York and now Vermont since my birth in 1954. My mother reminds me how she used to worry about the annual return of my severe depression as a young child, which turned more serious in January. I have childhood memories of colds, bronchitis and pneumonia.

However, after attending a lecture in Lenox, Mass., two years ago on the subject of vitamin D, I have been taking larger doses of vitamin D and my depression has virtually disappeared.

When my doctor learned that I was doing this, he shared his concern about potential toxicity. But tests showed my blood levels for vitamin D were normal. I would imagine that everyone has to define the exact amounts right for their body for themselves, but I do know that this little golden and translucent pill has saved my life.

**Liz Winn,** Marshfield, Vt.

*Many studies have linked vitamin D deficiency with depression. A German study in 2000 found that people with depression had lower levels of vitamin D than those without the condition, and in 1999 a U.S. study showed that a megadose of vitamin D (100,000 IU) resulted in improvement in depression scores in people with seasonal affective disorder. A third study in Norway in 2008 randomly assigned depressed, overweight people to get vitamin D supplements or placebos for a year without knowing which. Those receiving vitamin D showed substantial improvement; those on placebo did not.*
*— Nathan Seppa*

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In your five-page article on vitamin D, you report that 30 minutes of exposure to sunlight provides about 10 times the upper recommended daily allowance (2,000 international units or IU recommended by the Endocrine Society) of the vitamin, yet devote much of the discussion of the appropriate level of vitamin D to far less effective means (natural and fortified food, and pharmaceuticals). Wouldn't recommending that everybody take each day a five-minute tan (free, less time-consuming than other means of obtaining vitamin D, and certainly not sufficient to get a sunburn) render this whole matter moot?

**Ernst L. Leiss,** via e-mail

In order to neither underdose nor overdose on vitamin D, it seems to make sense to measure vitamin D blood levels before deciding on how much to supplement.

**Stan Rosenfeld,** Fairfax, Calif.

In "The power of D," two additional aspects should have been included. First, it is ultraviolet B sunlight, the burning wavelength region, which is necessary to create vitamin D in our skin. During the winter, even in southern regions of the United States, it may be difficult to get enough exposure to ultraviolet B from the sun.

Second, you did not deeply discuss concerns about exposure to high, possibly toxic levels of vitamin D supplements. I believe this issue involves possible kidney damage, but I am not aware of the evidence behind these concerns. Such a discussion would have further enriched your excellent review.

**James P. Collman,** via e-mail

*Overdosing on vitamin D from the sun appears impossible. The body has a fail-safe mechanism that shuts down the vitamin D–making apparatus in the skin when levels are topped up. Supplements are another matter, but it still takes a lot to overdose on vitamin D. Danish researchers in 1986 found that people taking 4,000 IU of vitamin D daily for two months ended up with blood levels of about 45 nanograms per milliliter, well within the normal range and somewhat less than an outdoor lifeguard would have all summer. Reinhold Vieth of the University of Toronto finds that his and other studies arrive at 10,000 IU a day as a safe upper daily limit.*

*The Institute of Medicine in 2010 set the safe upper limit of vitamin D per day for an adult at 4,000 IU. The Endocrine Society in 2011 put the daily limit for adults at risk for vitamin D deficiency at 10,000 IU. The 10,000 IU mark falls within evolutionary bounds by not exceeding what full-body exposure to sun delivers in a day.*
*— Nathan Seppa*

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## IQ droppers

According to "Chemicals linked to kids' lower IQs" (*SN: 5/21/11, p. 15*), neurotoxic chemicals may lower children's IQs by up to 7 points. There is another substance associated with a similar IQ point difference in children, but no one mentions it. The point spread between breast-fed and formula-fed children has been that large in some studies.

Parents are told about the IQ drop of up to 7 points with pesticides. They're told about the IQ drop with low-level lead exposure. Don't they deserve to know about the population-wide IQ deficit linked to formula-feeding? Maybe if they knew, they'd insist on more than the mediocre breast-feeding help with which most women are forced to make do.

**Diane Wiessinger,** Ithaca, N.Y.

## Compliments

I am a retired chemical engineer who has had a subscription to *Science News* magazine for a couple of years. It excels in covering many science disciplines concisely, understandably and timely. Because it is valuable to my continuing interest in science, I look forward to receiving each issue.

**William Scudder,** Sarasota, Fla.

**Send communications to:** Editor, Science News, 1719 N Street, NW, Washington, D.C. 20036 or **editors@sciencenews.org**. Letters subject to editing.

# From the Archive

For the full 1926 article, visit
**www.sciencenews.org/archive_coulter**

## Evolution should be taught to all students, says botanist

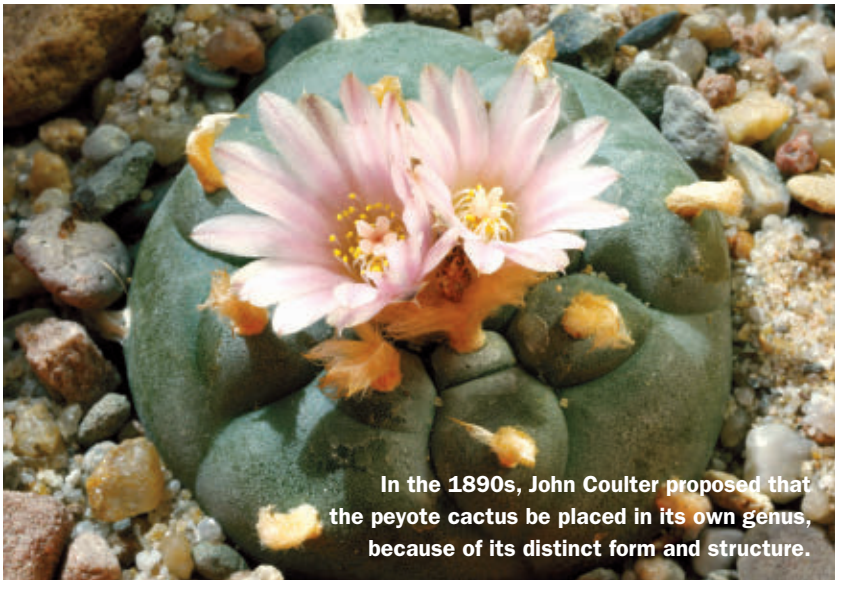
Instruction in evolution for all college students is advocated in a recent number of *Science* by Dr. John M. Coulter, formerly head of the department of botany at the University of Chicago and now associated with the Boyce Thompson Institute for Plant Research at Yonkers.

There are at least three important reasons why evolution should be regarded as a necessary part of college training, Dr. Coulter says.

"It has revolutionized modern thought. Every subject today is being attacked on the basis of its evolution. Not only are inorganic and organic evolution being considered, but also the evolution of language, of literature, of society, of government, of religion. In other words, it is a point of view which represents the atmosphere of modern investigation in every field.

"It is persistently misunderstood. From the press, the lecture platform and even the pulpit, one frequently hears or reads amazing statements in reference to organic evolution. If it were made an essential feature of student training, there would be developed a propaganda of information instead of misinformation.

"It has revolutionized agriculture. The practical handling of plants and animals, in the way of improving old forms and securing new ones, was made possible and definite when the laws of inheritance began to be uncovered through experimental work in evolution."



In the 1890s, John Coulter proposed that the peyote cactus be placed in its own genus, because of its distinct form and structure.

UPDATE

## Antievolution movement lives on

Evolution needed as many defenders as it could get in the mid-1920s. In 1925, John Scopes was found guilty of breaking a newly passed Tennessee law forbidding the teaching of evolution. Within the next two years, more than a dozen states considered antievolution bills, with Arkansas and Mississippi enacting such laws.

Though evolution may have lost the court case, its scientific support became widely publicized. Botanist John Coulter was one among many whose opinions were made known in the pages of the *Science News-Letter*. In June 1925, a council of the American Association for the Advancement of Science affirmed that "the evidences in favor of the evolution of man are sufficient to convince every scientist of note in the world, and that these evidences are increasing in number and importance every year." That same month, Watson Davis, managing editor of the *Science News-Letter*, noted that the very ground on which the Scopes trial was argued contains fossils that "will all be irrefutable witnesses for the defense if men will but use their eyes and their brains."

The issue was rekindled in the late 1950s. In an apparent response to the perceived superiority of the Sputnik-launching Soviets, U.S. school curricula were revamped to boost science literacy. New textbooks highlighted evolution as a unifying biological principle. By the 1960s a "creation science" movement was in full swing; it has since morphed into the "intelligent design" movement. Ongoing debate reveals that denial of Darwin's ideas doesn't die; it just evolves. — *Elizabeth Quill*

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*Thank-you.*
*– G. Austin, MA*

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Neutronic Ear has been designed with the finest micro-digital electronic components available to offer superb performance and years of use. Many years of engineering and development have created a product that's ready to use right out of the box. The patented case design and unique clear tube make it practical and easy to use. The entire unit weighs only 1/10th of an ounce, and it hides comfortably behind either ear. The tube is designed to deliver clear crisp sound while leaving the ear canal open. The electronic components are safe from moisture and wax buildup, and you won't feel like you have a circus peanut jammed in your ear. Thanks to a state-of-the-art manufacturing process and superior design, we can make Neutronic Ear affordable and pass the savings on to you.

It works… but don't take our word for it. Why pay thousands to make everything sound louder when what you really need is a Personal Sound Amplification Product? We're so sure you'll be absolutely thrilled with the quality and effectiveness of this product that we are offering it to the public at a low introductory price with our exclusive trial offer. If, for any reason, you are not completely amazed by how this product improves your life, simply return it for a refund of the product purchase price within 30 days. Call now.

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**For people like me, who want a cell phone that's easy to use.** Over the years, cell phones have become smaller and smaller with so many complicated features. They are harder to program and harder to use. But the Jitterbug cell phone has simplified everything, so it's not only easy to use, it's easy to try. No crowded malls, no waiting in line, no confusing sales people, or complicated plans. Affordable and convenient cell phone service is only a toll-free phone call away.

**The cell phone that's right for me.** Sometimes I think the people who designed this phone and the rate plans had me in mind. The phone fits easily in my pocket, and flips open to reach from my mouth to my ear. The display is large and backlit, so I can actually see who is calling. With a push of a button I can amplify the volume, and if I don't know a number, I can simply push "0" for a friendly, helpful operator that will look it up and even dial it for me. The Jitterbug also reduces background noise, making the sound loud and clear. There's even a dial tone, so I know the phone is ready to use.

**Affordable plans that I can understand – and no contract to sign!** Unlike other cell phones, Jitterbug has plans that make sense. Why should I pay for minutes I'm never going to use? And if I do talk more than I plan, I won't find myself with no minutes like my friend who has a prepaid phone. Best of all, there is no contract to sign – so I'm not locked in for years at a time or subject to termination fees. The U.S.–based customer service is second to none, and the phone gets service virtually anywhere in the country.


Available in Graphite and Red.

| Monthly Minutes | 50 | 100 |
|---|---|---|
| Monthly Rate | $14.99 | $19.99 |
| Operator Assistance | 24/7 | 24/7 |
| 911 Access | FREE | FREE |
| Long Distance Calls | No add'l charge | No add'l charge |
| Voice Dial | FREE | FREE |
| Nationwide Coverage | Yes | Yes |
| Friendly Return Policy[1] | 30 days | 30 days |

More minute plans available. Ask your Jitterbug expert for details.

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