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# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ FEBRUARY 28, 2009

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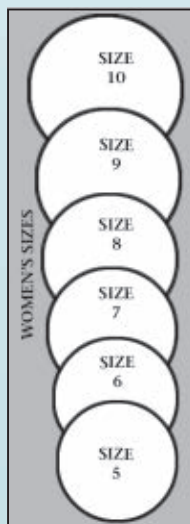
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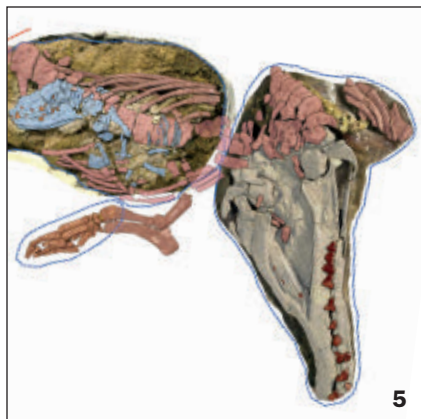
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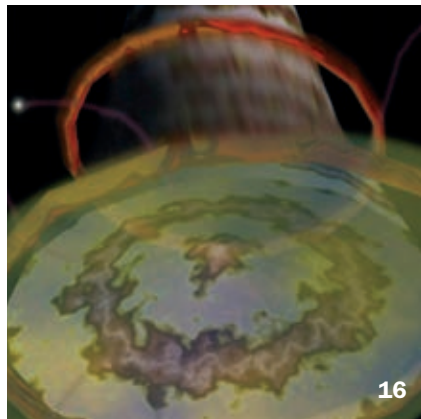
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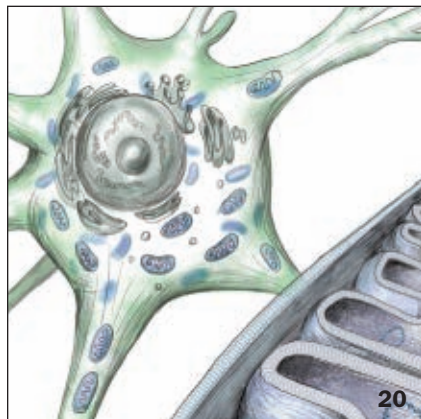
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**COVER** Like its larger, populated neighbors, this small island in the Maldives is threatened by rising seas.

*Photograph by Craig Tuttle/Corbis*

FROM TOP: UNIVERSITY OF MICHIGAN MUSEUM OF PALEONTOLOGY; DANIEL STAHLER/NPS; M. DEBORD, R. RAMATY AND B. KOZLOVSKY/GSFC; R. LINGENFELTER/UCSD, NASA; NICOLLE RAGER FULLER

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**EDITORIAL, ADVERTISING AND BUSINESS OFFICES**

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*Subscriptions* subs@sciencenews.org • *Editorial/Letters* editors@sciencenews.org

*Advertising/Business* snsales@sciencenews.org

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## FROM THE EDITOR

# Science's status trumps winning Super Bowl rings



Had Vince Lombardi been a scientist, he would no doubt have won a Nobel Prize or two instead of just Super Bowls, and Bartlett's would include a variant on the football coach's most famous quote: "Science isn't everything," scientist Lombardi would have uttered. "It's the only thing."

It's a little exaggerated, of course. Just as there's actually more to life than football, science shouldn't claim domination over every form of human belief and experience. On the other hand, the basic sentiment makes more sense for science than for "winning." Looked at in a certain way, science (broadly understood) is the one thing the universe offers. Anything else is some sort of manifestation of science.

What keeps the world from being dull as a textbook are the many curious variants of science's manifestations, from gravity to fire to the electrical impulses rushing along nerve cells in the brain. Some of those manifestations are reasonably well understood; some have barely been recognized and remain subjects of industrious investigation. Some are at the heart of human life and health; others hint at deep mysteries about the nature of existence.

Every issue of *Science News* explores some of these manifestations, usually stretching across the spectrum from matters of immediate practical importance to arcane items of pure intellectual curiosity.

In this issue, for instance, freelance writer Laura Beil reports on medical implications of mitochondria, structures within cells that may conceal significant secrets about aging and disease (Page 20). Of only slightly less immediate relevance is a report on two island nations facing possible extinction from rising sea levels in the decades ahead (Page 24). Cristine Russell, president of the Council for the Advancement of Science Writing and a fellow at the Harvard Kennedy School, reports on the importance of understanding climate science for the leaders of those two nations as they plan to salvage a future for their citizenry.

A third feature in this issue departs from perils for the body and the planet to the relative safety of space. Freelance writer Susan Gaidos describes some mysterious measurements of high-energy cosmic rays that have recently confused astrophysicists (Page 16). These cosmic rays are of no particular importance for solving global economic crises or curing the common cold. But they hint at the possibility of particles traveling in extra dimensions of space beyond the ordinary 3-D world accessible to perception, suggesting a potentially dramatic expansion of the human conception of reality. Which is, after all, the only thing. —Tom Siegfried, Editor in Chief

# A floor lamp that spreads sunshine all over a room.

*The Balanced Spectrum® floor lamp brings many of the benefits of natural daylight indoors for glare-free lighting that's perfect for a variety of indoor activities.*

Ever since the first humans built a fire in their dark cave, people have realized the importance of proper indoor lighting. But ever since Edison invented the light bulb, lighting technology has, unfortunately, remained relatively prehistoric.

Modern light fixtures do little to overcome problems associated with improper lighting, such as eyestrain, dryness, and burning. As more and more of us spend longer and longer hours in front of our computer monitor, these problems are compounded. And the effects of improper indoor lighting are not necessarily limited to a physical problem: the quantity and quality of light can also play a part in both our mood and work performance.

Studies show that sunshine can both lift your mood and enhance your energy levels. But as we all know, the sun does not always shine. Now, however, there's a solution to the problem—The **Balanced Spectrum® floor lamp** will change not only the way you see, but also the way you

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—Stanley G., M.D.

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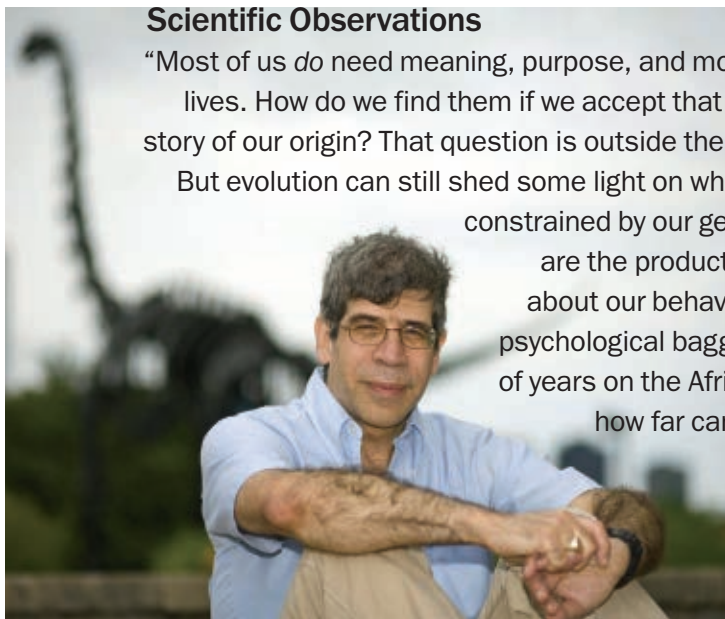


## Scientific Observations

"Most of us *do* need meaning, purpose, and moral guidance in our lives. How do we find them if we accept that evolution is the real story of our origin? That question is outside the domain of science.

But evolution can still shed some light on whether our morality is constrained by our genetics. If our bodies are the product of evolution, what about our behavior? Do we carry the psychological baggage of our millions of years on the African savanna? If so, how far can we overcome it?"

JERRY A. COYNE, AN  
EVOLUTIONARY GENETICIST  
AT THE UNIVERSITY OF  
CHICAGO, IN *WHY EVOLUTION  
IS TRUE* (VIKING, 2009)

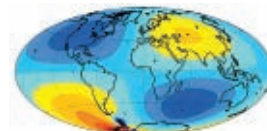


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### SN MULTIMEDIA

Access SN images and audio at the bottom of the home page. Visit "Sea level rise not uniform" for a map of where sea level rise would be highest (darkest blues) should the West Antarctic Ice Sheet melt.



### SCIENCE & SOCIETY

The Washington, D.C., government erred in changing water treatment, and then tried to cover up the mistake, a team of scientists reports. Read "Water-cleanup experiment caused lead poisoning."

## Science Past | FEBRUARY 28, 1959

**WEATHER SATELLITE ORBITING** — The United States has launched into orbit the first baby weather station in space. It was hurled into its earth-circling path at 10:55 a.m.



Feb. 17, and its predicted lifetime is several decades. The batteries powering the radio transmitting weather information, however, have only a two-week lifetime. The 20-inch, 21.5-pound satellite was one unit in the Navy's trouble-plagued Project Vanguard,

originally scheduled to launch several satellites during the International Geophysical Year that ended last Dec. 31. It is now a National Aeronautics and Space Administration project. The satellite's scientific equipment consists of two photocells designed to provide the first pictures of earth's cloud cover.... The experiment represents a first step toward obtaining continuous weather mapping of global scope.

## Science Future

### Until March 1

Vote for one of six astronomical objects for the Hubble Space Telescope to observe in honor of the International Year of Astronomy. See the candidates at [youdecide.hubblesite.org](http://youdecide.hubblesite.org)

### March 6

"Sacred Waters: India's Great Kumbha Mela Pilgrimage" opens at The Field Museum in Chicago. Learn more at [www.fieldmuseum.org](http://www.fieldmuseum.org)

### April 24

Arbor Day will be celebrated across the United States. Visit [www.arborday.org](http://www.arborday.org)

## The (-est)

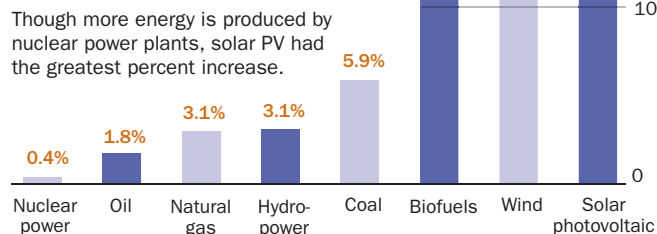
White eyes disperse to form new species faster than any other known birds. These "great speciators" diversify into between 1.95 and 2.63 species per million years, often failing to maintain gene flow across water gaps as narrow as a couple of kilometers, a team reports in the Feb. 10 *Proceedings of the National Academy of Sciences*.



## Science Stats

### Growing renewables

World average annual growth rates for energy resources production, 2002–07



SOURCE: 2009 STATE OF THE WORLD: INTO A WARMING WORLD, W.W. NORTON

CLOCKWISE FROM TOP LEFT: PAUL MERIDETH; KONSTANTIN MIKHAILOV

“ For the first time in human history, we can study a solid planet located outside our solar system. ” — MICHAEL GILLON, PAGE 9

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**Atom & Cosmos** Tiny terrestrial transiter  
Galaxy's center bursts with star birth

**Body & Brain** Don't regret kidney donation

**Life** Locusts' chemical transformation

**Humans** Dreams can come true  
You gotta see the baby

# In the News

## STORY ONE

### Early whales gave birth on land

Fossils fill gaps in story of land-to-water transition

By Sid Perkins

It took early whales a while to fully break free of the land: For at least one species, females came back to shore to give birth, a new study suggests.

Newly described fossils of ancient whales, including the unprecedented discovery of a pregnant female, were unearthed in the hinterlands of central Pakistan in 2000 and 2004. The finds are providing scientists with clues about the life, times and even the possible social structure of these enigmatic creatures.

The discoveries “are rather spectacular, to say the least,” says Erich Fitzgerald of the Smithsonian Institution in Washington, D.C. “They’re quite incredible.”

The family tree of today’s cetaceans — the varied group of aquatic mammals that includes whales, dolphins and porpoises — probably sprouted in southern Asia around 55 million years ago,

as land-dwelling creatures began their march back to the sea. In that region, paleontologists have discovered many semiaquatic protowhales deemed to be charter members in cetacean diversification, including wolf-sized creatures that dived into streams about 50 million years ago (*SN*: 9/22/01, p. 180) and small fox-sized mammals that lived about 48 million years ago (*SN*: 1/5/08, p. 5). Many such creatures, some of them apparently evolutionary dead ends, appeared in southern Asia during this era. By 30 million years ago, the modern groups of toothed and baleen whales had evolved (*SN*: 5/14/05, p. 314).

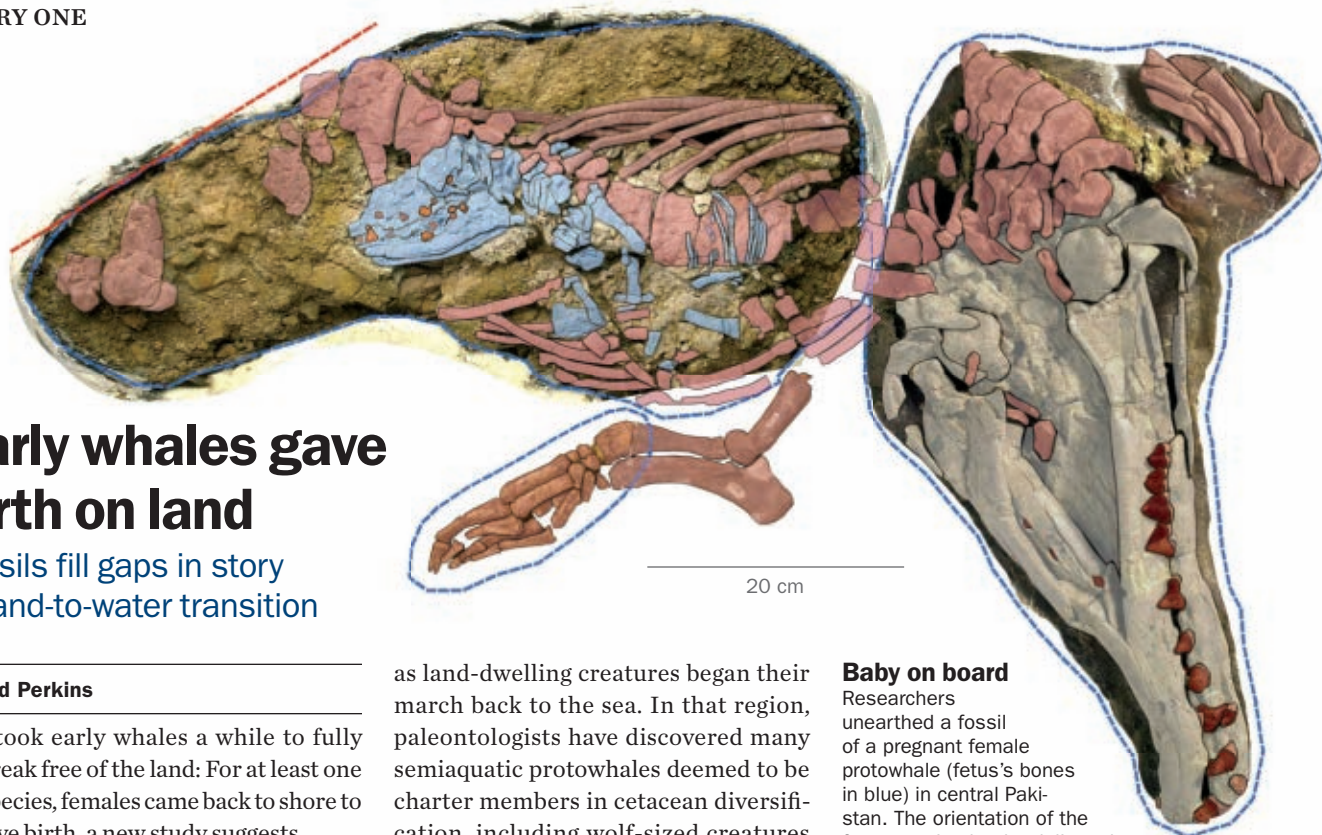
Now, Philip Gingerich of the University of Michigan in Ann Arbor and his colleagues add a new twig to the cetacean family tree — a 2.6-meter-long, mostly aquatic mammal that lived along the coast of southern Asia about 47.5 million years ago. Fossils of the species are

#### Baby on board

Researchers unearthed a fossil of a pregnant female protowhale (fetus's bones in blue) in central Pakistan. The orientation of the fetus — poised to be delivered headfirst — suggests the ancient creature returned to land to give birth.

described online February 3 in *PLoS ONE*. The researchers dubbed the creature *Maiacetus inuus* — *Maiacetus* means mother whale in Greek, and *Inuus* was a Roman fertility god — in part because one of the fossils includes what the researchers say is a near-term fetus, a first for ancient whales.

Those tiny remains, which include the skull, measure about 33 centimeters long and lie within the remains of the larger animal, says Gingerich. That the skull and other bones lack damage supports the idea that the fossils are those of a





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fetus and not of a small, unrelated creature that had been eaten by the ancient whale, he notes. Many of the bones were only partially calcified at the time of the creature's death, another clue that the tiny remains are those of a fetus.

Position and orientation of the fetus within the mother provide important clues about the species, the researchers contend. The head is located near the opening to the birth canal, a sign that the whale would have been born head-first. That, in turn, is a sign that the species came on land to deliver their young: While all large land mammals are typically delivered headfirst, so they can breathe during their birth, all modern cetaceans are born tail first to ensure they don't drown during delivery.

"This is really exciting stuff," says Mark D. Uhen of the Alabama Museum of Natural History at the University of Alabama in Tuscaloosa. Fossilization of a pregnant female "is a very rare event, but a very nice one."

Because the fetus's first molars are well-mineralized, Gingerich and his colleagues suggest that *Maiacetus* young were precocial, or able to supplement their mother's milk with other food sources soon after birth, as are all of today's marine mammals.

"From what we understand of cetacean evolution, you could predict that a fossil like this would be found," says

Fitzgerald. "I've been trying to convince myself that there's a problem with it, but the evidence is there."

Another fossil of *Maiacetus*, recovered about a kilometer away from the specimen that includes fetal remains, is the most complete fossil yet found of an ancient whale, Gingerich says. Only a few vertebrae from the tip of the creature's tail and a few bones from the ends of the digits are missing, he notes. Analyses suggest the animal's feet were webbed.

Several aspects of this particular specimen, including its pelvic structure, suggest that the creature was male. For one thing, most of its bones are about 12 percent longer than those of the female *Maiacetus*. Also, the canine teeth of the fossil are about 20 percent longer than the female's. That trait is common for males in species that display sexual dimorphism, in which the sexes differ substantially in size or appearance.

The features of this near-complete fossil, especially those of the tail, indicate that *Maiacetus* didn't have a fluked tail like modern cetaceans, says Uhen. So, the creature probably dog-paddled its way through the water.

*Maiacetus* is "a fantastic example of an early whale with aquatic specializations," an "early experiment" in evolution that isn't survived by any known descendants, Fitzgerald notes. The newly described species is quite different from living

whales and dolphins, but also quite different from other ancestral species in the cetacean lineage, he says.

The new fossils are very important, Fitzgerald continues, because those of many previously described species of protowhales include only one creature and are often fragmentary. "It's quite rare to have remains of adults as well as young," he notes.

In modern semiaquatic mammals such as seals and their relatives, species in which males are more than 16 percent larger than females have a harem-style mating system. During breeding season one male controls a territory and mates with several females. Since *Maiacetus* doesn't show such a large difference, it probably had a one-to-one, or dispersed, mating structure, Gingerich and his colleagues argue. The environment in which *Maiacetus* lived — along coasts with plenty of breeding room and plenty of food — bolsters the notion that populations could spread out rather than compete.

The evidence described by Gingerich and his team "is consistent with sexual dimorphism, but not 100 percent conclusive," Fitzgerald suggests.

It's possible that the presumed male and the female are different sizes because they're different ages or members of two closely related species, Uhen says. Still he adds, "Sometimes you can only go with the evidence that you've got." ■

## Back Story | WHALES WADE BACK TO THE WATER



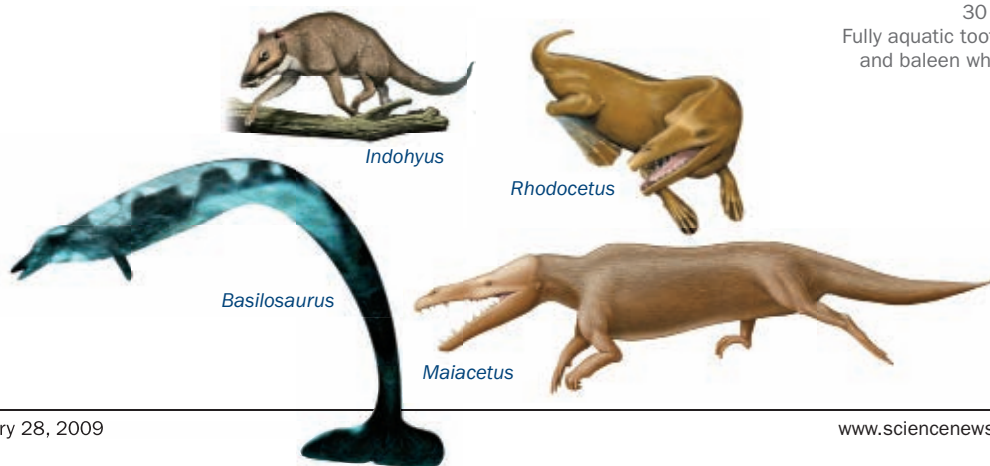
55 million years ago  
Land mammal ancestor

Some transitional forms



30 mya  
Fully aquatic toothed  
and baleen whales

Paleontologists have unearthed fossil evidence of several creatures that provide clues to the evolutionary journey from land mammal to fully aquatic whale.



CLOCKWISE FROM TOP LEFT: C. BUELL; J. KLAUSMEYER/SCIENCE; J. KLAUSMEYER AND B. MILJOUR, UNIVERSITY OF MICHIGAN MUSEUMS OF NATURAL HISTORY; CHRISTIAN DARKIN/PHOTO RESEARCHERS



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# Matter & Energy



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## Superconductors escape Flatland

Iron-based materials allow electric current to flow in 3-D

By Patrick Barry

A flat, two-dimensional flow of electric current has long been thought essential to the secret of high-temperature superconductors. But new research shows that an iron-based high-temperature superconductor lets current flow in three dimensions.

High-temperature superconductors carry resistance-free current at temperatures above  $-243^{\circ}$  Celsius. Now researchers show that, for at least some, the mechanism that enables electrons to flow with zero resistance doesn't depend on the electrons moving along the boundary between layers in the material. In previous experiments on copper-based superconductors, the free-flowing current always occurred at these 2-D boundaries, so most theorists have thought 2-Dness is somehow essential to how this category of superconductors works.

Finding a 3-D high-temperature superconductor was surprising, says Huiqiu Yuan of Zhejiang University

in Hangzhou, China, who coauthored the study published in the Jan. 29 *Nature*. "The two-dimensionality is not a necessary condition for getting a high superconducting transition temperature."

These 3-D high-temperature superconductors could also be more useful than their 2-D cousins. When superconducting electric current is confined to a 2-D plane, strong magnetic fields disrupt the current. But superconductors are often used specifically to create strong magnetic fields. This limitation is a major reason why copper-based superconductors have not been widely adopted. High-temperature superconductors capable of 3-D flow wouldn't have the same problem.

"Three-dimensionality would help a great deal," comments Jan Zaanen of Leiden University in the Netherlands, who wrote a commentary on the research in the same issue of *Nature*.

Unimpeded flow of electrons makes conventional superconductors useful for loss-free transmission of electricity and for powerful electromagnets in MRI machines and levitating trains. But these superconductors have transition temperatures near absolute zero ( $-273^{\circ}\text{C}$ ) and require expensive liquid helium to

keep them cold. Until recently, all known high-temperature superconductors were copper-based materials. Some of these work at temperatures high enough to allow cooling with liquid nitrogen, which is cheaper and more widely available than liquid helium. But scientists still don't fully understand how the copper-based superconductors work.

Yuan and his colleagues studied a relatively new kind of superconductor that is iron based. So far, these iron compounds require temperatures too chilly

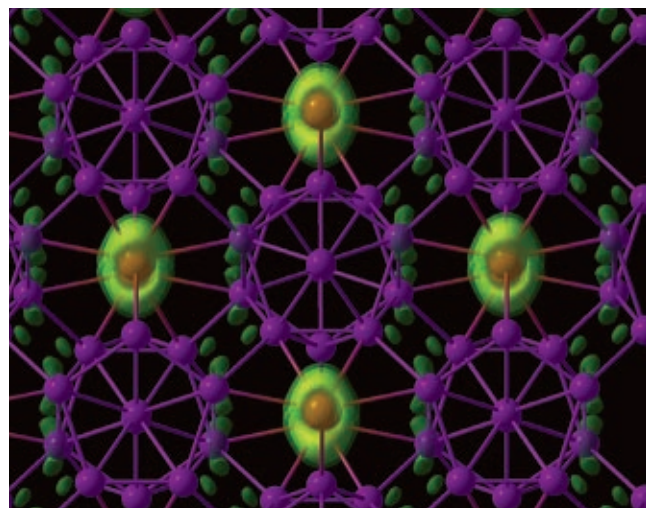
for liquid nitrogen. But this new family has generated excitement because its chemistry is different from that of copper-based superconductors. Physicists hope that comparing the two could reveal some

common, essential mechanism for high-temperature superconductivity.

"There's a widespread belief that these [iron-based superconductors] share this basic secret" with copper-based conductors, Zaanen says.

Yuan's team used a magnetic field to force current flow in various directions through a superconductor made from iron, arsenic, potassium and barium. The current flowed well no matter the field's direction. ■

**3-D high-temperature superconductors could be more useful than their 2-D cousins.**



## Boron's stable form

A newly discovered solid form of boron has a remarkable structure: 20-sided cages (purple) made of boron atoms interspersed with smaller groups of two boron atoms (brown). (Likely electron locations are in green.) The cages and groups alternate in a 3-D lattice, much like the arrangement of large chloride ions and small sodium ions in table salt. It's the first stable form of boron to be experimentally confirmed, and the first ionic, saltlike solid scientists have found that's made from a single element. "Finding an ionic structure of an element is something stunning," says Artem Oganov of Stony Brook University in New York, coauthor of the study, which appeared online January 28 in *Nature*. Boron sometimes behaves like a metal and other times like an insulator. Because of this odd behavior, the natural, stable forms Boron assumes at various temperatures and pressures have been difficult to confirm. — Patrick Barry





## Astronomers discover the smallest known transiting extrasolar planet

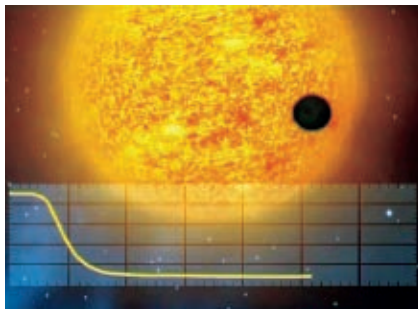
Finding could provide clues to composition and structure

By Ron Cowen

Astronomers have found an extrasolar planet no more than 11 Earth masses, with a diameter about twice that of Earth's. The discovery of the planet, dubbed COROT-Exo-7b, may ultimately provide groundbreaking information about the composition and structure of terrestrial planets beyond the solar system.

Once the team can refine an estimate of the planet's mass, "this could be a potentially huge discovery," comments theorist Sara Seager of MIT. "I'm excited to see what more the team will find out about this prospective terrestrial planet."

Located about 450 light-years from Earth, the planet is too small for imaging. Classified as a hot superEarth, it lies too close to the heat of its parent star to sup-



**One way to find an extrasolar planet is to detect a drop in brightness as the body passes in front of its parent star.**

port life. The planet whips about its star in just 20 hours, has a surface temperature between 1,000° and 1,500° Celsius and might be covered by lava or water vapor.

Although scientists have found a few extrasolar planets with smaller masses,

the newly found body is the tiniest known that periodically passes between its parent star and Earth, blocking a tiny fraction of starlight during each transit.

These minieclipses yield a planet's radius and, in combination with another technique, provide a trove of information, including the exact mass, density and composition of a body, notes Daniel Rouan of the Observatory of Paris in Meudon, France. He and his colleagues reported the find February 3 at a symposium in Paris about the European Space Agency's COROT satellite, the craft that detected the planet's transits. Rouan says an accurate mass for the planet, which will soon be available, can help determine its density and composition.

"For the very first time in human history, we can study a solid planet located outside our solar system," says team member Michael Gillon of the Observatory of Geneva in Sauverny, Switzerland. "This is a major step towards the detection and study of actual Earth twins orbiting other stars." 📡

## Galaxy bulges in its middle

New evidence suggests growth from the inside out

By Ron Cowen

Peering 12.8 billion years back in time to examine the flame of star birth in one of the earliest known galaxies, astronomers have captured the first snapshot of the formation of a galaxy's bulge—a central concentration of stars that is one of the oldest components of galaxies.

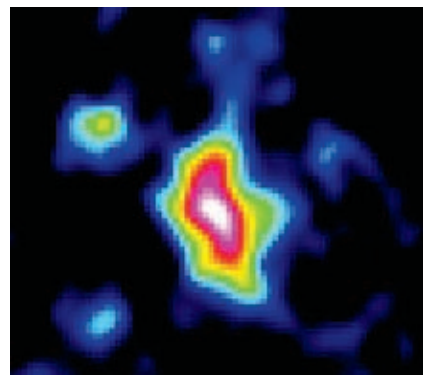
Fabian Walter of the Max Planck Institute for Astronomy in Heidelberg, Germany, and his colleagues had already established in 2004 that a remote galaxy called J114816.64+525150.3, seen as it appeared when the universe was less than a billion years old, was going gangbusters,

forging the equivalent of 1,000 suns every year. (By contrast, the Milky Way galaxy today makes about one sun per year.)

Now, using a network of radio telescopes in the French Alps, Walter and colleagues have found that star birth in the young galaxy is limited to a central region only 4,000 light-years in diameter. For comparison, the Milky Way has a diameter of 100,000 light-years. The findings are reported in the Feb. 5 *Nature*.

The compact, central star-forming region provides additional evidence that galaxies grow from the inside out. Other episodes of star formation can occur throughout galaxies. The team proposes that the central starburst is the first flicker of what will become a spherical bulge like the one in the Milky Way's center, but much larger.

Most galaxies in the universe have bulges, but researchers don't know whether J114816.64+525150.3 is typical or



**This false-color radio wave portrait of a young galaxy shows that star formation is concentrated in the galaxy's center.**

an extreme example of that formation.

"The crucial element is that for the first time, someone has measured the size of the region in which the dust-obscured starburst [of one of the first galaxies] is occurring," comments Ian Smail of Durham University in England. 📡

# Body & Brain



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## Fingerprints filter vibrations

Ridges may help make touch sensation efficient

By Laura Sanders

The intricate patterns of swirls on human fingers may do more than help cops nab crooks. A study in the January 30 issue of *Science* helps crack the case of fingerprints' real job: Epidermal ridges, fingerprints' professional name, likely serve as filters to help in the efficient detection of fine textures.

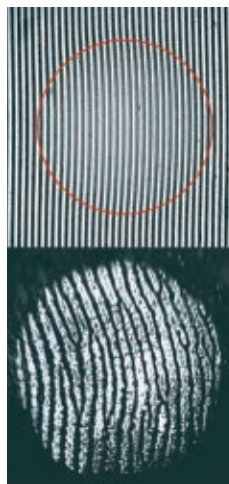
"The functional role of fingerprints has remained something of a mystery," says Sliman Bensmaia of Johns Hopkins University in Baltimore. But the new results show that "fingerprints enhance our ability to perceive surface texture."

When a finger sweeps over a finely textured surface, such as a cotton sleeve or a wooden table, the interaction sends a large range of vibrations into the skin. Specialized sensors called Pacinian fibers, the tips of nerve fibers, detect only a select few of the vibrations — those right around 250 hertz — before sending the signal to the brain. Other receptors in the finger detect different frequencies.

To study the details of touch, a group of physicists led by Georges Debrégeas at the CNRS École Normale Supérieure research center in Paris took a robotics approach. The researchers developed biomimetic sensors to detect vibrations similar to those created when fingers move over a fine texture. Elastic caps that mimicked human fingertip skin covered the sensors. One fake tip had ridges similar in size and distribution to human fingerprints, and another was smooth.

The vibrations detected by the two sensors showed different properties. The sensor covered in fingerprints registered much less variation in vibrations, while the smooth sensor picked up a much larger range of signals.

Like sunglasses that filter out UV light and let the useful visible light through, the artificial fingerprints filtered out vibrations above and below 250 hertz, leav-



By designing artificial fingertips (top), researchers found that real human fingerprints (bottom) may help the finger sense fine-scale textures efficiently.

ing only the vibrations that could be detected by Pacinian fibers. Fingerprints, the researchers propose, make the touch-sensing system more efficient by sculpting the input to activate only the receptor meant to sense it.

"If you take white noise, like a completely random texture, and scan across it, the low and high vibrations get dampened," says Ellen Lumpkin of Baylor College of Medicine in Houston.

The team also found that fingerprints do their filtering job only when finger motion is perpendicular to the fingerprint ridges. But human prints are patterned in swirls, so every swiping direction will activate some filtering.

Debrégeas says that the distinctiveness of fingerprint patterns from one person to the next doesn't seem to affect filtering capability.

## Kidney donation OK in long term

End-stage renal disease risk is lower among organ donors

By Nathan Seppa

When kidney transplants from living donors were first performed, doctors didn't know whether living with just one kidney might cause long-term medical repercussions.

Now, researchers report in the Jan. 29 *New England Journal of Medicine* that people who donate a kidney have about the same probability of survival over several decades as people in the general

population. And donors seem to have adequate kidney function and even less risk of severe kidney disease than occurs in the general public, Hassan Ibrahim of the University of Minnesota in Minneapolis and his colleagues report.

To arrive at these findings, the team pored over a database of kidney transplants performed at the University of Minnesota between 1963 and 2007 and tried to reach as many of the donors as possible. Using this data and death records from the Social Security Administration, the scientists assessed the mortality rate among 3,698 people who gave away a kidney during that time span.

The researchers also randomly selected 255 of the donors to undergo kidney function tests between 2003 and 2007. The

team compared those results with tests done on a group of people who had both kidneys and who matched the donors in race, gender, body weight and age.

To be eligible to donate a kidney, a person must pass a physical examination and cannot have diabetes, high blood pressure or other serious ailments.

With that in mind, it's not surprising that kidney donors would have low mortality rates compared with people in the general population, say physicians Jane Tan and Glenn Chertow of Stanford University School of Medicine, writing in the same *NEJM* issue. "Nevertheless," they note, "it is somewhat surprising and quite reassuring that rates of end-stage renal disease were also lower in kidney donors than in the general population."



# Tests identify the immune proteins that defend against West Nile virus

Mice without the proteins are more susceptible to pathogen

By Nathan Seppa

Scientists have found two immune proteins that orchestrate a defense against West Nile virus. By identifying the protein that initially senses the virus and another that enables immune forces to kill it, the findings might open new avenues for research into drugs for treating severe West Nile infections, the researchers say.

The study in mice shows that an immune protein called toll-like receptor 7 serves as the linchpin in fending off an assault by the virus. TLR7 sets in motion a cascade of events that rev up production of a second protein, interleukin-23, which guides immune cells on seek-and-destroy missions against cells infected with the virus. In mice missing TLR7 or interleukin-23, this chain reaction fails and the virus spreads, the researchers report in the Feb. 20 *Immunity*.

Most people fend off a West Nile infection without even developing noticeable symptoms, thanks apparently to TLR7 and interleukin-23.

But the findings suggest that elderly and immune-compromised people, who sometimes develop the brain inflammation encephalitis from a West Nile infection, may lack a full complement of TLR7, says study coauthor Richard Flavell, an immunologist and Howard Hughes Medical Institute investigator at Yale University School of Medicine.

It makes sense that TLR7 would play a part in defending against West Nile, he says. The TLR proteins are immune stalwarts that reside on the surface of immune cells and on cells that serve as linings in the body, such as skin and membranes. TLRs act as sentinels, recognizing bacteria, fungi and viruses, which stick to TLRs and cause a reac-

tion that alerts the cell to the invader's presence.

TLR7 binds to the RNA of the West Nile virus, the researchers report. TLR7 then uses an intermediary compound to send a signal into the cell that spurs production of interleukin-23. That protein enters the bloodstream and guides immune cells called macrophages to cells infected with West Nile. Macrophages do much of the dirty work of destroying these infected cells and stopping the virus from spreading, the researchers find.

In mice genetically engineered to lack either TLR7 or interleukin-23, the virus spreads unabated. About half of normal mice die from a West Nile infection. In this study, mice lacking TLR7 had a death rate of about 90 percent when exposed to the virus. In a separate test of mice lacking various interleukins, some survived as well as normal mice. But all mice lacking interleukin-23 died. Mice lacking the intermediary compound were also highly susceptible to the virus.

"This is a very exciting paper," says Andrea Cooper of the Trudeau Institute in Saranac Lake, N.Y. At a minimum, she says, "it broadens our understanding of the activity of interleukin-23."

The study also opens other lines of research, Cooper says. Scientists could obtain blood from elderly people, culture the samples in a lab and expose them to West Nile virus particles. "Then they could see whether the cells make interleukin-23 or not, whether macrophages respond," she says.

Such a test might clarify why some elderly people are susceptible to the virus. "We don't know enough about the effect of aging on the innate immune system," she says. "Perhaps [elderly people] can't get cells to the right location quickly enough." ■

## NEWS BRIEFS

### Needles rely on placebo effect

Acupuncture, the ancient Chinese practice of sticking needles into a patient at specific points to relieve pain and treat other conditions, seems to alleviate pain just barely better than sticking needles into nonspecified parts of the body, a new analysis shows. Researchers in Denmark came to this conclusion, reported in the Feb. 7 *British Medical Journal*, after analyzing 13 studies in which people received real acupuncture, sham acupuncture or standard pain treatments such as drugs. — Nathan Seppa

### Drug-use risk beyond genetics

Good parenting provides a potent buffer against some youngsters' genetic predisposition to use alcohol, cigarettes and marijuana by age 14, a study finds. Uninvolved, unsupportive parenting heralds a spike in consumption of these substances among genetically vulnerable teens, a team led by psychologist Gene Brody of the University of Georgia in Athens reports in the February *Journal of Consulting and Clinical Psychology*. — Bruce Bower

### Excess sugar and cognition

Chronically elevated blood levels of the simple sugar glucose may contribute to poor cognitive function in elderly people with diabetes, a paper in the February *Diabetes Care* suggests. But whether these levels add to a person's risk of developing dementia is unclear, the study authors say. In the study, an international team assessed blood glucose levels in nearly 3,000 diabetes patients and asked the volunteers to take tests that determined cognitive abilities. — Nathan Seppa



# Serotonin turns loner locusts into swarming, gregarious cereal killers

Smells, sights, tickles boost levels of the neurotransmitter

By Susan Milius

Neighbors say he seemed like such a nice, quiet locust. But a surge of serotonin, researchers now say, sent this solitary type to join a crop-destroying plague.

Desert locusts (*Schistocerca gregaria*) often live as shy loners that try to avoid others of their kind. If they do get crowded for several hours, though, the locusts start to switch behavior dramatically, almost becoming another animal.

"Party animal" is the way Stephen Simpson of the University of Sydney in Australia describes the new form. Loners get livelier. They move toward, rather than away from, other locusts. And if swarming persists, locusts can sweep across the landscape and devour pretty much all vegetation.

That switch in behavior turns out to rely on a compound known to be important in human moods, the neurotransmitter serotonin, Simpson says. Experiments show serotonin is both necessary and sufficient for the locusts' flip from solitary to gregarious forms, he and his colleagues from the University of Oxford and the University of Cambridge in England report in the Jan. 30 *Science*.

**When desert locusts switch from a crowd-hating lifestyle (nymph, right) to a livelier social mode (nymph, left), they also experience a change in body color.**

Serotonin concentrations soar in a critical part of the locust nervous system during the first few hours of the transformation, the researchers say.

"That's pharmacologically similar to being on antidepressants, and on Ecstasy," Simpson says.

Serotonin itself won't make a good target for some new mass locust control, Simpson warns. The compound plays a major role in so many animal nervous systems, including people's, that researchers will have to look for more locust-specific parts of the swarming biochemistry, he says.

People certainly need better ways to control locust swarms, says Jeffrey Lockwood of the University of Wyoming in Laramie, an entomologist and writer whose book *Locust* discusses North America's now-vanished swarming pest. Desert locusts still devastate crops in their native North Africa, the Middle East and Asia. And the world is plagued by about a dozen species of locusts in total. They have considerable diversity, so Lockwood hesitates to speculate that all their chemistries would work exactly the same way.

Still, the new work "is a major step in understanding what makes locusts form swarms," says Paul A. Stevenson of Leipzig University in Germany. The research is the first to show that a particular nervous-system compound is necessary for the switch and can do the job by



**In the more gregarious of their two forms, desert locusts readily crowd together in a research enclosure.**

itself. The work also helps explain how social interactions can lead to changes in animal behavior, Stevenson says.

The current study grows out of previous work on the social cues that change the locusts' behavior as well as their color. Simpson and his colleagues had discovered two triggers for the transformation. A loner locust that smells and sees other locusts for long enough will go gregarious. In the lab, researchers keeping solitary locusts pipe in air to individual locust chambers to prevent the smell of neighbors from initiating the change.

Physical jostling also changes loners, and Simpson tickled locust body parts with paintbrushes, discovering that the hind legs are critical. A five-second tickle on a loner's leg every minute for several hours will start the transformation.

Now exploring the underlying biochemistry, the collaborating researchers have found that smells and sights or tickles send serotonin concentrations soaring in the thoracic ganglia within a few hours. Injecting serotonin into that spot also initiated the change.

Yet locusts treated with serotonin-blocking chemicals didn't get social even when trapped in a crowd. ■





**5,000**  
kilometers

Distance a swarm of locusts flew in 10 days to cross the Atlantic in 1988

**80**  
million

Upper limit on the number of adult locusts in a square kilometer of a swarm

# Animal ancestor probably survived ancient ice age

Chemical fossils date back to at least 635 million years ago

By Rachel Ehrenberg

A new analysis of ancient chemical fossils has rocked the cradle of early animal evolution, bumping back compelling evidence of animal life to at least 635 million years ago.

The findings, published in the Feb. 5 *Nature*, suggest that the ancient ancestor of fully formed animals survived a massive glaciation that enshrouded the Earth in ice at the end of the Cryogenian period. Debate continues over how much of the planet was frozen during two ice ages, each possibly a “snowball Earth” event, that flanked this period, which extended from about 790 million to 630 million years ago. The new results suggest that even if glaciers reached the equator during the second ice age, warm pockets may have persisted and harbored life.

The find is “really something,” says Jochen Brocks of the Australian National University in Canberra, who coauthored a *Nature* commentary on the work.

The Cambrian explosion is often cited as the inaugural ball of animal evolution, a period of roughly 20 million years that began about 520 million years ago, and a time when representatives of many of today’s major animal groups became established. But there’s evidence that some animals evolved before the Cambrian, including the Ediacaran fauna, a bizarre assemblage that flourished between the Cryogenian and Cambrian.

Many scientists believe these multicellular animals were an early experiment in animal evolution that ended badly.

Sponges, however, may have come on the scene before the Ediacaran period and lived through it. The new analysis, led by organic geochemist Gordon Love of the University of California, Riverside, documents the molecular remains of an animal steroid in ancient Ediacaran strata and in the layers beneath.

The steroid fossil, 24-isopropylcholestane, or 24-ipc, is a form of a steroid known today from the cellular membranes of a class of sponges, the Demospongiae. Some algae also make the molecule, but the ratios of 24-ipc to other compounds rules them out as a source.


Working with cores from a salt basin in south Oman, Love and his team document the presence of 24-ipc in rock deposited 150 meters below the end of the Cryogenian. The findings can’t say when multicellular animals first appeared but can say that they had to be around by at least 635 million years ago and, the researchers report, maybe as early as 751 million years ago. The creatures may have evolved in the warm-

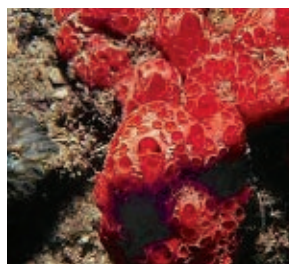
ing period between the Cryogenian’s two snowball Earth events.

Putative fossil embryos dating to about 580 million years ago were previously the oldest fossils considered ancestors of today’s animals.

Even if the glaciations during the second snowball Earth event didn’t freeze the seas,


they would have forever altered ocean chemistry, says Love. The environmental upheaval could have opened new niches and presented an opportunity for multicellular sponges to spread.

These early sponges might have helped bring about the oxygenation of the deep oceans, paving the way for more life, says molecular paleobiologist Kevin Peterson of Dartmouth College. 



**A fossil steroid, known today from demosponges (above), offers clues to early animals.**

## Wolves borrow coat color

Dogs flash back to their early days as wolves when they howl at the full moon or pace in a circle before lying down. But new research shows that some wolves probably inherited a trait from their domesticated cousins. Black wolves received a gene for coat color from domesticated dogs through interspecies mating, researchers report online February 5 in *Science*. “This may be the first time a domestic trait has gone into the wild and been beneficial,” says coauthor Tovi Anderson of Stanford University. The researchers found that black-colored wolves, unlike their lighter-colored brethren, carry the same mutation in their DNA as black dogs. The mutation appeared first in dogs and then moved to wolves, the researchers report. Although the benefit for wolves is unclear, Anderson says dark wolves may have better camouflage while hunting in the forest. — Laura Sanders 



# Humans



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## Hot chocolate, with foam please

Cacao beverages appeared early in the U.S. Southwest

By Rachel Ehrenberg

Americans liked their chocolate drinks tall and frothy long before Starbucks. People were making cacao beverages in the American Southwest as early as A.D. 1000, suggests a new chemical analysis of ancient jars.

The study, published online February 2 in the *Proceedings of the National Academy of Sciences*, reports the earliest known use of cacao north of the U.S.–Mexico border and may stir up debate regarding the Chaco Canyon culture and its relationship with Mesoamerican societies to the south.

Scientists have long puzzled over the purpose of tall, cylindrical jars found at Pueblo Bonito, a site in Chaco Canyon in northwestern New Mexico. Excavations have uncovered 166 of the ceramic jars from the site, a

multistory pueblo occupied from roughly A.D. 860 to the 12th century. Questions remain about the people who dwelled there and their culture.

The jars may have been used for drinking a cacao beverage, perhaps as part of a ritual, says Patricia Crown of the University of New Mexico in Albuquerque. Among the artifacts excavated were a stone, possibly for grinding the cacao beans, and stirring sticks. Frothing a drink with sticks or pouring it from up high was not uncommon in some Mesoamerican cultures.

That the jars were for cacao beverages “really did seem like a stretch,” says Crown,

**An analysis of ancient jars suggests people in the U.S. Southwest drank chocolate beverages as early as A.D. 1000.**



who led the new work. Cacao use didn’t become widespread in the area until the Spanish arrived in the 16th century. But Crown learned of similar jars from Maya sites that were specialty vessels for cacao drinks. She sent shards from several of the Chaco jars and a pitcher to coauthor Jeffrey Hurst of the Hershey Center for Health and Nutrition in Hershey, Pa.

Using mass spectrometry and high performance liquid chromatography, Hurst found that three of the shards had traces of the chemical theobromine. The compound gives cacao away because it comes only from the cacao plant, a neotropical tree that doesn’t grow north of Mexico.

The results are likely to renew debate over the people of Chaco Canyon, says Bruce Smith of the Smithsonian Institution National Museum of Natural History.

“There will be a kerfuffle,” he says.

The findings don’t negate the view that Chaco Canyon was a mere outpost of Mesoamerica, where the real cultural action was happening. But they could support the view of a Chaco society in its own right that borrowed items from Mesoamerica but put its own stamp on them.

## Nighttime thoughts see light of day

People interpret dreams in ways that affect their waking lives

By Bruce Bower

Dreams don’t just bubble up at night and then evaporate like morning dew once the sun rises. What you dream shapes what you think about your upcoming plans and your closest confidants, especially if nighttime reveries fit with what you already believe, a new report finds.

To see whether people take their dreams seriously, Carey Morewedge of Carnegie Mellon University in Pittsburgh and Michael Norton of Harvard University surveyed students attending universities in India, South Korea and the United States about theories of dream function.

In a series of experiments, the researchers also interviewed people in the United States about their interpretations of real and imagined dreams.

People across cultures often assume that dreams contain hidden truths, much as Sigmund Freud posited more than a century ago. Morewedge and Norton report in the February *Journal of Personality and Social Psychology*. In fact, many people think dreams provide more meaningful information regarding daily affairs than comparable waking thoughts do.

In one experiment, participants reported feeling closer to a friend after imagining a dream in which the friend

defended them, versus betrayed them.

“This is very good evidence that dreamed-of actions can result in a self-fulfilling prophecy,” says Mark Blagrove of Swansea University in Wales. A person who dreams about a loyal friend may then act in ways that encourage the friend to behave loyally.

The team also found that imagined dreams about communications from God were more meaningful to religious believers than agnostics. Still, agnostics said they’d see more meaning in a dream of God commanding them to do something enjoyable than something unpleasant.

“Our results suggest that the dreams most likely to affect our daily lives and relationships are the dreams that accord with our existing beliefs and desires,” Morewedge says.

"This is very good evidence that dreamed-of actions can result in a self-fulfilling prophecy." — MARK BLAGROVE

## Hormonal cues for baby cuteness

Women on oral contraceptives know when a face is adorable

By Bruce Bower

Everyone oohs and ahs over babies. Ironically, new research suggests that young women taking oral contraceptives are especially good at picking out babies with the most adorable little mugs.

Female sex hormones sensitize women to differences in babies' cuteness and may encourage mothers to bond with their babies, propose Reiner Sprengelmeyer of the University of St. Andrews in Scotland and his colleagues. When given choices between computer-manipulated images of a baby's face, premenopausal women discern gradations in the cuteness of the face better than either postmenopausal

women or men of all ages, the team reports in the February *Psychological Science*.

In the study, young women taking hormone-boosting contraceptive pills outdid those not taking contraceptives at detecting babies' cuteness.


"It's tough to know what to make of these findings without knowing the ways in which cute babies differ from uncute babies," says Steven Gangestad of the University of New Mexico in Albuquerque.

Earlier research found that mothers of babies independently rated as more attractive were particularly affectionate and playful with their children. It's not known whether a cute face signals an advantage for a baby, Gangestad notes,



Women were better than men at picking out the cuter (left) of two baby faces.

or whether mothers who invest special effort in raising cute babies reap big dividends later.

Sprengelmeyer's team used a computer program to define the average shape of cute and less cute baby faces based on previously ranked faces. The team used those findings to create images of varying cuteness for 10 new baby faces. Adult volunteers viewed pairs of faces of the same baby and identified the cuter face. 

R. SPRENGELMEYER

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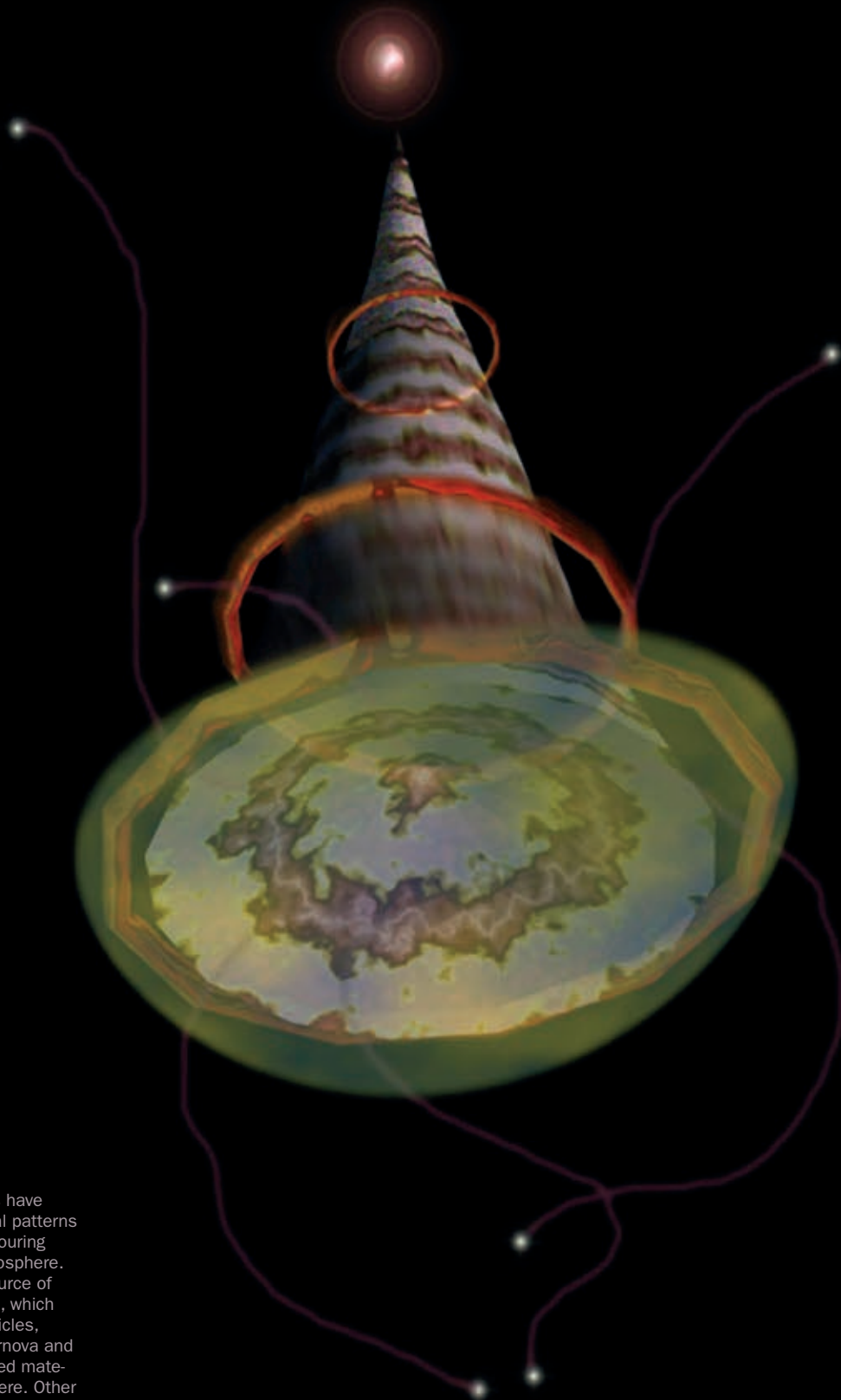
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### Cosmic rays

Two experiments have detected unusual patterns in cosmic rays pouring into Earth's atmosphere. One possible source of the unusual rays, which are actually particles, could be a supernova and its cone of ejected material, illustrated here. Other possible sources could be a pulsar or dark matter.

# High-energy invaders from space could signal a nearby pulsar, or perhaps dark matter **By Susan Gaidos**

# Cosmic mystery

**T**here's an air of excitement in the astrophysics community, created by a surplus of particles from space invading Earth's atmosphere.

Balloon flights high in the stratosphere over Antarctica detected electrons in numbers and energies much higher than what usually pours in from space, scientists on a project called ATIC reported in November.

About the same time, a separate report from Milagro, a ground-based detector near Los Alamos, N.M., described two unexpected patches of high-energy protons in the sky. A review of seven years of Milagro data revealed an unusual distribution in the energies of these cosmic rays.

Both experiments seem to show that the Earth is being bombarded with high-energy cosmic rays from a mysterious, nearby source. But scientists aren't sure whether the results are related.

"You can't say yes, and you can't say no, because they're measuring something different," says Jordan Goodman, a University of Maryland, College Park, physicist and spokesman for Milagro. The ATIC group "is seeing an excess of electrons, and we're at higher energies seeing the protons."

An as yet undetected source, perhaps a pulsar, might generate both protons and electrons at these energies, he says. "If this is the case, this would be very exciting because no one has yet definitively found a source of these high-energy cosmic ray protons."

But if the events are unrelated, they suggest an even more tantalizing possibility: dark matter.

The findings have inspired efforts to use additional instruments to gather more clues. NASA's recently launched Fermi Gamma-ray Space Telescope, for instance, could reveal any astrophysical objects that might be candidate culprits.

## Not business as usual

Cosmic rays are actually subatomic particles, such as protons and electrons, that slam into the Earth's atmosphere with a variety of energies. About 90 percent are protons. The rest are mostly helium nuclei, with a smattering of electrons.

Billions of cosmic ray particles hit Earth's atmosphere every second; most come from the sun and are the low-energy variety. An energetic few, however, are believed to get an extra oomph because they are created by high-energy cosmic objects and events, such as supernovas or their occasional offspring, the spinning neutron stars known as pulsars.

Such high-energy cosmic rays have remained a mystery since the Austrian physicist Victor Hess discovered them in 1912. Nobody knows exactly where these rays come from or how they have been generated. But astrophysicists believe that a variety of astrophysical processes, such as shock waves from supernovas, can generate the high-energy rays.

Pinning down a specific source that generates high-energy cosmic rays has proven difficult. Because the magnetic fields of the galaxy and Earth scramble the flight paths of these particles, scientists have not been able to trace their trajectories back to their sources. This random scrambling effect means a map of cosmic

ray intensities should appear completely uniform throughout the sky.

Or so scientists thought. In November, Milagro researchers reported seeing “hot spots” of high-energy cosmic ray protons in two distinct regions of the sky. It was the first time scientists could trace such protons back to a particular location.

Jordan and colleagues discovered the hot spots with the Milagro detector, which resembles a giant swimming pool. It is lined with light sensors that can record particles produced when cosmic ray protons collide with the atmosphere.

Researchers normally use the detector to investigate gamma rays, which also trigger a shower of particles. When the particles hit Milagro’s water tank they produce flashes of light that the sensors record. Actually, though, nearly all of the Milagro flashes are from cosmic ray protons, Goodman says. Identifying gamma rays requires routinely subtracting out cosmic ray background signals.

In 200 billion cosmic ray collisions recorded during a seven-year period ending in April 2008, the scientists found two areas of the sky that appeared to have an excess number of high-energy protons in the background. The protons also appeared to have a higher average energy — up to 10,000 trillion electronvolts — than the background.

It’s hard to imagine any peculiarity of the detector that would give particular regions of the sky higher energies, Goodman says. “The fact that it’s a relatively small scale and it’s definitely an excess is a tip that it’s a real phenomenon.”

The excess in the localized regions, he says, could show a “propagation effect,” created when high-energy rays are funneled from a distant source.

But more likely, he says, the protons are produced near black holes or neutron stars, astrophysical objects capable of accelerating particles to high energies. The protons may also get their energy from a nearby pulsar, such as Geminga, a relatively young pulsar surrounded by a highly magnetized nebula capable of generating high-energy particles.

Geminga, or some other nearby source, may also be the culprit generating high-

energy electrons, such as those recently captured over Antarctica. The balloon-borne ATIC, or Advanced Thin Ionization Calorimeter, counted 70 excess electrons above the usual number expected from the galactic background. While that may not sound like a lot of electrons, statistically speaking it’s a significant surplus, says Yousaf Butt, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics. The findings and Butt’s commentary appeared last November in *Nature*.

### High energies are for WIMPs

Butt says there are at least two possible explanations for the electron spike. One, the electrons could come from a nearby astrophysical object, such as a pulsar or microquasar, that propelled the electrons to high energies.

An alternative explanation is that the electrons were produced by dark matter. Dark matter is believed to account for 85 percent of the universe’s mass, though scientists have yet to identify what it is made of. A few exotic particles have been suggested as prime candidates for dark matter, including WIMPs — weakly interacting massive particles. Two WIMPs meeting and annihilating each other could produce a spray of particle and antiparticle pairs, such as positrons and electrons. Such a collision would produce a peak in the spectrum of electron energies.

The ATIC balloon collaboration, led by John Wefel of Louisiana State University in Baton Rouge, found such a bump in the spectrum of cosmic ray electrons during five weeks of ballooning in 2000 and 2003. What’s more, the signal peaked at 620 gigaelectronvolts and then rapidly declined to the background level. Butt says the signature is a kind that would emerge if a WIMP known as a Kaluza-Klein particle was a prime dark matter component.

If they are real, Kaluza-Klein particles would owe their existence to “extra” dimensions beyond the three of ordinary experience. Theoretically, these particles travel in the extra dimensions, but should they collide and annihilate they would spit out electrons and positrons that would travel through the ordinary dimen-

sions and could therefore be detected.

While bumps in the cosmic ray electron spectrum have been measured before, they didn’t cover the energy range seen in the ATIC experiment, Butt says. Last fall, for example, scientists reported hints of dark matter in measurements taken by the Russian-European orbiting observatory known as PAMELA (*SN: 9/27/08, p. 8*). The findings were based on measurements of positrons, the electron’s antiparticle. While they don’t encompass the energy range ATIC detected, the PAMELA measurements are consistent with the ATIC results, says Butt. Together, the two data sets bolster the case for Kaluza-Klein dark matter.

Dan Hooper, a theoretical physicist at the University of Chicago, says the presence of another theoretical dark matter particle — the neutralino — could account for the bump in the cosmic ray electron spectrum. He presented his idea in a recent paper posted online ([arxiv.org/abs/0812.3202](http://arxiv.org/abs/0812.3202)).

Neutralinos would also be WIMPs and are favored by models invoking a special type of dark matter: cold dark matter, which moves relatively slowly. Typically, annihilation of neutralino dark matter would not produce the bump in the cosmic ray spectrum seen in the PAMELA and ATIC experiments, Hooper says.

“However, if we abandon the assumption that neutralinos are distributed throughout the galaxy in a smooth way, but instead imagine that there happens to be a big clump of the dark matter nearby, then you can get something that climbs with energy like these experiments see,” he says.

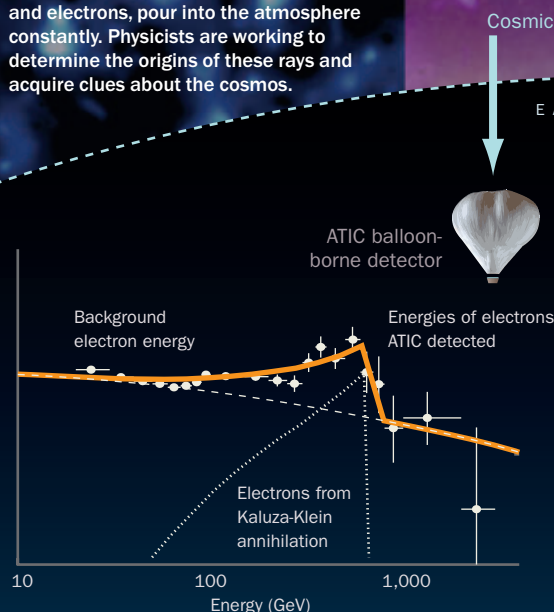
Some scientists express caution in reading too much from the recent studies. Greg Tarlé, an astrophysicist at the University of Michigan in Ann Arbor, says despite these groups’ careful analyses, getting rid of the background is difficult. In the 1990s, Tarlé helped launch a balloonborne experiment called HEAT that flew over New Mexico. The experiment was the first to measure the positron spectrum in cosmic rays, as reported in *Physical Review Letters* in 2001.

“One of the most important things in

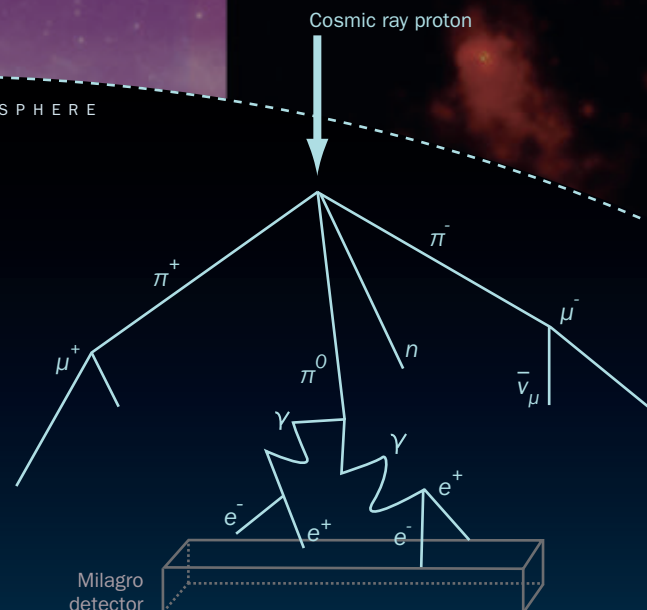


## Catching Cosmic Rays

Cosmic rays, particles such as protons and electrons, pour into the atmosphere constantly. Physicists are working to determine the origins of these rays and acquire clues about the cosmos.



**Cosmic ray electrons** High over Antarctica, the balloonborne ATIC detected a surprising excess of high-energy electrons. The spike's signature matches what theory says would emerge from the annihilation of proposed Kaluza-Klein particles, candidates for dark matter.



**Cosmic ray protons** The Milagro ground-based detector registers the shower of particles produced when a cosmic ray proton hits the atmosphere. Seven years of data from Milagro reveal hot spots of high-energy protons, offering a chance to pinpoint a specific source for these rays.

these measurements is to get rid of protons that may masquerade as positrons,” he says. “In the HEAT experiment we did that by measuring and separating protons and positrons in three different ways.”

When the group eliminated any one of those techniques, the number of positrons rose. “That’s why, when I look at the new results, PAMELA results for example, and I see a rising positron fraction, it looks just like the rising fraction that we saw when we turned off our TRD,” one of the correction methods, Tarlé says.

### More dots to connect

Determining whether the bump was caused by a nearby source, such as a pulsar, or by the annihilation of dark matter will require more data from a variety of instruments, the scientists say.

“I think the clearest way to settle this is to try to measure the sharpness of the peak of this electron bump,” Butt says. “If it’s an astrophysical object, like a pulsar or a microquasar, that’s making this electron bump, it’s going to be a smooth bump.” But if it’s really from the decay of dark matter particles, the energy spectrum bump will have a characteristic sharp peak and sudden drop, he says.

To get such measurements, scientists need a variety of instruments to collect electron events over a wide energy range for a long period of time. A Japanese group, led by Shoji Torii of Waseda University, is designing an instrument called CALorimetric Electron Telescope, or CALET, with the hope that it will be placed on the International Space Station in 2013. CALET would collect electrons over Earth for at least 1,000 days, Torii says, as opposed to ATIC’s five weeks.

Earlier results, Butt says, could come if the Large Hadron Collider near Geneva provides insights into annihilation of dark matter particles. By tuning the collider’s beams to 620 GeV—the proposed energy range of Kaluza-Klein particles—scientists could simulate or re-create what they observed in the sky. While such studies wouldn’t detect dark matter particles, they could be used to scan this peak energy region for a corresponding excess of electrons in the LHC, Butt says.

Hooper suggests that ground-based gamma ray telescopes, such as the High Energy Stereoscopic System (H.E.S.S.) in southern Africa, or the Very Energetic Radiation Imaging Telescope Array System (VERITAS) located on Mount Hop-

kins in Arizona, could be used to collect huge numbers of electrons. Even though these telescopes are designed to study gamma rays, they can also detect electrons. Hooper and coauthor Jeter Hall of Fermilab in Batavia, Ill., propose a strategy for doing so in a recent paper posted online ([arxiv.org/abs/0811.3362](http://arxiv.org/abs/0811.3362)).

“The advantage is that they can see hundreds of thousands of square meters of electrons at a given time,” Hooper says. “So they can collect hundreds of thousands times more electrons in this way than the balloon experiment.”

Using all of these resources, scientists may soon be able to get to the bottom of the cosmic ray mystery, Butt says. “Between all the various efforts, I think within the next two years, we should be able to say either yes or no as to whether or not these features seen in the electron spectrum are due to dark matter or something else.” ■

*Susan Gaidos is a freelance science writer in Maine.*

### Explore more

■ Cosmic ray primer from NASA: [helios.gsfc.nasa.gov/cosmic.html](http://helios.gsfc.nasa.gov/cosmic.html)

# Mitochondria Gone Bad

Problems in the cell's energy factories power new ideas on disease and aging

By Laura Beil • Illustration by Nicolle Rager Fuller

**T**he patient, known as only “MBM,” was just 7 years old the first time doctors saw her. She had always been prone to night sweats, but now excessive perspiration was forcing her to change clothes several times a day. She was endlessly thirsty, fatigued and losing weight despite a voracious appetite. A dozen years later, at age 19, doctors checked her into a hospital, thinking she had some kind of unusual metabolic condition. After aggressive treatment with drugs, her symptoms improved, but only for a short time, and the next year surgeons removed most of her thyroid. When she was 35 — gaunt, weak and losing hair — doctors began searching every tissue of her body for a diagnosis.

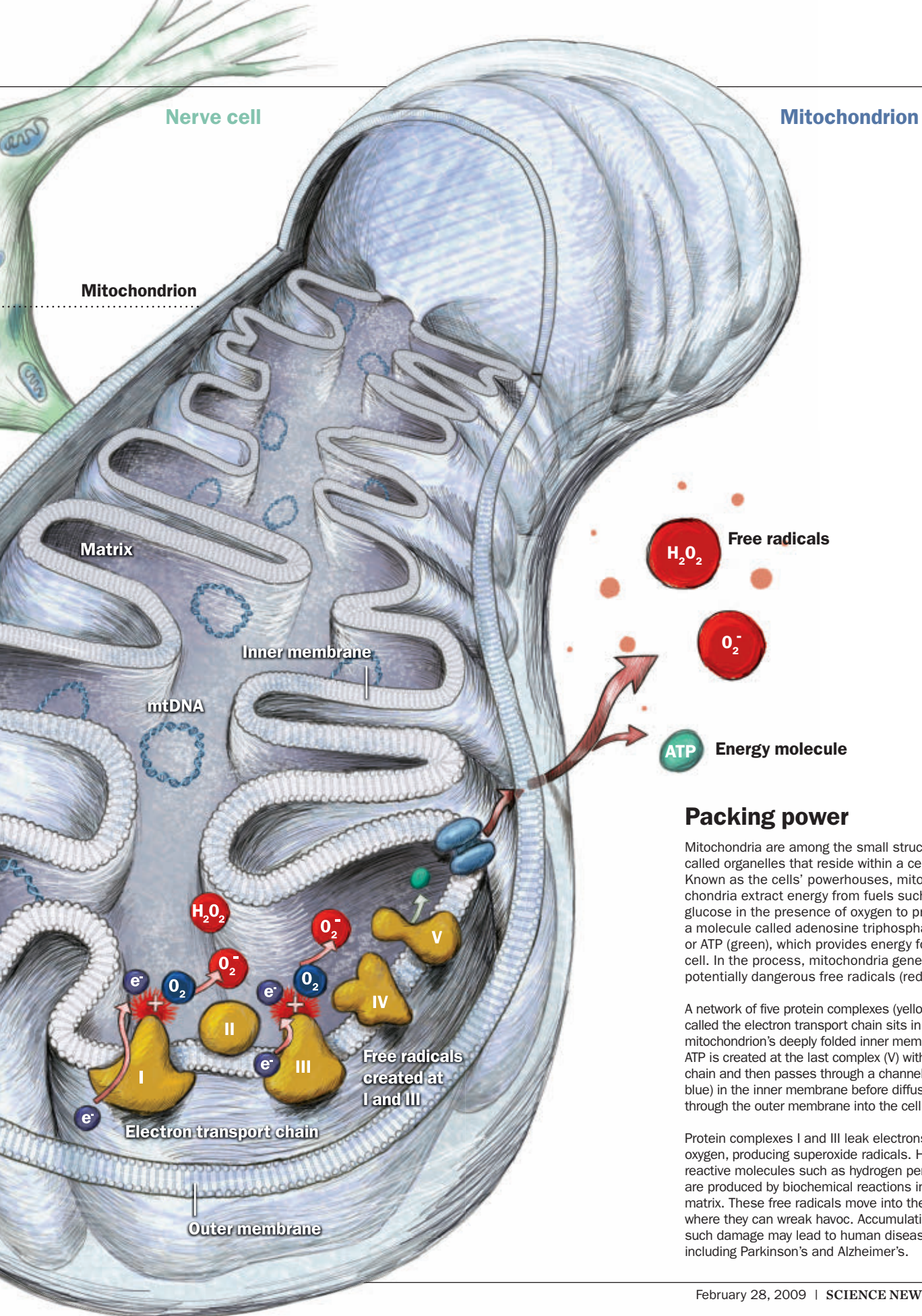
They finally located the problem. It was MBM's mitochondria, the organelles that supply the energy for cells to function. Thanks to mitochondria, the sandwich you had for lunch is now powering your heart and brain. Somehow the mitochondria inside MBM's cells had gone haywire, becoming too large and too numerous. Such damage was “the first instance of a spontaneous functional defect of the mitochondrial enzyme organization.” The mysterious case of patient MBM was considered so remarkable that the *Journal of Clinical Investigation* published a description of it. That was in 1962.

Today, scientists suspect that millions of people may be suffering from mitochondria gone awry, in more subtle but nonetheless insidious forms. Evidence suggests that malfunctioning mitochondria could explain Alzheimer's disease, Parkinson's, diabetes, cardiovascular disease, obesity, cancer and other consequences of aging. Given the organelle's core function in the body, some think mitochondria might even be the biological epicenter of aging itself: If you live long enough, all your cells might experience a kind of energy crisis. “I strongly believe that mitochondrial metabolism is the key to aging,” says Hemachandra Reddy of Oregon Health & Science University in Beaverton.

Even before scientists suspected a role in common diseases, mitochondria had some biological celebrity. The sometimes tubular, sometimes bean-shaped structures are remnants of an ancient bacterium captured by a one-celled organism more than a billion years ago, experts believe. In animal cells, mitochondria are the only cellular components outside the nucleus that boast their own DNA, which is passed on from mother to child almost in its entirety. Douglas Wallace of the University of California, Irvine, a self-described “mitochondriac,” has used variations in mitochondrial DNA to help construct a global human family tree, tracing the migration of ancient humans from Africa.









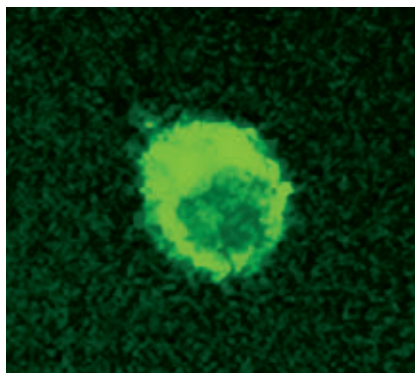
These days, however, Wallace concerns himself with the living. “All these diseases that no one has been able to solve might be solved by understanding the mitochondria,” he says. This is, he contends, a new way of thinking about illness. “Up until very recently, mitochondria were considered very arcane and certainly not part of mainstream medicine,” he says. Questions about mitochondria were mostly confined to rare brain and muscle syndromes linked to inherited defects in the organelles.

In a move that will push mitochondria studies further into the mainstream, this year the National Institutes of Health has put aside grant money to encourage more mitochondria research, hoping to “transform our understanding of the role of this critical organelle in human health and disease,” according to the funding announcement. Already scientists have found clues that link defects in mitochondria to Alzheimer’s disease, Parkinson’s, heart failure and other breakdowns in the body that come with age.

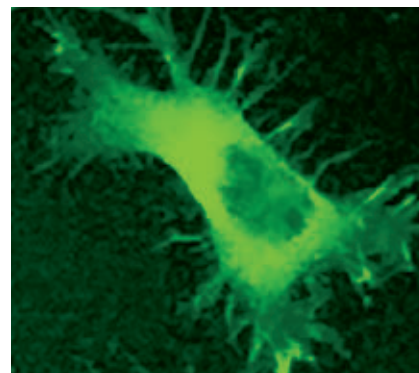
### The price of energy

While scientists have theorized for at least three decades that mitochondria might be the basis for aging, renewed interest has come from the growing realization that a mitochondrion is more than just a cellular furnace. Mitochondria’s main purpose is indeed energy production — they make molecules of adenosine triphosphate, or ATP, the gasoline of a cell. But these energy factories also flip the levers on other functions, such as protecting against highly damaging incarnations of oxygen known as free radicals, orchestrating chemical communication within a cell and triggering the natural death of cells that become broken down or aged. Still, skeptics point out that there’s not enough evidence yet to conclude whether mitochondria are the causes of illness, the victims of it or just innocent bystanders.

Free radical damage has long been suspected as a culprit in aging, and mitochondria are both the primary source of free radicals in a cell and the main protection against them. “As you get older, the number of mitochondria that are not function-



**In nerve cells, mitochondria are key to the growth of axons and dendrites, which send and receive signals from other cells. Antioxidants that target mitochondria may protect cells and spur axon and dendrite development: An untreated mouse nerve cell (left) shows less growth than does a cell treated with the antioxidant MitoQ (right).**



ing increases,” says Mark Mattson, chief of the National Institute on Aging’s Laboratory of Neurosciences in Baltimore. Over time, mutations accumulate in mitochondrial genes. These and other changes may cause the power plants to work less efficiently, producing less energy for the same amount of glucose — the way a less energy-efficient car travels fewer miles on a tank of gas. Cells eventually become less able to rid themselves of these defective mitochondria. As life goes on, the body moves closer to a brownout — or so says the mitochondrial aging theory.

Mattson points out that the only known way to extend life span, at least in animal experiments, is through calorie restriction. Studies have found that mice fed very-low-calorie diets live longer than their better-fed brethren. While the explanation is still under study, Mattson says that such food restriction may affect mitochondria most acutely, putting the organelles under stress. The stress forces mitochondria to operate more efficiently. In a state of slight starvation, “the mitochondria maintain their function longer, and they also seem to produce less free radicals,” he says.

To examine the efficiency of old mitochondria, researchers from the University of Washington Medical Center in Seattle measured whether mitochondria from older muscle cells work as well as mitochondria from younger ones. The investigators followed the production of ATP, the energy molecule, along with oxygen

consumption. In the body, food is broken down into sugar molecules called glucose; mitochondria use oxygen to convert glucose into ATP. Older muscles seem to struggle with ATP production, the scientists reported in 2007 in *Proceedings of the National Academy of Sciences*.

“In aging muscles, there is a mitochondria dysfunction,” says Seattle researcher David Marcinek. “They produce less ATP for the same amount of oxygen consumed.”

In Mattson’s view, and that of other researchers who suspect that people are only as young as their mitochondria, mild amounts of stress force mitochondria to make better use of the glucose available — whether that stress is from calorie restriction or another source. Stress also causes cells to produce proteins that protect the mitochondria from free radical damage. And Mattson points out that other conditions that strain energy production — such as physical and mental activity — also appear to strengthen tissues at the same time.

He points to other lines of evidence linking mitochondria to aging. For example, mice bred to have deletions in a gene called *PolgA*, which encodes an enzyme critical for the replication of mitochondrial DNA, experience accelerated aging, including hair loss, weight loss and curvature of the spine. More recently, in the journal *Science*, Wallace and his colleagues reported that a mutation in the mitochondrial genes of mice led to heart

failure, a disease that becomes more common with age, even when the DNA in the cell nucleus remained unaffected.

## Death in the brain

If mitochondria are the architects of aging, they may also be responsible for some of the most notorious afflictions of old age. Mitochondria aren't distributed evenly in the body. A cell may have a few dozen of them or a few thousand, depending on the energy demand. Not surprisingly, the diseases most under scrutiny for a mitochondrial origin are those involving tissues that consume a lot of energy, and therefore maintain small armies of mitochondria. And a particularly greedy organ — consuming about 20 percent of the body's energy — is the brain.

In the December issue of the journal *NeuroMolecular Medicine*, Reddy makes the case for Alzheimer's being a mitochondrial disease. For starters, it now appears that brain cells involved in Alzheimer's show damage from free radicals early in the disease process. Studies have found decreased production of mitochondrial enzymes in the brains of Alzheimer's patients. Also, one of the toxic proteins that collects in Alzheimer's-afflicted brains, called amyloid-beta, appears to conspire with mitochondrial proteins.

A study published in *Nature Medicine* in October investigated the relationship between amyloid-beta and mitochondria. Scientists from Columbia University Medical Center blocked the action of a molecule used by mitochondria, called cyclophilin D, which appears to have a role in cell death in the brains of Alzheimer's patients. That experiment, combined with other studies using mice lacking cyclophilin D, indicated that amyloid-beta and cyclophilin D may be partners in crime, working together to cause mitochondria to rupture and release their deadly contents into the cell. Without cyclophilin D, amyloid-beta wasn't as destructive, and mice with a version of Alzheimer's improved in learning and memory.

Other scientists believe that another aging-related brain disease — Parkinson's — starts and ends with mitochondria. "If you have mitochondria that are

not functioning, the first thing is you've got impaired energy production," says Claire Henchcliffe of Weill Cornell Medical College in New York City. "That could reset the threshold for a cell's demise."

In November, in *Nature Clinical Practice Neurology*, Henchcliffe described the evidence linking mitochondria to Parkinson's. Among the key points: The genes known to be associated with Parkinson's code for proteins thought to be involved in mitochondrial operation. "That's a major supportive argument," Henchcliffe says. "There seem to be functional links between all of them and the mitochondria." Also, she says, studies have found that major mitochondrial genes and proteins are depleted in the region of the brain that dies during Parkinson's disease. But she also acknowledges that mitochondrial defects have not been detected in everyone with Parkinson's, illustrating both the disease's complexity and the need to figure out how to better tailor treatments to individual patients.

## Behind the power failure

Though mitochondria experts have an intense interest in neurological problems, the scope of investigation extends to almost every major human illness. Wallace investigates not only neurodegenerative and heart diseases, but also diabetes and obesity (which are ultimately energy-balance and storage issues). Other researchers are looking into cancer and muscle problems. Such an extensive list should not be surprising, Wallace says, given the mitochondrion's importance in every cell. "Energy is the one thing you can't live without," he says. Last summer, in the journal *Genetics*, Wallace wrote a commentary proposing that Asian medicine, which is directed at the mysterious energy force of living things known as "chi," might have the right idea. When mitochondria can't keep up with the body's energy demands, he says, cells die, tissues age and organs fail.

But what makes mitochondria lose steam? Some damage may come from normal wear and tear. Mitochondrial DNA gets copied a lot more often than does nuclear DNA. Mitochondrial genetic

material is more vulnerable to damage, and less able to make repairs. In many cases, mitochondria might take a hit from the environment. Parkinson's researchers cite MPTP, a contaminant that made its way into synthetic heroin in the 1970s. Users who injected the drug soon developed acute Parkinson's symptoms, including tremors and rigidity. Further tests have found that MPTP can cause damage to neurons in the substantia nigra in the brain — the dopamine-producing area that dies in Parkinson's — and can disrupt mitochondrial function. Another chemical that damages mitochondria, the pesticide rotenone, also causes Parkinson's symptoms in laboratory animals.

"Not that we are anywhere close to identifying the environmental causes of Parkinson's," Henchcliffe notes. Rather, the examples of rotenone and MPTP suggest that mitochondria might be vulnerable to environmental assaults, no matter the source. One paper, published last year in *Molecular Nutrition & Food Research*, suggested that medications — including some of the most common pills in the medicine cabinet, such as aspirin and cholesterol drugs — might harm mitochondria.

Once scientists figure out the cause of mitochondrial problems, the hope is to devise a way to prevent or repair the damage. For those with congenital mitochondrial disease, doctors have no cures, only symptom relief. But clinical trials are underway for some age-related diseases. One is looking at whether high doses of an antioxidant that acts in the mitochondria, coenzyme Q-10, might slow disease progression in Parkinson's patients.

In the case of patient MBM, researchers offer no hint about how long she survived, or how well, after doctors discovered the source of her problem. No one knows how she died, but maybe one day scientists will understand how she lived. ■

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*Laura Beil is a freelance science writer in Cedar Hill, Texas.*

## Explore more

■ Douglas C. Wallace. "Mitochondria as Chi." *Genetics*. June 2008.



Tiaon Bwere, seen here in 2006, battles one of the extremely high tides that wash into seaside villages of the South Pacific island nation of Kiribati. Low-lying coastal areas could be the first to experience one of global warming's biggest effects, rising sea level.







# First Wave

The presidents of two island nations draft escape plans, anticipating sea level rise

By **Cristine Russell**

**T**he Maldives, a chain of some 1,200 islands in the middle of the Indian Ocean, sits about 700 kilometers southwest of Sri Lanka and lures more than half a million adventurers each year. They come to this smallest of Asian countries to scuba dive, surf, fish and cruise in picturesque atolls known for white sandy beaches, crystal-clear turquoise waters and coral reefs teeming with tropical fish of rainbow colors.

About 11,000 kilometers east, halfway between Hawaii and Fiji, lies the little-known nation of Kiribati. Spread over about 3.5 million square kilometers in the central Pacific Ocean, its three major island groups — the Gilbert, Phoenix and Line islands — are too remote and inaccessible to attract much tourism. Kiribati, however, gained scientific notice when it recently set aside more than one-tenth of its territory to establish the world's largest marine preserve harboring one of the last pristine coral reef ecosystems.

These two exotic equatorial paradises may soon be known for something far less desirable than ecological preservation and idyllic vacationing. They are among the lowest spots on Earth and consequently are in danger of becoming the first drowning victims of global warming.

JEREMY SUTTON-HIBBERT, COPYRIGHT GREENPEACE

## Special and vulnerable

The Maldives and Kiribati highlight a hidden challenge for coping with climate change. It's not just about slowing the emissions of greenhouse gases. It's also about figuring out what to do for localities threatened with the possibility of extinction from rising ocean waters.

"They are like the canary in the coal mine in terms of the dramatic impact of climate change on a whole civilization of people," says Harvard University biological oceanographer James J. McCarthy, past president of the American Association for the Advancement of Science. "They didn't cause the problem, but they will be among the first to feel it."

You might call this a cautionary tale of two countries with vastly more ocean than land, intertwined by similar geologic ancestry and uncertain environmental futures. Although not geographic neighbors, the republics of Kiribati and the Maldives have a lot in common. Born of ancient undersea volcanoes topped with fragile atolls, or islands of coral encircling lagoons, Kiribati (pronounced KEE-ree-buhss) and the Maldives (MALL-deevz) face the prospect of slow submersion in this century if temperatures keep increasing and polar ice keeps melting, causing ocean waters to rise significantly. Most of the countries' small, flat islands are less than two meters above sea level, with many spots even lower.

"They are harbingers of things to

come," warns Lonnie Thompson of Ohio State University, who has been studying how global warming impacts polar and tropical glaciers from Antarctica to Tibet. "Unfortunately, because of the lag time, many of these islands are going to suffer from rising sea level regardless of what we do right now," he says. The lag time arises from two factors: Greenhouse gases already in the atmosphere will continue to do damage for years to come, and damage from gases will be added during the time it would take to implement any public or private sector plans to curb future emissions.

R.K. Pachauri, who chairs the Nobel Prize-winning Intergovernmental Panel on Climate Change, warned in December at a United Nations climate conference in Poznan, Poland, that inaction would allow continuing and unabated rises in air and ocean temperatures that could lead to an "abrupt and irreversible change" in the Greenland and West Antarctic ice sheets — and, as a result, a possible sea level rise of several meters. "Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events," he said.

Amid the rising international din of what to do about climate change, the primary focus has been on reducing future damage to the planet from greenhouse gases emitted from power plants and

cars and from those allowed to build up when tropical forests are cleared. Increasingly, however, experts believe that greenhouse gases such as carbon dioxide in the atmosphere may already be making a worldwide environmental impact, contributing to more severe storms, drought, fire and ocean warming. So helping the hardest-hit developing countries adapt to climate change is garnering new emphasis.

But in island and coastal countries, the impact may become so drastic that adaptation is not really an option, eventually forcing people out of their homes. Some vocal leaders in Kiribati, the Maldives and other threatened countries are pressing for international assistance to plan for that worst-case scenario.

In November, Mohamed Nasheed took office as president of the Maldives. The first democratically elected president in this country of about 360,000 people, Nasheed drew international attention with a dramatic proposal to set aside money to purchase land abroad for the extreme case of relocating his country's growing population later this century. In a recent statement to *Science News*, President Nasheed warned that, without deep cuts in carbon dioxide emissions, projected rises in sea level could ultimately inundate the Maldives.

"If we are unable to save countries like the Maldives, it may be too late to save the rest of the world from the apocalyp-



Much of the Maldives, including the land on which the Malé International Airport sits, is already very near sea level.

PETER ESSICK/AURORA/GETTY IMAGES



tic effects of self-reinforcing, runaway global warming,” Nasheed said.

He plans to start investing tourism proceeds in a sovereign wealth fund. “This trust fund will act as a national insurance policy to help pay for a new homeland, should future generations have to evacuate a country disappearing under the waves,” said Nasheed. “For the sake of the Maldives and the rest of the world, I hope this fund never needs to be used for its ultimate purpose.”

London-educated Anote Tong, president of Kiribati since 2003, has traveled the globe throughout his presidency, speaking to the United Nations and at other international gatherings about how climate change threatens his nation’s survival. He is not optimistic about getting new land elsewhere, so he has proposed a different solution: starting to send his citizens offshore now, before they are forced to evacuate later. He is already asking for help from nearby countries, including Australia and New Zealand, to train a steady stream of Kiribati’s younger people in skilled professions such as nursing, with an initial target of training about 1,000 annually. He wants these citizens to lead the way in finding jobs and permanent new homes abroad.

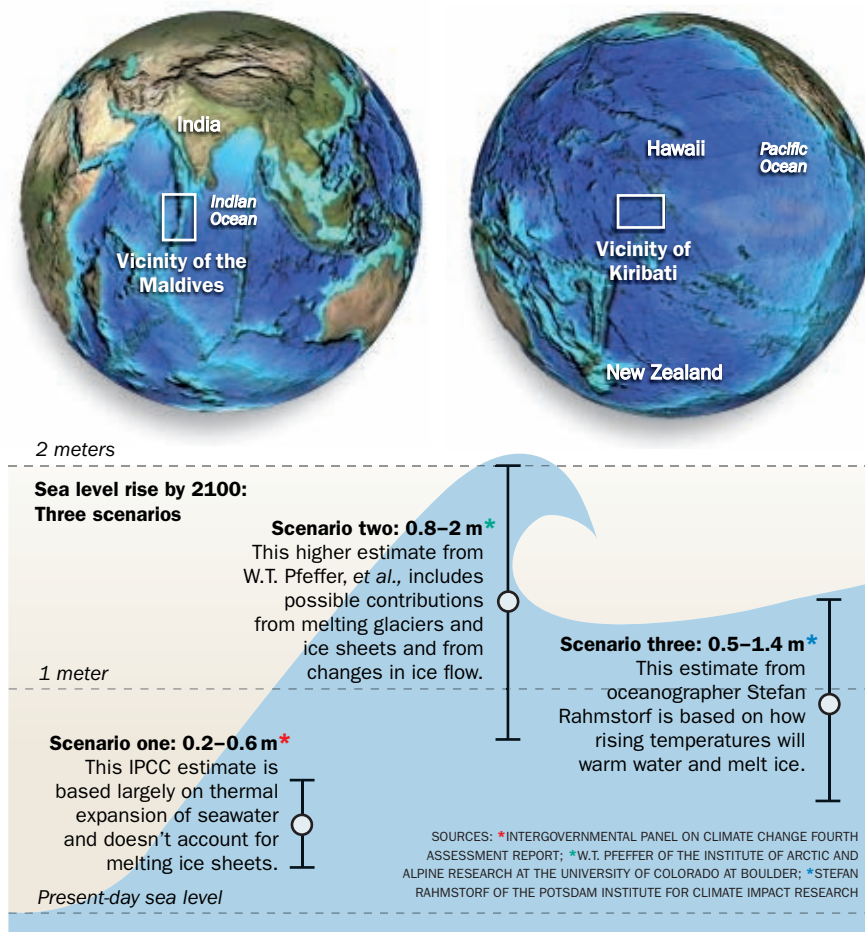
## Sea level forecasting

“There is a need for direct attention to the human dimension,” Tong said last fall in Cambridge, Mass., at a public lecture sponsored by the Harvard University Center for the Environment. He called climate change “the most fundamental moral challenge for humans in this century. The future of real people is on the line.”

Even a marginal increase in sea level would be disastrous for his country, he said. Warning signs are already appearing, including higher tides and coastal flooding, less rainfall and diminishing freshwater supplies, as well as bleaching of some coral reefs that cradle Kiribati’s islands. He said that increased flooding had already forced some villagers to move inland, but that this short trip is a temporary solution since “we’re in danger of falling off if we keep moving back.” (Many of the country’s islands are

## By 2100 sea level could overtake low-lying coastal areas

Much of the land of the Maldives and Kiribati is about 2 meters above present-day sea level. Below are three predictions for how many meters the ocean could rise this century.



so narrow that there really is no place to go.) Kiribati has roughly 100,000 citizens and its capital city, Tarawa, suffers from severe overcrowding.

“The reality is that we have to find alternative homes,” Tong said. “The levels already in the atmosphere cannot be reversed.”

The potential hazards of rising oceans because of climate change are not limited, of course, to small tropical islands. Such islands simply serve as a warning sign for vast coastal parts of the developing and industrialized world, from Bangladesh to Florida, where advancing ocean waters would also threaten areas with extensive shoreline development.

But a realistic, scientific handle on the timing and magnitude of sea level rise over this century remains a moving target. Human-induced climate change

can lead to sea level rise by heating of the ocean surfaces, causing the water to expand (thermal expansion). Or it may occur through melting of land-based glaciers and ice caps or the melting and disintegration of polar ice sheets. “The science relating to sea level rise has been in a great state of flux,” says Harvard’s McCarthy.

The 2007 IPCC report took an extremely conservative approach to potential sea level rise, focusing on thermal expansion. It estimated that sea level increases could range from 0.2 to 0.6 meters by 2100. Experts cautioned, however, that these numbers were highly uncertain and probably underestimated the potential change. The IPCC analysis did not take into account the unexpectedly rapid rate of melting and decay of polar ice sheets, particularly in Greenland, that has been observed recently, or



the prospect of accelerated breakdown of polar ice sheets in the future. “That’s not something that was anticipated,” says McCarthy.

Two other studies published in *Science* made higher projections of possible sea level rise during the 21st century. In 2007, oceanographer Stefan Rahmstorf of the Potsdam Institute for Climate Impact Research in Germany calculated an estimated range of 0.5 to 1.4 meters. But, Rahmstorf wrote, “the possibility of a faster sea-level rise needs to be considered when planning adaptation measures, such as coastal defenses, or mitigation measures designed to keep future sea-level rise within certain limits.” Last September, W.T. Pfeffer of the Institute of Arctic and Alpine Research at the University of Colorado at Boulder estimated that acceleration in ice flow might cause sea level rises of about 0.8 to 2 meters by 2100.

And all bets are off if the Greenland or West Antarctic ice sheet should become seriously unstable. A study in the Feb. 6 *Science* predicts that meltwater from a collapse of the West Antarctic Ice Sheet wouldn’t spread evenly around the globe. It could build up and cause catastrophically higher sea level rise in some areas, such as coastal North America.

Sea rise forecasting will remain uncertain into the foreseeable future. But the levels under discussion are particularly worrisome for low-lying islands, creating growing impatience on the political front. The recent Poland conference was the midway point in a two-year U.N. negotiating process to draw up a comprehensive international climate change agreement to replace the Kyoto Protocol. The negotiations are scheduled to culminate in a summit meeting in Copenhagen in December 2009, a target that many now consider optimistic, particularly since it will take time for the United States’ new administration to get into gear. The Obama team is expected to remove the Bush administration’s roadblock and endorse strong controls.

### Climate change evacuees

At the Poland meeting, several organizations representing about 40 small island



Mohamed Nasheed



Anote Tong

**“This trust fund  
will act as a national  
insurance policy  
to help pay for a new  
homeland.”**

**MOHAMED NASHEED  
PRESIDENT, THE MALDIVES**

**“We’re in danger  
of falling off if we keep  
moving back.”**

**ANOTE TONG  
PRESIDENT, KIRIBATI**

states and the poorest 50 developing countries pushed hard for industrialized nations to take tougher action against climate change. “Together they have been raising their voices here, and I’m hopeful that the call from these countries will be heard,” said Saleemul Huq, senior fellow with the nonprofit London research group International Institute for Environment and Development. In a phone interview from the conference, he said that adaptation assistance should include relocation: “The people of small island countries may not be able to live in their own countries anymore, and bigger countries with low-lying coastal areas may need help to move people inland in their own countries.”

Assisting possible climate evacuees remains a thorny issue. “This is a very difficult question, as environmental refugees are not [legally] recognized,” says Espen Ronneberg, climate change adviser to the Pacific Regional Environment Programme. “Options at the moment appear to be to adapt as much as we can, negotiate strong mitigation efforts and more dollars for adaptation, but at the same time speak to the total disaster that is pending if not enough is done.” The goal, he adds, is to

prevent, if possible, the most vulnerable populated island states from disappearing entirely.

Many worry that any future actions may come too late to prevent crippling damage to some of the endangered island countries. It is possible that nations such as Kiribati may have already reached a tipping point because of the long delay involved in reducing greenhouse gas levels. There will be a considerable lag time in cutting new emissions significantly, and gases already in the atmosphere may remain there for decades, even centuries, so sea level could keep rising over that period, despite current efforts to slow emissions. Along the way, more frequent or severe ocean storm surges may increase coastal erosion, saltwater may intrude further into soil and freshwater supplies may dwindle due to saltwater, lower rainfall and growing populations. This loss would make it increasingly difficult for people, plants and animals to survive on these islands. “Ocean acidification from climate change can also eat away at the coral reefs, making it harder for them to recover,” says Stanford oceanographer Rob Dunbar, who has done research in the Line Islands.

A study from the National Oceanic and Atmospheric Administration reports that “climate change that takes place due to increases in carbon dioxide concentrations is largely irreversible for 1,000 years after emissions stop.” The study, published in the Feb. 10 *Proceedings of the National Academy of Sciences*, was conducted by an international team headed by Susan Solomon, a NOAA senior scientist who works from a lab in Boulder, Colo. It warns that potential increases in carbon dioxide in this century could essentially lock in a sea level rise that could “equal or exceed several meters over the next millennium or longer” and that “many coastal and island features would ultimately become submerged.”

Geochemist Daniel Schrag, the head of the Harvard environment center where Tong spoke in September, says, “Climate change mitigation is extremely unlikely to reduce emissions sufficiently to protect places like Kiribati.” Schrag fears

that Kiribati “literally faces going out of existence,” but he is also impressed with Tong’s foresight in promoting an orderly long-range plan for his country’s highly uncertain future. “I find what the president of Kiribati is doing extraordinary. He’s socially engineering an exit solution over a timetable that may take several decades. That’s unusual in government,” Schrag says, noting that long-term disaster planning is often sorely lacking in other coastal communities. (Schrag is pushing for more climate change planning now in the Boston region.)

Tong is also getting kudos in the scientific and environmental communities for giving back to the world with his important conservation initiative: creation of the Phoenix Islands Protected Area, a remote archipelago of eight coral atolls and two submerged reef systems in an expanse of ocean totaling 410,000 square kilometers, roughly the size of California. The Kiribati government partnered with

the New England Aquarium in Boston and with Conservation International to set up an endowment funded by international donors that compensates the country for revenue it will lose from granting fewer fishing licenses. In 2008, the aquarium awarded Tong its top award for “distinguished service on behalf of oceans.”

Marine biologist Gregory Stone, the aquarium’s vice president for global marine programs, says the isolated Phoenix Islands (where Amelia Earhart’s plane may have disappeared) are a treasure because of their pristine wilderness and marine and land biodiversity—including some 120 species of coral and 500 species of reef fish, not to mention countless dolphins, sea turtles and birds (but almost no people). “The islands provide insight into what oceans and coral reefs may have been like 1,000 years ago,” offering “a scientific baseline for understanding how climate change and environmental stressors are already impacting other

marine communities,” Stone says. “The Phoenix Islands give us a window into the past and what a healthy, robust coral reef ecosystem looks like.”

Growing greenhouse gas emissions may threaten the future of these irreplaceable environmental treasures, as well as that of other tropical atolls. Their fates hang on whether the international community has the political will to push through tough climate controls and, if so, whether these actions will be sufficient to save vulnerable low-lying islands and coastal areas from encroaching ocean waters. ■

*Cristine Russell is a freelance science writer and senior fellow at the Belfer Center for Science and International Affairs, Harvard Kennedy School.*

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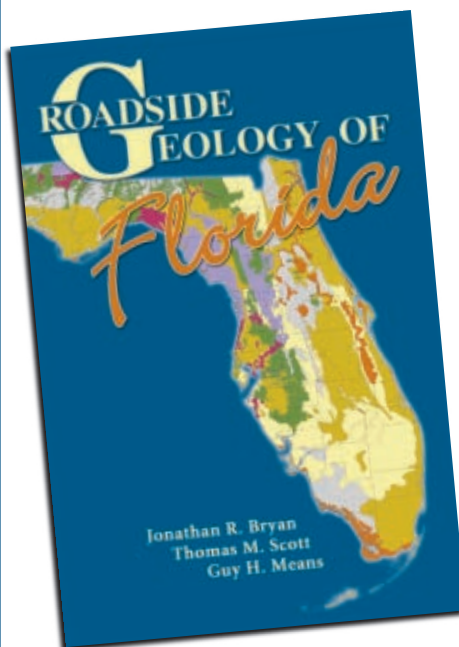
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## Galaxy clusters slide

Could the general motion of galaxy clusters (“Galaxy clusters slide to the south,” *SN*: 10/25/08, p. 12) be evidence of rotational motion of the matter components of the universe on a scale much larger than the observable universe? Would such motion not also result in accelerating expansion of the observable universe, as gravitational attraction opposing rotational expansion weakened as a result of expansion?

**Arden Slotter**, Castle Pines North, Colo.

*“The question of an overall rotation for the universe is an interesting one,” says Glenn Starkman of Case Western Reserve University. “Some attention has been paid to it, but without any convincing evidence to support it. I don’t think this work on large-scale motions particularly encourages interpretation of the motion as rotation. That would require some observation of a coherence to that motion over large swaths of the sky.”— Ron Cowen*

## Treating itch with acupuncture

Concerning “Itch” (*SN*: 11/22/08, p. 16): One of the theories behind acupuncture is the interrelation of nerves throughout the body so that stimulation in one area will have an effect on another. Since the researchers have discovered a new network of fibers, albeit itch fibers, it serves to corroborate the existence of a large involved network. This begets the question, is it possible that acupuncture could be a possible treatment for the “itch” or has it been already tried and found ineffective?

**Ted Blinder**, Havertown, Pa.

*To date, acupuncture’s effect on any kind of itch has been addressed by just a few small-scale studies. Clinician Gil Yosipovitch, who treats patients with chronic itch, says that he is a bit skeptical of the benefits of acupuncture for relieving chronic itch. But he adds that some reports of acupuncture’s efficacy for chronic pain make it plausible that itch might also be alleviated. “Bottom line,” Yosipovitch says, “as long as*

*it is done by an expert and is devoid of adverse effects,” it could be used as an adjunct treatment.* — *Laura Sanders*

## What’s in a name

I thought that Alan Stern’s article (“Debates over definition of planet continue and inspire,” *SN*: 12/6/08, p. 32) was right on. As a docent at the Detroit Science Center, I have found the lay public to be somewhat confused by the IAU decision. Some visitors to the DSC have even asked what changed about Pluto to cause it to stop being a planet. I explain that nothing changed about the planet itself, that the change in nomenclature was the result of an arbitrary semantic decision. I like Stern’s consideration of a planet to be “any natural object in space that is large enough to be rounded by self-gravity.” This is a definition that people can easily understand, and one that I will quote to visitors as an alternative definition in addition to the one voted on by the IAU. A planet by any other name would be just as round.

**Dick Simmons**, Clarkston, Mich.

I have no strong feelings on this, but do note that Alan Stern’s complete definition of planet, “any natural object in space that is large enough to be rounded by self-gravity,” emphatically includes the stars.

**R. Antonucci**, Santa Barbara, Calif.

*The sharp-eyed reader is correct; I goofed. Owing to space limitations, I shortened “any natural object in space that is large enough to be rounded by self-gravity, and not sustaining nuclear fusion in its interior” to just what was in the article. I guess I got what I deserved when the reader realized the words now imply something I did not mean — that there is no upper bound to planet size. The fact is, planetary scientists are careful to define planets with both a lower size limit set by the ability to “get round” (and thereby separate from rocks and asteroids), and an upper size limit set by the prohibition against “doing fusion” (and thereby becoming stars). — Alan Stern*

## The nocebo effect

In “Imagination Medicine” (*SN*: 12/20/08, p. 26) the author talks about how the placebo effect could be making a drug appear more effective than it really is. That part of the article made me wonder if the placebo effect could cause an opposite result also: someone so convinced the medicine would not help them that they did not get better. Has anyone researched or considered researching this type of “opposite” placebo effect?

**Kerry Learned**, Plattsburgh, N.Y.

*The placebo effect can indeed cause an opposite reaction and that’s called “the nocebo effect.” Studying the nocebo effect is difficult ethically because doctors would need to tell the patient, “Now I’m going to give you a substance that will increase your pain” but actually give a placebo,” says neuroscientist Fabrizio Benedetti. Research has shown that the nocebo negative effect is due to the activation of a molecule involved in anticipation of anxiety called cholecystokinin. Recent work on nocebo and pain by neuroscientist Jon-Kar Zubieta traced the nocebo effect to the same brain networks responsible for the placebo effect and showed that nocebo worked in opposite ways, to worsen pain rather than relieve it. Zubieta and others say that this reaction is common in many clinical trials.* — *Jeanne Erdmann*

**Correction:** The wording near the end of “For a big view of inner Earth, catch a few geoneutrinos” (*SN*: 1/17/09, p. 16) was misleading in saying that “only a fraction of potassium-40 is radioactive.” Actually, only the potassium-40 fraction of all potassium is radioactive. The isotopes potassium-39 and potassium-41 are not radioactive.

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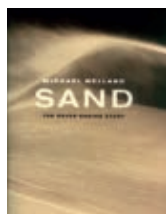


**Sand: The Never-Ending Story**

Michael Welland

**S**and, despite what one character in the film *Eternal Sunshine of the Spotless Mind* claims, is more than just tiny little rocks.

Sure, around 70 percent of the 1 billion or so sand grains born around the world each second are grains of quartz — bits of plain old silicon dioxide that have eroded from rocks such as the granites that make up Earth's moun-



tains. But many of the rest — wave-crushed coral, broken bits of shell, even the intact remains of tiny, star-shaped marine creatures — have

a biological origin, Welland writes. Intriguingly, he notes, what makes something sand is the size of its particles, not what those particles are made of.

In *Sand*, Welland chronicles the stories of individual sand grains — how

no two are alike, how they're used in archaeology and modern forensics, how a windblown grain becomes battered and rounded much more quickly than one carried by a river — as well as the tales of how large accumulations of sand behave, a topic of interest to everyone from golfers and sand castle sculptors to physicists and geologists.

Sand is one of Earth's most ubiquitous and fundamental materials, so much so that in ancient times it played an integral role in the creation myths of many cultures. Today, Welland notes, sand touches nearly every life as an ingredient in products as diverse as concrete and glass, cosmetics and shampoos, pharmaceuticals and foodstuffs. Besides being both a medium and a tool in nature's ever-changing sculptures, sand has served as an inspiration to poets and authors, and its imagery is embedded in math and art, literature and language.

There are worlds to see in a grain of sand, and a world of fascinating information in this book. —*Sid Perkins*  
*Univ. of California*, 2009, 343 p., \$24.95.

**The Pluto Files: The Rise and Fall of America's Favorite Planet**

Neil deGrasse Tyson

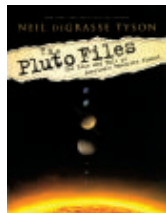
**A**mericans love the pla ... err, dwarf pla ... err, plutoid Pluto. The feeling is so strong, in fact, that it sparked an overwhelming public outcry when in 2006 the International Astronomical Union kicked Pluto from the planet club, writes astronomer Neil deGrasse Tyson.

His latest book chronicles the history, science and controversy that ultimately led to the planet's demotion. By reprinting song lyrics, editorial cartoons and letters from third graders, among others who challenged and still challenge the IAU decision, the author illustrates Americans' cultural love affair with Pluto. He also explains how Pluto's fall from grace divided the nation. Among all planet names, he writes, "Pluto sounds the most like a punch line of a hilarious joke," and now "Pluto is not a red-blooded planet.... How rude."

It's these jibes and Tyson's personal

anecdotes that make the book a fun read. But, had he toned down his signature writing style when describing the science supporting Pluto's demotion, *The Pluto Files* would have made a better case for rejecting the planet label for Pluto — and perhaps ultimately for all planets.

The author argues that children could instead learn about the solar system by grouping objects with similar features into families. A person interested in volcanoes, for example, might study Earth,



Mars, Jupiter's moon Io and Saturn's moon Titan. Explaining Pluto's lack of planethood in less stylized prose may have made the author's reasoning a bit crisper and perhaps would have made his family organization scheme sound a bit more practical. —*Ashley Yeager*  
*W.W. Norton & Co.*, 2009, 194 p., \$23.95.

**Supersizing the Mind: Embodiment, Action, and Cognitive Extension**

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Minds aren't limited to the confines of the brain. *Oxford Univ.*, 2008, 286 p., \$35.

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Experimental math embraces computers. *A K Peters*, 2009, 158 p., \$29.95.

**Prairie Dogs: Communication and Community in an Animal Society**

C.N. Slobodchikoff, Bianca S. Perla and Jennifer L. Verdolin

An investigation into how prairie dogs communicate a predator's presence. *Harvard Univ.*, 2009, 264 p., \$39.95.

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## David Spergel



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## Nation needs recovery plan for science faculty jobs

Over the past few months, many graduate students and postdocs have been receiving letters from department chairs apologetically explaining that the faculty job search at Institution X has been canceled. State and private universities are facing declining tax revenues and falling endowments, and are unwilling to raise tuition on newly impoverished families. From Harvard to small local colleges, junior faculty searches are being put on hold as the nation suffers its worst economic downturn in most of our lifetimes.

Even if the economy were to recover over the next one to two years, the academic job market for the next few years is likely to be bleak. It will probably take several years for university finances to recover. Even more significantly, the collapse of the stock market has led many faculty members to defer retirement plans. Many professors in their late 60s and early 70s who were planning to retire in the next two to three years have decided to stay on and work for an additional few years so that they can recover some of their market losses.

While this choice makes a great deal of sense for each individual, it will likely have tragic side effects. If all of the faculty members who were planning on retiring at age 67 defer retirement to 72, then universities will not be able to hire any new faculty for the next five years! (This claim rests on the assumption that universities are not likely to rapidly grow their faculty size during an economic downturn and early in the recovery.) When the current cohort of 67-year-olds and the current cohort of 62-year-olds retire over the next five to 10 years, this wave of retirements may create a job bump; however, the next several years will be a difficult time for any scholar seeking a faculty position.

Recent days have made many scien-

tists optimistic about the future. In his inaugural address, President Obama has pledged to “restore science to its rightful place” and to “transform our schools and colleges and universities to meet the demands of a new age.” The economic stimulus package includes funds to significantly augment the budgets of NSF, NIH, DOE and NASA. If these funds are directed toward research grants and toward large science projects, they will have a very positive effect but will create primarily postdoctoral positions rather than faculty jobs.

While most of my generation of scientists benefited from spending the first few years after our Ph.D.s as postdoctoral researchers, few young Ph.D.s are looking forward to spending 10 years working under the direction of a more senior scientist and having to move every two to three years to a new part of the country. Facing strains on their family lives, many of our best young scientists and engineers will choose to leave academia and seek jobs in other fields. These pressures will likely have even more devastating effects on the current cohort of promising young women scientists and on young people who come from families with limited financial resources.

The lack of tenure-track jobs in the United States will likely lead many of our best young U.S.-trained scientists and engineers to seek faculty positions in Europe and Asia, or to abandon their scientific careers. Many of our promising young Ph.D.s are foreign-born scientists who will likely return to their home

countries. Most other advanced nations have mandatory retirement ages at their universities and do not have retirement pensions connected to the stock market.

What is to be done? If Congress were to direct 10 percent of its planned increase in science spending toward

creating junior faculty positions, the resulting new jobs would replace many lost positions and completely alter the job landscape over the next several years. A federally sponsored “advanced” fellowship program to provide support for the first three years of a junior faculty position would create many new academic jobs. As part of this program, universities would commit to providing support for the next three years to guarantee a six-year appointment. The British and Spanish governments have already implemented a program on this model. By restricting the number of government-supported advanced fellows at any

given university, this program would foster the creation of new jobs at universities across the country.

This investment in creating new faculty jobs will likely save a generation of researchers and yield long-term benefits. These young faculty members will produce new advances in medicine, new technologies to spur long-term economic growth and new insights that will deepen our understanding of the world around us. ■



**The lack of tenure-track jobs in the United States will likely lead many of our best U.S.-trained scientists and engineers to seek faculty positions in Europe or Asia.**

*David Spergel is chair of the department of astrophysical sciences at Princeton University.*



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I just threw my watch in the trash. I got it as a gift a while back—and it was something else. It had four different digital displays, about a dozen buttons, was waterproof to about a thousand feet, and I think it could even tell me the weather. I'll never know, though, because, like I said, it's in the trash. Turns out it couldn't do the one thing I want a watch to do ... tell me the correct time. It always ran a little slow, which was bad enough, but there were so many displays and they were so small that I couldn't tell the time even if it was accurate. When I tried to reset it I pushed the wrong button and set it on military time, and I couldn't figure out how to switch it back. That was the last straw. Now, I've got a great watch. It's super-accurate, easy-to-read, and it will even tell ... yes tell ... me the time. Best of all, I'll never have to set it! This is the watch I've been waiting for.

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This Talking Atomic Watch from *firstSTREET* maintains its phenomenal accuracy because it is designed to receive a signal from the US Atomic Clock in Fort Collins, Colorado. This clock is the standard for time measurement worldwide... it can go 20 million years without gaining or losing a second! It never needs to be set, because it automatically adjusts itself for daylight savings time and leap years.

## Easy to read, Even easier to hear.

The most accurate watch in the world is of no use if you can't read it. This timepiece is designed to tell you the correct time... anytime. It features a clear, uncluttered analog display that you won't need reading glasses to see. Best of all, you can press a button and it will tell you the time in a clear, easy-to-understand voice. So whether you're driving to an appointment or dining in a candle-lit restaurant ... you are sure to know the exact time. Press another button and it will even tell you the day and date if you want. There's even an automatic hourly chime.



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The US Atomic Clock cost billions to build and maintain, but you can have the next best thing for less than one hundred dollars. Thanks to a special arrangement with the manufacturer, we can offer you this watch at a special price with our exclusive home trial. Call now, and we'll give you a \$10 INSTANT DISCOUNT and FREE SHIPPING. If you are not completely amazed by the accuracy and quality of this product, simply return it within 90 days for a full "No Questions Asked" refund.

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