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ScienceNews

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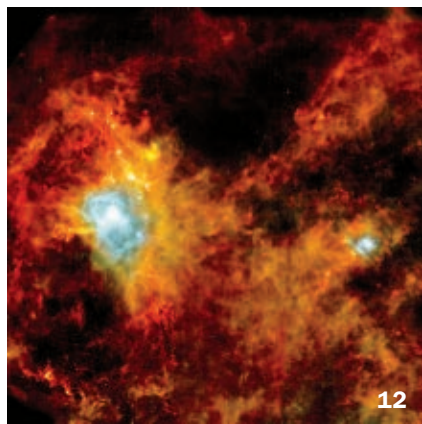
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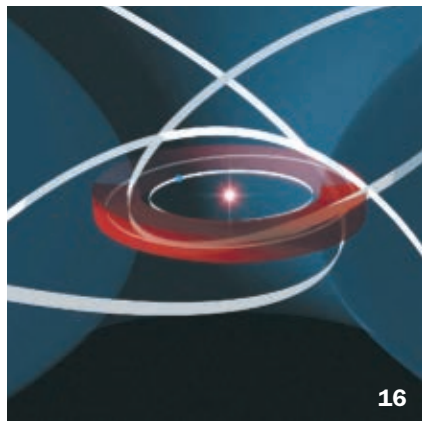
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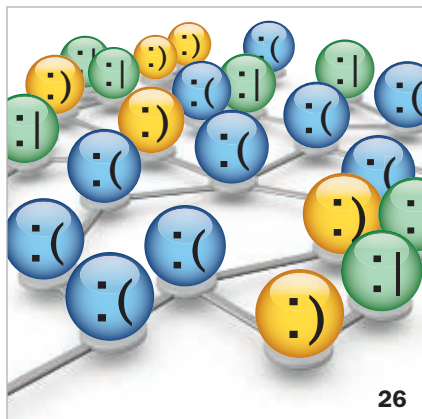
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COVER Intensive studies of fossils of *Ardipithecus ramidus* (artist's conception shown) are stirring debate about what early human ancestors were like.
Jay Matternes © 2009

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FROM THE EDITOR

Ardi offers deep lessons for study of human history



When the 19th century English historian Henry Thomas Buckle undertook the writing of the whole history of human civilization, he called it the *History of Civilization in England*, as though that was the whole of human history.

Of course, Buckle recognized and wrote of earlier human civilizations, such as those of India, Egypt and Greece. He evidently considered those cultures less noteworthy than that of the empire always at least partially bathed by sunlight. But civilization's origins extend even further back in time, and human history itself (or "prehistory," if you insist on written records for "history") began millions of years ago, with the hominid ancestors of today's *Homo sapiens*. It has been less than a century since fossil-based knowledge of that history began to unfold, and new chapters continue to appear — most recently, the tale of *Ardipithecus ramidus*, as Bruce Bower describes in this issue (Page 22).

Examinations of a 4.4-million-year-old skeleton of an *A. ramidus* female, nicknamed Ardi, have opened a new vista to the protohuman past. Anthropologists are now in the midst of a vigorous debate over just what exactly Ardi has to say about human origins — whether she was a distant cousin or direct ancestor of modern humans (perhaps the last common ancestor of humans and chimps), for example. Ardi also raises questions about the origin of two-legged upright walking, considered a defining feature of the human evolutionary family.

Whatever the outcome of these debates, Ardi teaches some important lessons. One is that the human story began long before historians arrived to tell it; modern humanness derives in no small measure from the experiences of pre-human primates imprinted into the DNA blueprint inherited by *H. sapiens*. Another lesson is that major gaps in modern knowledge of human origins remain. Ardi's discovery offers hope that those gaps will someday be more nearly filled. And not least among her lessons is Ardi's reminder that science can inform history, a message that Buckle himself emphasized decades before fossil evidence of protohumans first came to light. Long ago history was preserved in the ballads sung by tribal oral historians; later the written word enabled the recording of more detail (but also, Buckle noted, the introduction of historical errors). Now science can provide a human history deeper than anything that Buckle could have imagined. —Tom Siegfried, Editor in Chief

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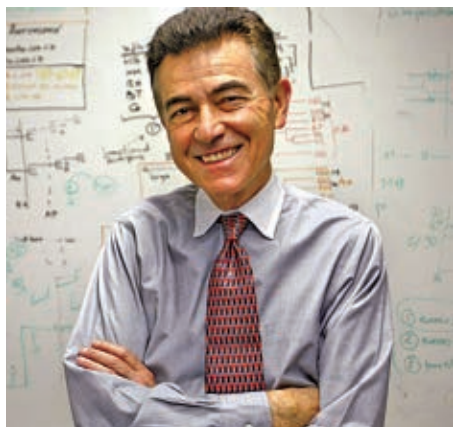
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Scientific Observations

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world. Apparent contradictions only emerge when either the science or the beliefs, or often both, trespass their own boundaries and wrongfully encroach upon one another’s subject matter.” —UNIVERSITY OF CALIFORNIA, IRVINE

BIOLOGIST AND PHILOSOPHER FRANCISCO J. AYALA IN THE DEC. 15 *CURRENT BIOLOGY*

Science Past | FROM THE ISSUE OF JANUARY 16, 1960

MEN TO MARS POSSIBLE IN 60’s, EXPERTS SAY — The United States will be able to send three men on a 14-month expedition to Mars in a nuclear-powered two-stage rocket ship



during the 1960’s, three space experts assert. The rocket ship would go into orbit around Mars, and the exploring party would use a chemically propelled “taxi” to go down for a close look at the Martian landscape. After exploring for two months, the party would refuel their orbit-

ing space ship and head back to earth. Tanks of hydrogen, for refueling purposes, would be launched about a month earlier than the manned ship to make certain they are on course... In addition to its three-man crew, the space ship would carry 55,000 pounds in life-support materials.

Science Future

February 4–5

Annual meeting of the American Association of Behavioral and Social Sciences occurs in Las Vegas. See aabss.org

February 13–17

The American Physical Society and American Association of Physics Teachers meet in Washington, D.C. See www.aps.org

March 17

Human origins exhibit premieres at the National Museum of Natural History in Washington, D.C. See humanorigins.si.edu

SN Online

www.sciencenews.org

BODY & BRAIN

It’s not just about how much you drink — the liquor’s color affects how you’ll feel the next day, too. Read “Darker liquor, never sicker.”

Texting while driving is dangerous, research confirms. See “Texting and driving don’t mix, as suspected” for story and video.



SCIENCE & THE PUBLIC BLOG

Controversy swirls around what Copenhagen’s climate accord *didn’t* say. Read “Climate deal reached, importance debated.”

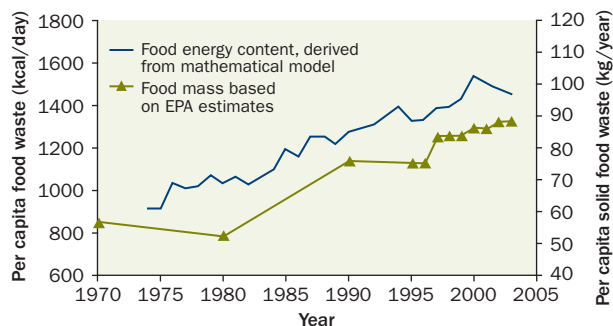
LIFE

High-speed cameras show how Muscovy ducks use genitalia in a battle of the sexes. See “Sexual conflict takes shape in ducks.”

Science Stats | WASTE NOT, WANT NOT

Food waste in the United States, tallied by comparing the food supply with consumption estimates, has risen over the past 30 years.

U.S. food waste per year by mass and energy content



SOURCE: HALL ET AL./PLOS ONE, 2009

How Bizarre...

The male pipefish can do without the fatherly sacrifice bit, thank you. A study of 17 male pipefish, which brood the eggs in this species (shown), shows that fathers leach nutrients from failed embryos in their care. Males brood embryos in a pouch near their tails, but not all embryos survive the brooding period. But no one knew whether dad or the siblings got the extra nutrients from the failed embryos. To find out, researchers mated male pipefish with females that had been treated to lay eggs carrying radioactive amino acids. When the researchers tested the surviving embryos and the father, only Papa Pipefish’s tissue showed radioactive traces, the team reports online November 25 in the *Proceedings of the Royal Society B*.



“We’re on the eve of a new phase of exoplanet studies.... This planet is a harbinger of what’s to come.... It’s the torch, telling us about this new thing that’s going to happen.” —SARA SEAGER

Life Virus co-opts plant to fool aphid
Fossil hints at dino’s stunning bite

Matter & Energy Flash-freezing laser light

Atom & Cosmos Many stars are born

Body & Brain Lupus risk not just in genes

Earth California groundwater falling fast
Volcanic fireworks in the deep sea

In the News

STORY ONE

Super-Earth may host water, but probably not life

Further studies could reveal close-by planet’s composition

By Lisa Grossman

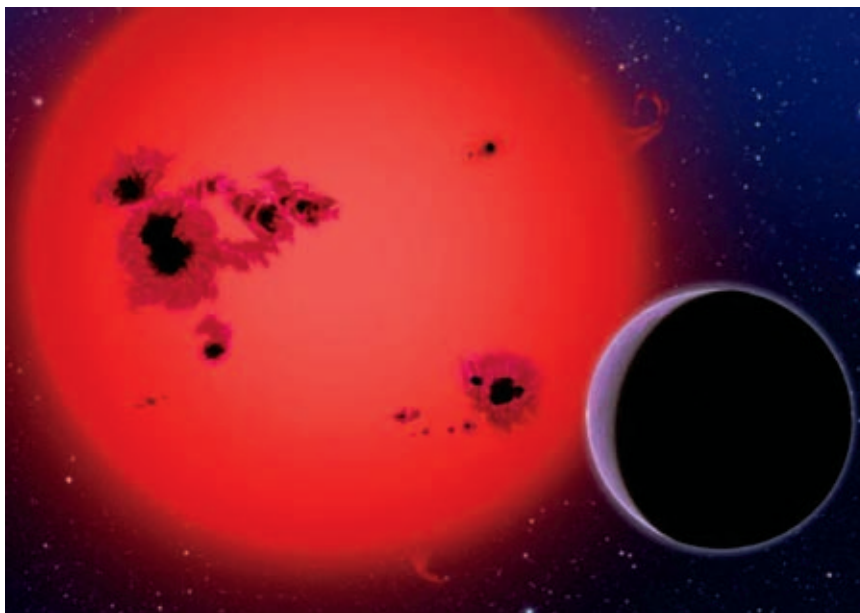
A relatively small planet orbiting a star not far from Earth may be made mostly of water, new observations show.

“This planet is the most Earthlike planet yet discovered,” comments planet hunter Geoffrey Marcy of the University of California, Berkeley.

Called GJ 1214b, the planet is the second super-Earth—a planet with a mass roughly between five and 10 times Earth’s mass—detected passing in front of its parent star. GJ 1214b is 6.5 times more massive than Earth and 2.7 times wider, scientists report in the Dec. 17 *Nature*. It is the first super-Earth found that is close enough for astronomers to study its atmosphere.

“We’re on the eve of a new phase of exoplanet studies,” says astronomer Sara Seager of MIT. “This planet is a harbinger of what’s to come. It’s not just that we can study this one object in more detail. It’s the torch, telling us about this new thing that’s going to happen.”

The discovery comes on the heels of other exoplanet sightings, two of which also may be super-Earths. All three possible super-Earths have masses between those of Earth and Uranus—a range not represented in the solar system.



A newly discovered super-Earth (illustrated in foreground) orbits a red dwarf star. The planet, GJ 1214b, offers hope that habitable planets will be found, scientists say.

“This is completely unexpected,” says Greg Laughlin of the University of California, Santa Cruz, a coauthor of two reports appearing online December 14 about the potential super-Earths. “It tells us that planets really form very easily.”

Scientists led by David Charbonneau of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., studied GJ 1214b as it passed in front of its star from Earth’s point of view. The team determined GJ 1214b’s radius by measuring how much light the planet blocked during this transit. The planet’s mass was calculated using follow-up observations from the European Southern Observatory’s High Accuracy Radial Velocity Planet Searcher instrument, which measures how much the planet’s gravity tugs at the parent star. Charbonneau and colleagues then used

GJ 1214b’s size and mass to calculate density, a clue to the orb’s composition.

Only by knowing a planet’s mass and size is it possible to figure out what it’s made of, Charbonneau says—and making both of those measurements is possible only for a transiting planet. “Those are the most precious planets by far,” he says.

The only other known transiting super-Earth, COROT-7b, has a rocky composition (*SN: 10/10/09, p. 8*). With a density nearly twice that of water, GJ 1214b could be as much as 75 percent water by mass, though there are a number of other possible compositions (see Back Story, Page 6).

GJ 1214b orbits its star, a red dwarf 42 light-years from Earth, once every 38 hours at a distance of 2 million kilometers—about one-thirtieth the distance between Mercury and the sun. Despite its close orbit, the planet reaches



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temperatures of only about 280° Celsius because its star is relatively cool.

"If the sun is a 1,000-watt light bulb, this star is a three-watt light bulb," says Charbonneau. Most of the 400-plus extrasolar planets found to date have surfaces that boil at thousands of degrees Celsius. Although GJ 1214b is as hot as an oven, possible scenarios posit that the planet could have an atmosphere of water vapor or of hydrogen and helium that provides enough pressure to keep water liquid at the surface, even at such high temperatures.

The planet's discovery marks an early success of the MEarth survey. That survey uses eight ground-based, amateur-grade telescopes to automatically follow 2,000 small, dim stars in a search for transiting planets (*SN: 12/20/08, p. 16*). GJ 1214b showed up in the first six months of observations.

"The fact that we found it in the first six months means either we were very lucky, or these planets are very common," Charbonneau says.

Laughlin and his colleagues' recent exoplanet discoveries also suggest that super-Earths may be common, he says.

Using the Keck telescopes in Hawaii



On the sunny side

Of three recently discovered exoplanets considered potential super-Earths, two orbit sunlike stars. (An artist's illustration shows one such planet.) Since neither transits in front of its star, scientists can't be sure of the planets' masses or compositions. But the many low-mass planets already found hint that super-Earths may be more common than previously thought.

and the Anglo-Australian Telescope in Australia, two teams, both including Laughlin, found at least four and possibly six new planets orbiting sunlike stars. One planet, orbiting the star 61 Virginis, is at least five times Earth's mass. Its detection, slated to appear in the *Astrophysical Journal*, is described at arXiv.org/abs/0912.2599. The other candidate super-Earth, which orbits the star HD 1461, is at least 7.4 times Earth's mass, researchers report in a second paper, posted at arXiv.org/abs/0912.2566.

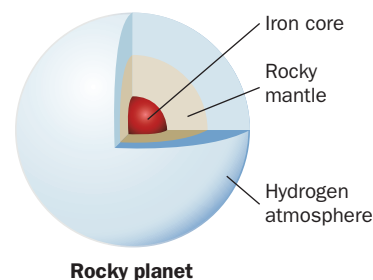
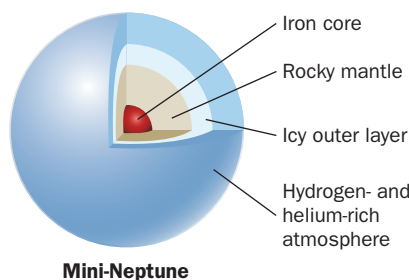
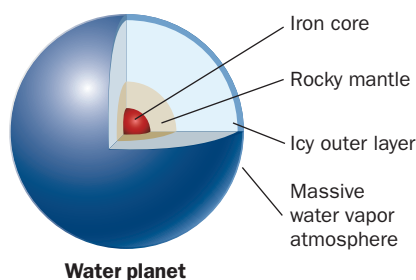
None of the new planets are likely to

be habitable, though. The planets near sunlike stars are too hot, and the possible atmosphere of GJ 1214b would be thick enough to block all incoming light, an important ingredient for life on Earth. But when Charbonneau, Seager and Laughlin talk about finding habitable—and perhaps inhabited—planets, the researchers all say the same thing: It's only a matter of time.

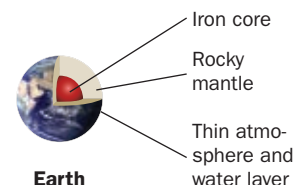
"These planets are like mileposts on the road rather than a destination itself," Laughlin says. "It's very exciting to know that we're getting close." ■

Back Story | ALTERNATIVE VISIONS OF SUPER-EARTH GJ 1214B

With only a few properties of exoplanets nailed down, astronomers are struggling to understand what these planets are like and to determine which ones could most closely resemble Earth—and perhaps support life. Theorists have developed widely different possible models for the composition of the recently discovered super-Earth GJ 1214b. Using the only information available—the mass, radius and estimated temperature of this transiting exoplanet—scientists say that the orb could be a water planet (below, left), a mini-Neptune (below, middle) or a rocky planet (below, right), among others. For comparison, Earth is illustrated at right. —Ron Cowen



SOURCE: L. ROGERS AND S. SEAGER 2009, ARXIV:0912.3243



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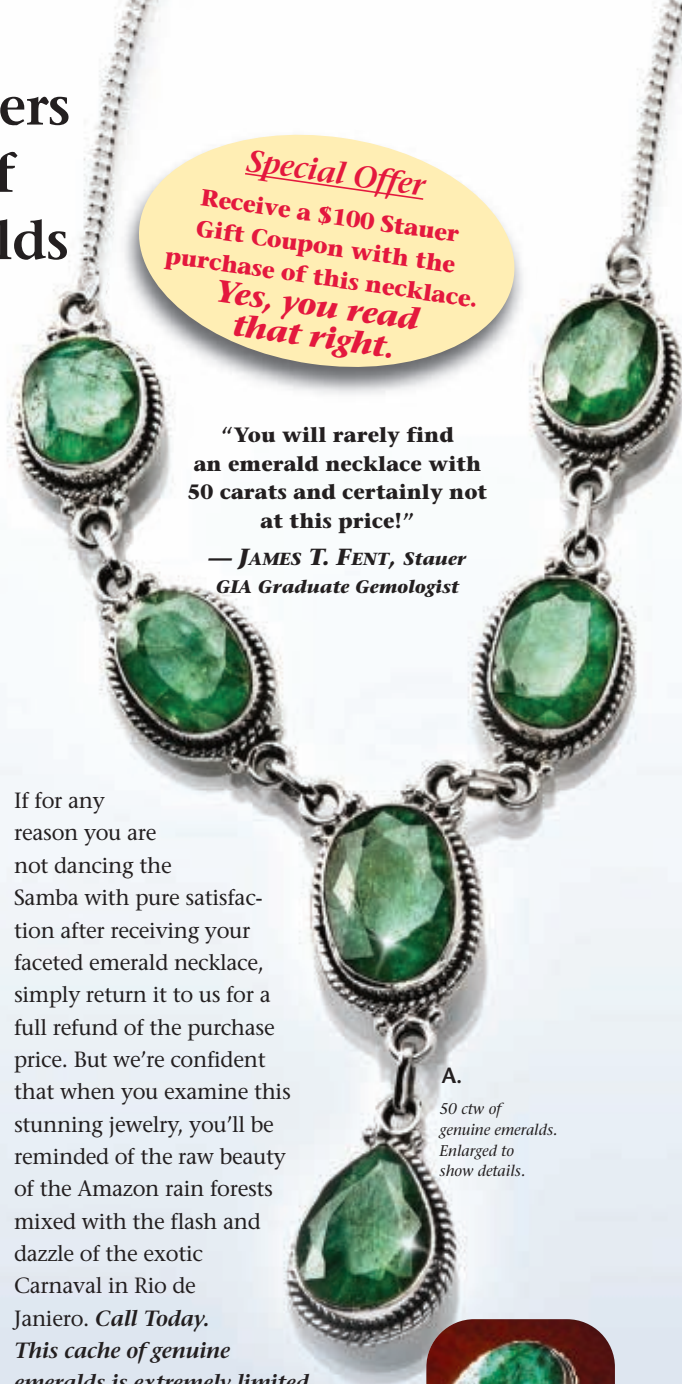
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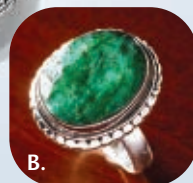
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Life



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Virus makes liars of squash plants

Lured by a deceptive odor, aphids transmit pathogen

By Susan Milius

A common virus turns a squash plant into just the right kind of deceptive advertiser.

When cucumber mosaic virus, known as CMV, infects garden-variety squash plants, the plants smell more alluring to aphids than healthy plants do, reported ecologist Kerry Mauck of Pennsylvania State University in University Park. The infected plants don't live up to their odor, though. Upon landing on a virus-ridden plant, the aphids take a taste and, yuck, move on.

That swift retreat works out well for the virus, Mauck reported December 14. CMV spreads when aphids pick up the virus while probing an infected plant and then pass along the hitchhiker to the next leaf they explore. Unlike some other plant viruses, though, CMV lurks only within the outer layer of plant tissue. An aphid picks up virus particles just by tasting the outer cell layers of a leaf.

And if the leaf tasted as good as it smells, the virus would be in trouble, Mauck said. Aphids might settle down for a long feed on a tasty plant, working their needlelike mouthparts deep into the plant's plumbing and sucking sap. There's no CMV there, and in the course of deep feeding, the aphid would wash out any infectious material caught inside its mouthparts. So an advertising scam that collapses quickly sends the aphids off at a fortuitous time for CMV, Mauck said.

This aphid cheater is the first virus found to manipulate a plant victim into a deception, Mauck said. Researchers have proposed that some other pathogens and parasites drive their hosts to do things that help infections spread.

Mauck and colleagues at Penn State



Cotton aphids can be tricked into tasting a virus-infected plant and then spreading the virus to other plants.

The aroma of infected squash contains the same 20 or so components as scents from healthy plants, Mauck

uncovered the deception by testing yellow crookneck squash. Cotton aphids that were forced to feed on sick plants didn't reproduce as well as those eating healthy plants. Yet in a special lab setup that blocks cues other than smell, the odor alone of infected plants drew more aphids than the smell of an adjacent healthy plant. In a different experiment that gave aphids the chance to move among plants, aphids started abandoning the infected plants within half an hour of arriving—rather than settling in for hours or days.

and her team found. The ratios of these chemicals look roughly the same, but the infected plants put out a stronger signal. Mauck speculates that the virus may be making the squash mimic a really big, healthy plant.

"Very good work," commented Bryony Bonning of Iowa State University in Ames. What she'd like to know, she said, is how this scenario would work where a lot of plants are infected. Aphids flitting among infected plants might not do the virus much good. 

Dry ice in a jug attracts bed bugs

Team designs low-cost detector out of household products

By Susan Milius

After trying some 50 arrangements of household objects, researchers have come up with a new low-cost, homemade bed bug detector.

To lure the bugs, Wan-Tien Tsai of Rutgers University in New Brunswick, N.J., put dry ice in an insulated, one-third-gallon jug, the kind available at sports or camping stores. Adding a little more than a kilogram of dry ice pellets and not quite closing the pour hole let the carbon dioxide leak out at a bug-teasing rate for some 11 hours, she reported December 16.

Tsai stood the jug in a cat food dish with a piece of paper taped on the outside of the dish as a ramp. The bowl's steep, slippery inside, with a dusting of talcum powder, trapped the bugs.

In apartment tests, this setup detected

bed bugs as well as, or better than, two brands of equipment used by professional exterminators, Tsai said.

Tsai worked with Rutgers colleague Changlu Wang, who has experimented with dry ice in travel mugs. As an attractant, the carbon dioxide from dry ice beats heat or chemicals, Wang reported.

In North America, bed bugs are back after being rare for decades. "We have literally skipped a generation of knowledge with this pest," said Stephen Kells of the University of Minnesota in St. Paul.

Long-ago studies may not help control today's pesticide-resistant strains coddled by central heating, said Andrea Polanco-Pinzón of Virginia Tech in Blacksburg. But on the bright side, the modern strain she studies doesn't live as long without feeding as strains documented in earlier research, she said. 

“We have literally skipped a generation of knowledge with this pest.” —STEPHEN KELLS

Coot hatching order tells identity

Birds learn to discern their own hatchlings from impostors

By Rachel Ehrenberg

Calling someone an old coot may compliment their ingenuity. American coots have the cognitive skill to discern their own chicks from impostors. The wetland birds use hatching order to identify their offspring, researchers report online December 16 in *Nature*.

Brood parasitism, in which birds slip their eggs into other birds' nests on the sly, is costly for the tricked birds.

With coots, a host chick may die for each parasitic chick that lives. Some species can recognize their own eggs, but in some cases, parasitic birds precisely match the host's egg color and patterning, gaining an evolutionary advantage. Egg recognition by host birds is common, but chick



Moving native and foreign hatchlings among nests revealed one way a coot identified a baby as its own.

recognition has been reported rarely. Some birds, says Rebecca Kilner of the University of Cambridge in England, “are happy to feed an enormous chick who looks nothing like their offspring.”

One idea for why evolution hasn't led to sophisticated recognition of chicks is

that learning can be imperfect. Parents could ping the wrong bird as their own, a mix-up that could mean rejecting, sometimes violently, their own children.

“The idea is bite the bullet,” says Daizaburo Shizuka, coauthor of the study with Bruce Lyon, both of the University of California, Santa Cruz. “Forgo recognition and feed what is in your nest.” The new work suggests that coots can develop the ability to recognize their chicks if a reliable method presents itself.

Field studies by Lyon and Shizuka, who spied on coots near Williams Lake in British Columbia, show that parasitic chicks are less likely to survive than native chicks. An empty nester would know a parasitic egg if it suddenly showed up, so the first egg laid — also the first egg hatched — is likely to be the host's own chick.

To test whether hatching order had something to do with chick survival, Lyon and Shizuka transplanted hatchlings among nests. When parasitic chicks arrived at a nest before native chicks, coot parents discriminated against their own young. And when a native and foreign chick appeared first together, native and parasite chicks fared equally well. 

Teeth are clues for dino venom

Features in skull could be glands, delivery pathways

By Sid Perkins

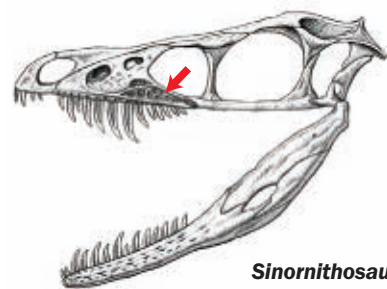
Well-preserved fossils of a feathered dinosaur that lived about 125 million years ago — along with certain aspects of its teeth and skull — suggest that the turkey-sized creature was venomous.

Sinornithosaurus was unearthed in China and first described by scientists about 10 years ago, but the telling details of the creature's cranial anatomy are just now being reported, says David Burnham, a paleontologist at the

University of Kansas in Lawrence.

Most of the teeth in each side of the creature's upper jaw have grooves that run from the base of each tooth to the tip, a characteristic seen in some of today's venomous reptiles. A large triangular depression on the creature's upper jawbone — a feature not previously reported in other dinosaurs or their relatives — probably held venom-producing glands, Burnham and his colleagues report online December 21 in the *Proceedings of the National Academy of Sciences*. Venom flowing from those glands probably pooled in reservoirs at the base of each grooved tooth until the dino bit its prey, Burnham says.

A few of *Sinornithosaurus*' narrow teeth were quite a bit longer than the others. Modern creatures that have a



Sinornithosaurus could have delivered venom from glands (arrow) in its jaw.

similar variability in tooth length typically bite and hold their prey, Burnham says. So, he and his colleagues speculate, *Sinornithosaurus* probably used its venom to quickly stun struggling victims, which could have included small-to-medium-sized birds, by sending them into shock. ■



Trapped in cloud of ultracold atoms, light stayed frozen for 1.5 seconds

Technique, if improved, could lead to light-storage devices

By Laura Sanders

Forget about ziplock bags. A cloud of ultracold atoms can store a beam of yellow light for 1.5 seconds, researchers led by Lene Hau of Harvard University report December 4 in *Physical Review Letters*. That timescale isn't impressive for frozen peas, but it's enough time for light to circle the Earth 10 times under normal conditions.

This ability to store light may lead to more efficient ways to communicate and new ways to explore quantum mechanical properties such as entanglement.

The new study is "a beautiful demonstration," says Irina Novikova, a physicist at the College of William & Mary in Williamsburg, Va. Before this result, she says, light storage was measured in milliseconds. "Here, it's fractional seconds. It's a really dramatic time."

Researchers knew that the information carried in light pulses could be transferred to clouds of ultracold atoms, called Bose-Einstein condensates. In this technique, a laser called a control laser prepares the atomic cloud for an incoming light beam. As they fly in, the photons leave an imprint in a subset of the atoms. This imprint, stored in a quantum property known as spin, contains all the relevant information needed to reconstitute the light beam. But the imprint is fragile and deteriorates in milliseconds. The light's information is lost as other atoms in the cloud interfere with the imprint.

Hau and colleagues overcame this problem by sequestering the matter imprint from the rest of the atoms in the cloud. The team shone a pulse of laser light—which looks like the yellow light from street lamps, Hau says—into a small cloud of sodium atoms. A three-microsecond pulse would produce a stretch of

light about a kilometer long if unimpeded, but as the pulse entered the atom cloud, it began to compress. Like an accordion closing, the light folded up and crammed itself into a space just 0.02 millimeters long, Hau says. The spin states of sodium atoms in the light's path were changed, forming the matter imprint. By turning off the control laser, the researchers were able to freeze the matter imprint.

Next, the researchers strengthened the magnetic field applied to the atom cloud to protect the imprint from interfering atoms. At a certain magnetic field strength, Hau says, interactions between the imprint and the rest of the atoms start to become repulsive, and the imprint separates from the cloud like a drop of oil in water. "This matter imprint digs a little hole for itself in the condensate," Hau says. "It can snugly sit there for long periods of time."

After waiting 1.5 seconds, the team revived the light beam. First, the researchers coaxed the matter imprint to the outside of the cloud by changing the

magnetic field, and then they turned the control laser back on. The light beam that emerged from the atom cloud was weaker than the light beam that went in but similar in other regards, such as frequency and polarization, Hau says. Improving the stability of the magnetic field will probably lead to longer storage times, she adds.

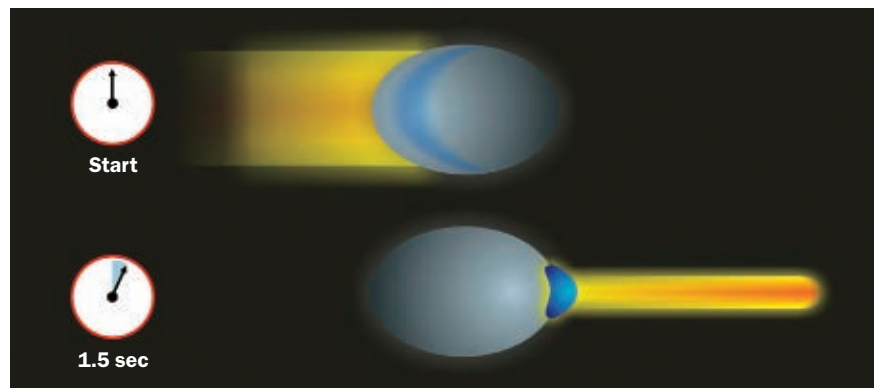
The new method is a vast improvement over earlier ones, the researchers report. The fidelity of the reconstructed light beam

was 100 times better than previous attempts, Hau says.

Transferring information between light and atoms could one day lead to improved communication networks. But while such networks are interesting, Novikova says they won't be practical unless "people figure out how to do a Bose-Einstein condensate that you can buy in Wal-Mart."

Light-storage devices could also enable quantum communication, says quantum physicist Ortwin Hess of the University of Surrey in Guildford, England, who calls the new study "elegant and impressive." Matter imprints of stored light could be manipulated in the atomic cloud to produce quantum messages, which could then be sent out in the form of light. The new study, Hess says, "prepares the grounds" for quantum operations. ■

The fidelity of the reconstructed light beam was 100 times better than previous attempts.



Researchers stored yellow laser light for more than a second in a matter imprint (blue) amid a cloud of ultracold sodium atoms (gray). The beam that emerged (bottom) had the same properties but was weaker than the original beam (top).

ANNE GOODSELL

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THE COLUMBIAN EXPOSITION HALF-DOLLAR

Designers: Charles Barber (obverse)
and George Morgan (reverse)

Diameter: 30.6 mm

Weight: 12.5 grams

Composition: .900 fine silver

Status: Legal-Tender Commemorative

Date: 1893

Atom & Cosmos

3.5
metersDiameter of Herschel Space
Observatory's mirror, largest
ever flown into space

Earliest stage of star birth detected

Telescope finds dust cloud contracting into prestellar core

By Ron Cowen

Before a star can be born, gas and dust from a cold interstellar cloud must gather into a distinct clump. Astronomers say they have now witnessed this earliest step in the star-birthing process.

French scientists used a radio telescope to home in on emissions from a dark, dusty cloud of material in the Taurus star-forming region some 400 light-years from Earth. By mapping dust emission from the cloud along with two chemical tracers of density, the researchers found that the cloud has begun to detach from its surroundings and contract. The density at the cloud's center, the team found, is higher than that at its outer edge.

"This is the discovery of a cloud at the really beginning of the star-formation process, with a new star expected in about 1 million years," says Laurent Pagani of the Paris Observatory. He and his colleagues posted the finding December 8 at <http://arxiv.org/abs/0912.1193>.

"What this represents is the earliest stage of the birth of stars," concurs astronomer Ted Bergin of the University of Michigan in Ann Arbor, who is not a coauthor of the study. Generally, when astronomers observe a cloud that doesn't contain a star, the cloud's motion is tied to any dust or gas around it, he adds. "This is one instance where clear differences are seen" and the core has its own identity, he says. The cloud is becoming an independent entity with its own properties, such as gravity, which are necessary, though not sufficient, for material to coalesce into a star.

Pagani and his collaborators used the 30-meter IRAM radio telescope atop Pico Veleta in Spain to study the cloud, known as L1506C. The object is still too diffuse to be considered a prestellar core, an early precursor to a star, Pagani says. But by

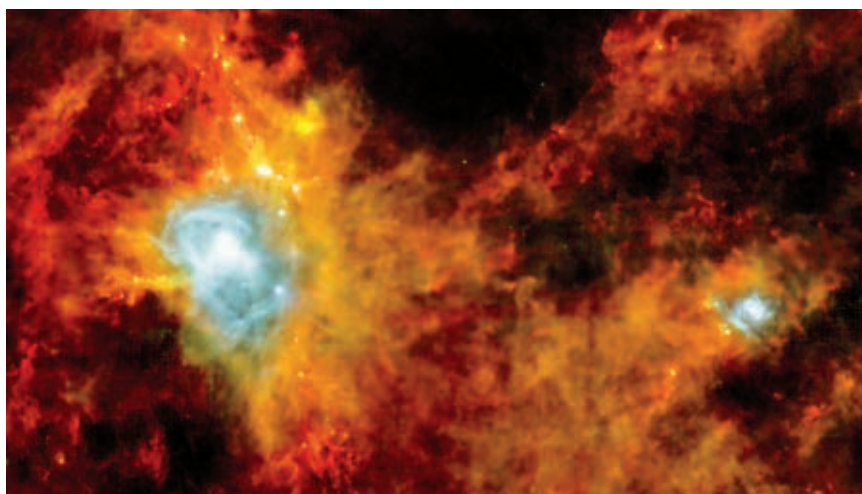
measuring telltale shifts in specific radio frequencies emitted by an assortment of molecules at the front and back parts of the cloud as observed from Earth, the team discerned that the object is clearly contracting, Pagani says. It is therefore "on its way to becoming denser" and evolving into a prestellar core, he adds.

Gravity ultimately transforms many such starless, cold cores into protostars, stellar embryos that release tremendous amounts of heat while packing on more and more material. Eventually, a protostar becomes dense enough to ignite nuclear reactions at its core, a sign that a bona fide star has been born.

"How these objects condense out of the

surrounding gas in the galaxy is something that we have not fully solved," Bergin says. "If you want to understand how stars are born, prestellar cores are the objects that will unlock those secrets." Once a star has fully formed, he adds, it's too late to discover how it got there.

Radio telescopes "are the instrument of choice" for investigating star formation, Bergin says. Because they are sensitive to emissions that penetrate the dusty debris surrounding infant stars and prestellar cores, the telescopes can peer into a cloud's interior. In particular, a highly sensitive network of radio dishes in Chile called the Atacama Large Millimeter Array "will revolutionize our understanding of star and planet birth," Bergin notes. Made up of 66 radio dishes, the array is expected to begin operation in 2012. ■



New observatory sees star babies

Peering into the heart of a stellar nursery, a new observatory has spied some 700 stars in the making. Most of the soon-to-be stars are just clumps of dust and gas, but 100 or so are protostars, embryonic bodies about to initiate nuclear fusion at their cores. The other 600 objects are less mature but will also become stars. The European Space Agency's Herschel Space Observatory, which launched in May 2009, discovered the fledgling stars by recording emissions of long-wavelength infrared radiation, which unlike visible light penetrates through the embryos' dusty cocoons. No other infrared satellite has been able to see into this dark, cold region (shown), which lies 1,000 light-years from Earth in the Eagle constellation. Herschel captured the image, which spans a region 65 light-years in diameter, in October. —Ron Cowen

ESA, THE SPIRE AND PACS CONSORTIA, AND P. ANDRÉ/CEA, SACLAY FOR THE GOULD'S BELT KEY PROGRAMME CONSORTIA

Body & Brain

1.5
millionPeople living
with lupus in the
United States**90**
percentProportion of
lupus patients
that are female

Differing chemical tags on DNA hint why lupus is not identical in twins

Study links epigenetic changes to the autoimmune disease

By Tina Hesman Saey

Lupus can tell identical twins apart by the distinguishing marks the pairs carry on their DNA.

Fewer DNA methylation marks may leave one twin vulnerable to the inflammatory autoimmune disease even while the other sibling remains healthy, a new study appearing online December 22 in *Genome Research* shows.

The finding suggests that environmental factors determine whether genetically susceptible twins will contract the most common type of lupus, systemic lupus erythematosus, in which the immune system attacks the body's own cells.

Researchers have previously identified at least 17 different genes involved in lupus. If genes alone were responsible for determining whether a person gets lupus, then every time one identical twin got the disease, the other would too.

But that doesn't happen. Between 40 percent and 75 percent of the time, when one twin develops lupus the other stays healthy, indicating that some environmental factor must trigger the disease, says Bruce Richardson, a rheumatologist at the University of Michigan Medical School in Ann Arbor.

By looking at differences beyond those in the genetic makeups of healthy people and those with autoimmune disorders, scientists have found that people with lupus and rheumatoid arthritis have lower levels of methylated DNA than healthy people do. Methylation places a type of chemical mark on DNA that generally reduces gene activity without changing the genes themselves. Lower levels of methylated DNA could lead to overactivity of genes, including ones that control immune responses. Environmental triggers can influence DNA methylation.

Previous studies haven't ruled out the possibility of a genetic contribution for lupus, Richardson says, because the healthy people and lupus patients in those studies didn't have exactly the same genetic makeup as one another.

Now, a study of identical twins in which one of the pair has lupus shows that sick twins have lower levels of methylated DNA on at least 49 different genes than their healthy siblings do, report scientists led by Esteban Ballestar of the Bellvitge Biomedical Research Institute in Barcelona. These methylation differences between the twins don't appear to be random: The team found that other people with lupus shared the same methylation pattern as the sick twins, a pattern not found in healthy people.

The team examined methylation of 807 genes. That is only a fraction of the number of genes in the human genome, and Ballestar plans to expand the search. He expects to find that many other genes also have fewer methylation marks in people with lupus.

It is not clear whether twins start out with different levels of methylated DNA or if something in the environment, such as a viral infection, triggers changes later in life, Ballestar says. The discovery also does not prove that methylation patterns alone cause lupus. An underlying genetic susceptibility is probably also necessary to develop the disease, he says.

Because changes in methylation don't alter genes, the finding may also suggest future treatment possibilities.

"Although it's really speculative in the context of autoimmune disorders, one thing about methylation changes is that they are potentially reversible," Ballestar says.

Currently there are no drugs that boost methylation in people. ■

NEWS BRIEFS

Nearsightedness increasing

It looks like nearsightedness is on the rise in the United States. Researchers tapped into a wide-ranging health survey to rate vision, comparing data for more than 4,400 people tested in 1971 and 1972 with that from another set of 8,300 people tested from 1999 to 2004. This broad survey showed that 25 percent of those examined in the early 1970s were deemed nearsighted, compared with 42 percent examined three decades later, researchers report in the December *Archives of Ophthalmology*. Severity also worsened, with moderate nearsightedness doubling between the time periods, says coauthor Susan Vitale, an epidemiologist at the National Eye Institute in Bethesda, Md. Past research has linked nearsightedness to both a genetic predisposition and to excessive near work, which includes tasks that require peering at written words or small objects. —Nathan Seppa

Gene variant may protect lungs

An uncommon form of a gene may protect people who carry it from emphysema and asthma, researchers report online December 16 in the *New England Journal of Medicine*. An international team analyzed data on lung function and genetics from seven studies of more than 5,000 people and found that 7 to 13 percent of people harbored the beneficial variant of the *MMP12* gene. Tobacco smokers carrying the helpful form were 35 percent less likely to develop chronic obstructive pulmonary disease than other smokers. Children with asthma who had the *MMP12* variant had substantially milder disease than their counterparts without it. —Nathan Seppa

Earth



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California hit by irrigation drain

GRACE mission tracks drop in aquifers of Central Valley

By Sid Perkins

During the past six years, crop irrigation in California's Central Valley has pulled groundwater from aquifers at unsustainable rates, scientists reported.

The Central Valley, which covers about 52,000 square kilometers, is one of the world's most productive agricultural regions, said Jay Famiglietti, director of the University of California Center for Hydrologic Modeling in Irvine. In 2002, Central Valley farmers produced more than 250 different crops worth a total of around \$17 billion — an amount that adds up to around one-twelfth of the nation's agricultural production, he noted.

But the productivity of those fertile fields is increasingly at risk: Satellite data suggest that more than 20 cubic kilometers of groundwater has been pumped from the valley's aquifers since October 2003, Famiglietti reported December 14.

Famiglietti and colleagues analyzed

data gathered by the twin satellites of the GRACE mission, which can discern and measure the movements of water, both above and below the ground, on a month-to-month basis (*SN*: 1/4/03, p. 6). Between October 2003 and March 2009, the San Joaquin and Sacramento River basins — the watersheds that include the Central Valley — together lost more than 31 cubic kilometers of water, the data suggest. About one-third of that net loss evaporated from the soil or flowed out to sea after melting from the region's snowpack or being pulled from surface reservoirs.

The rest, about 20.3 cubic kilometers, drained away after being pulled from underground aquifers, most likely for irrigation, the researchers said.

On average, water tables across the region dropped about 24 centimeters per year during the 66-month period studied. But most of the water loss occurred in the San Joaquin River basin, so water tables there probably dropped an average of about 50 centimeters each year.

Because drought conditions have afflicted central California since 2006,

state and local governments have imposed restrictions on how much water can be withdrawn from surface reservoirs. Those restrictions, in turn, have triggered an even greater reliance on groundwater withdrawals, just at a time when the precipitation needed to recharge the

region's aquifers is in short supply, Famiglietti said.

The GRACE satellites can detect changes in the amount of water in a region but can't detect how much is left. Regardless of how much water remains in the aquifer, the researchers noted, a declining water table will degrade water quality and

will eventually force Californians to drill deeper wells. In the long term, continued depletions of groundwater in the region could pose a significant threat to U.S. food production and to the California economy, the researchers contend.

"By providing data on large-scale groundwater depletion rates, GRACE can help California water managers make informed decisions about allocating water resources," commented Michael Watkins of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Continued depletions of groundwater in the region could pose a significant threat to food production.



Sub records volcano video

An unmanned submersible has captured high-definition video of a volcano erupting more than a kilometer below the surface of the South Pacific (still image shown). The summit of the West Mata undersea volcano lies about 200 kilometers southwest of Samoa. In late 2008, oceanographers noticed small bits of volcanic ash suspended in the deep water there and changes in ocean chemistry — possible signs of an undersea eruption in action. Researchers returned in May 2009 with the remotely operated vehicle *Jason* to find West Mata in a full-blown eruption, the deepest yet seen. "It was an underwater Fourth of July," Bob Embley, a marine geologist at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Oregon reported December 17. Rocks snatched from the volcano include boninite lavas, a chemically distinct type of lava previously found only around extinct volcanoes that erupted more than 1 million years ago. — Sid Perkins

NOAA

MEETING NOTES

Tracking of CO₂ outsourcing

International trade sometimes triggers outsourcing of jobs, but always results in outsourcing of carbon dioxide emissions. For the year 2004, about 23 percent of carbon dioxide emissions worldwide were generated during the production of goods or services that crossed national or regional borders, Steven J. Davis and Ken Caldeira of the Carnegie Institution for Science in Stanford, Calif., reported December 14.

About 11 percent of the greenhouse gases related to goods or services eventually consumed in the United States, the world's largest consumer nation, were produced elsewhere, the

team estimates. On the other hand, about 22.5 percent of the CO₂ emissions in China are associated with goods and services that are exported and consumed elsewhere. Attributing the responsibility for carbon dioxide emissions to the final consumer of goods, rather than to the producer of those goods, would be one way to allocate the burden of mitigating the effects of those emissions, Davis and Caldeira said. —*Sid Perkins* 

Seismology in your Twitter feed

The U.S. Geological Survey has begun collecting data about earthquakes from an unusual source: Twitter. The agency has developed software that scours

the torrent of "tweets" flowing through that popular social network. Analyses show that after a quake, the number of messages containing quake-related words spikes, said Paul Earle of the USGS in Denver. Information in the brief messages often provides clues about how widely an earthquake was felt and how strongly it shook various areas. One benefit of the new monitoring program is its speed, Earle noted in a news conference December 14. The info gleaned from Twitter posts is available almost instantly, whereas even the preliminary analyses the agency's scientists use to pinpoint a quake's origin and size often take 15 minutes or more. —*Sid Perkins* 

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On the

Astronomers look to the Kuiper belt for clues to the solar



By Ron Cowen

Beyond Neptune lies a reservoir of rejects — icy debris left to roam the solar system's dim outer limits having never coalesced into planets. But these frozen relics preserve a trove of clues about the earliest history and architecture of the solar system, astronomers are discovering.

Named for astronomer Gerard Kuiper, who in 1951 predicted the existence of this 3-billion-kilometer-wide swath of icy chunks, the Kuiper belt didn't begin to reveal itself to observers until 1992. Since then, researchers have found more than a thousand bodies filling a doughnut-shaped belt, which extends 30 to about 50 astronomical units from the sun. One astronomical unit is the average distance between the Earth and sun.

Pluto may be the most famous resi-

dent of this frozen netherworld, but other objects in this sparsely populated region stand out for their bewildering variety of shapes, colors, densities and orbits. Some travel sedately on circular paths that hew closely to the plane in which the planets orbit the sun. Many have wildly elliptical orbits and move on paths at high inclination to that plane.

The puffed-up, elongated orbits and present-day sparseness of the belt all but scream that the region had a close and violent encounter with at least one of the outer planets, says theorist Hal Levison of the Southwest Research Institute in Boulder, Colo. Recent findings are providing new evidence of this long-ago melee, and the details could help scientists reconstruct early conditions in the solar system.

Planetary scientists examining the Kuiper belt today are "like a CSI team

going into a room where there was a grisly murder," Levison says. And sometimes the blood spattered on the wall — the thousands of small bodies in the Kuiper belt — can tell you more about the early solar system than the actual planetary bodies can, he adds.

Astronomers don't yet have a complete picture of the Kuiper belt, and new riddles — some discussed for the first time in October in Fajardo, Puerto Rico, at the annual meeting of the American Astronomical Society's Division for Planetary Sciences — are emerging. A comprehensive new survey of the belt, set to begin by early spring, will likely explain some of these mysteries and uncover new ones.

Migration and mayhem

To understand how the Kuiper belt has retained so much information about planet formation, scientists must first

fringe

system's history



understand the planet-building process. All the planets and smaller bodies in the solar system formed from particles of gas and dust that stuck together within a protoplanetary disk surrounding the young sun, Levison notes.

But particles can't stick unless they collide gently. Careening rocks and ice chunks in elongated, high-inclination orbits — like many of those in the Kuiper belt today — would hit with high velocity, which would break them apart instead of building them up. Only objects in more circular orbits have low enough relative velocities to coalesce.

That means that the belt's biggest bodies, such as Pluto and Eris (the largest known in the region), would never have formed unless they originally followed more circular, low-inclination orbits. In addition, the belt must have been much more crowded and thousands of times

heavier than it is today. Like a ghostly highway with only a few cars, the belt nowadays has such a low density of objects that any collision — whether a high-speed crack-up or a low-speed merger — is improbable.

"You needed a massive Kuiper belt, and you needed relative velocities to be low" for large bodies to have formed during the first few millions years of the solar system, Levison notes. But then, "you need to perturb the objects and [tip] their orbits to get the highly inclined, elongated orbits we see today."

Such changes are a smoking gun that an intruder must have plowed into the Kuiper belt, he says. Whatever disturbed the belt also removed 99.99 percent of its mass.

The obvious suspect is Neptune, the closest large body to the belt, says observer Mike Brown of Caltech. "That's

Pluto and other icy bodies in the Kuiper belt (illustrated here) may help scientists re-create the solar system's past.

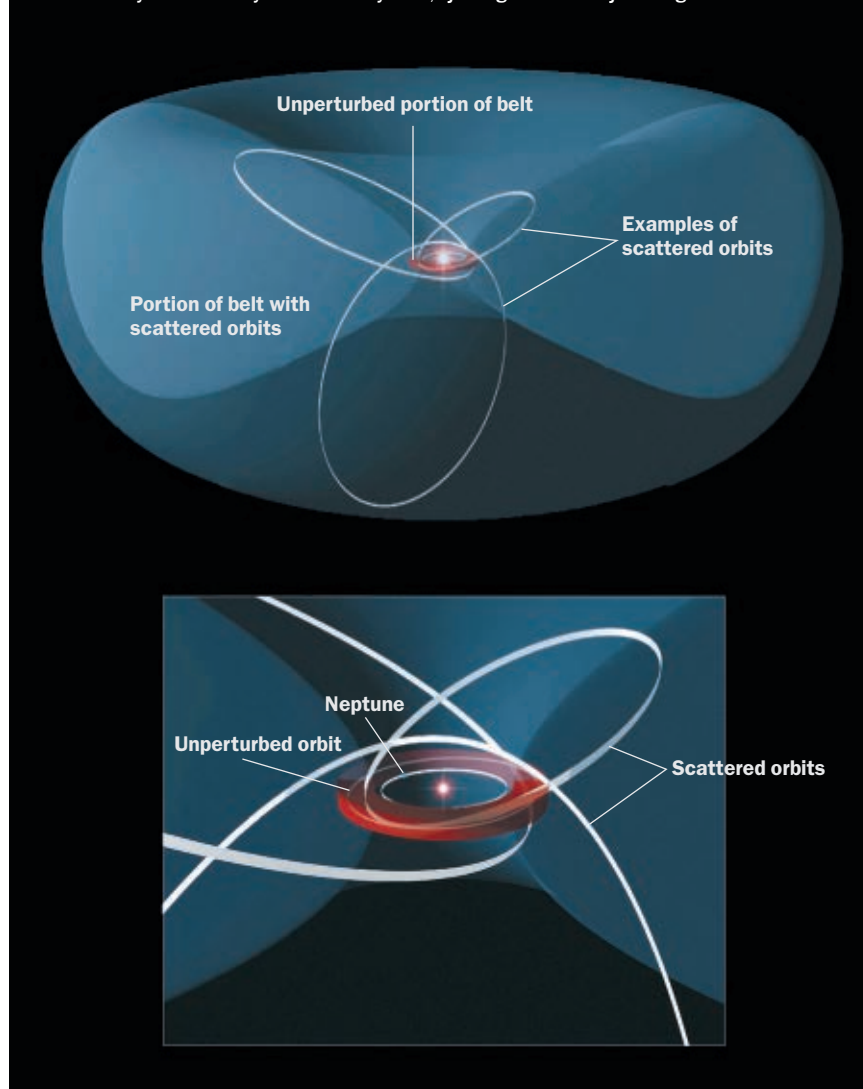
really the only thing that will scatter these objects all around."

Now researchers are trying to figure out how and when Neptune barged into the belt and how quickly it did so, details that could help explain how and when the planets assumed their final positions in the solar system.

In one scenario, suggested earlier in the decade by Levison and his colleagues, Neptune and its three larger compatriots — Jupiter, Saturn and Uranus — were once packed together into a region only about half the diameter of Neptune's current orbit (*SN*: 2/14/09, p. 26).

Gravitational interactions with the then-hefty belt gradually spread these planets out until the orbits of Jupiter

Today's Kuiper belt orbits The elongated, highly inclined orbits of many of the denizens in the doughnut-shaped Kuiper belt (shown in blue) suggest that a massive intruder barged into the belt early in the history of the solar system, ejecting bodies and jumbling orbits.



and Saturn reached a special synchrony. That synchrony strengthened the mutual gravity of Jupiter and Saturn, which in turn hurled Neptune, and possibly Uranus, headlong into the Kuiper belt. Like a bowling ball, Neptune scattered most of the icy bodies toward the sun or out of the solar system entirely, and scrambled the orbits of those denizens that remained. With the belt emptied of much of its material, the gravitational tussle lessened and Neptune came to rest there.

Researchers now think that comparing the number of Kuiper belt objects in two particular orbits relative to that of Neptune could reveal when and how quickly

Neptune's big migration occurred — a natural speedometer.

Scientists had realized that as Neptune moved toward the belt early in the solar system's history, some belt members fell under the planet's gravitational spell and settled into special orbits: Each time that Neptune orbits the sun twice, these objects go around once. Some of the objects in these orbits, classified as in a 2:1 resonance with Neptune, appear to trail the planet, while others lead it.

The number of Kuiper belt objects trailing Neptune in this resonance would increase relative to the number leading it the faster that Neptune

migrated, Ruth Murray-Clay of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and Eugene Chiang of the University of California, Berkeley reported in 2005. Counting these objects might ultimately reveal whether Neptune took roughly 1 million or 10 million years to migrate about 7 astronomical units from its birth site.

The timescale would help researchers “understand the properties of the protoplanetary disk around the sun at the time that Neptune formed,” Murray-Clay says. If the migration lasted only a million years, it could mean that the planetesimals in the disk were particularly abundant and had circular orbits. Which, in turn, could mean that planets coalesced relatively quickly.

Studies also show that giant extra-solar planets orbiting within roasting distance of their parent stars couldn't have formed so close and therefore must have migrated inward. New clues about how Neptune migrated could provide hints about the movement of planets in systems far beyond Earth's, Murray-Clay notes.

More answers, more mysteries

That goal isn't just wishful thinking. A sky survey called Pan-STARRS, which will feature the world's largest digital cameras — 1.4 billion pixels — attached to each of four small telescopes on Mount Haleakala in Maui, Hawaii, is poised to do the head count required to gauge Neptune's migration speed, Murray-Clay says.

The survey, set to begin early this year, covers a vast portion of the sky each night. The initial 3.5-year study has the capability to find Kuiper belt objects as small as about 250 kilometers across, or about one-tenth the diameter of Pluto, says Matt Holman of Harvard-Smithsonian. From the northern sky, Pan-STARRS “will do a complete census of the Kuiper belt” and will have a field of view wide enough to record objects at very high inclinations to the plane in which the planets orbit the sun, he says. Earlier studies were limited to finding objects in or near that plane.

By providing a fuller picture of the belt and possibly finding as many as 10 times the number of Kuiper belt denizens now known, the survey is also expected to quantify the rarity of particular classes of Kuiper belt objects and the extent to which such objects' orbits were altered by an early interaction with one or more of the outer planets.

And the survey will search for fainter, more remote bodies beyond the belt, such as Sedna, the most distant known object in the solar system (see "Solitary puzzle beyond the belt," Page 20).

Surveys about to get underway in Chile will be the first comprehensive studies of the Kuiper belt from the southern hemisphere. And around 2016, the mammoth Large Synoptic Survey Telescope is scheduled to begin operation, providing an even more detailed study of the belt.

Other ongoing surveys are finding Kuiper belt objects. In sifting through 4.5 years of data collected by the Hubble Space Telescope's Fine Guidance Sensors, researchers have found the first belt object smaller than a kilometer, observed as it passed in front of and occulted the light of a distant star. The newly discovered body has a diameter of 500 meters, Hilke Schlichting of the University of Toronto and Caltech and her colleagues report in the Dec. 17 *Nature*.

Another study, the Taiwanese-American Occultation Survey, has been using the same technique to look for small belt objects since 2005 and has found none.

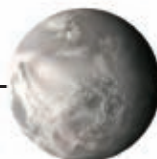
The single finding in Schlichting's study

is a surprise because she and her collaborators calculate that small Kuiper belt objects should be about 35 times more numerous than the observations indicate. The deficit, Schlichting's team concludes, suggests that over the lifetime of the solar system, small bodies in the belt have collided and ground down to dust. This process would produce a fainter version of the debris disks observed around a myriad of other stars believed to have planets and similar belts.

Millions of Quaoars

With new and continuing surveys, more clues to the early and still-evolving solar system are expected to emerge. And future findings may add to the list of odd belt characters already uncovered.

There's Haumea, with its highly elongated shape, an average diameter of 1,500 kilometers and a family of ice cubes — satellites made of pure water-ice, the only such moons known in the belt. And Eris is bizarre for its highly inclined orbit. "We blame Neptune for all the inclined orbits in the belt," Brown notes, but a 45-degree incline is too high to be generated by that planet's gravity. "No one has been able to explain Eris' incline; it's kind of



Eris



Pluto



Haumea



Orcus



Sedna



2005 FY9



Quaoar



Ixion

Large bodies, some oddballs, found past Neptune's orbit are like clues left at a crime scene.

the dirty secret no one wants to talk about," Brown says.

And then there's Quaoar.

Discovered by Brown and his colleagues in 2002, Quaoar took center stage at a session of the planetary science meeting in Puerto Rico. Wesley Fraser of Caltech reported that he and Brown had used the Hubble Space Telescope to observe both Quaoar and its tiny moon, Weywot. By measuring the motion of the orbiting moon, the researchers found that Quaoar is about 350 kilometers smaller than previously estimated, bringing its diameter to less than half that of Pluto. With a smaller diameter, Quaoar must be correspondingly denser; otherwise it wouldn't wield a large enough gravitational tug to keep Weywot in a bound orbit.

Quaoar must have a density akin to that of rock, despite its residency in the icy belt, Fraser reported. That not only makes Quaoar a supreme oddball — perhaps the densest body

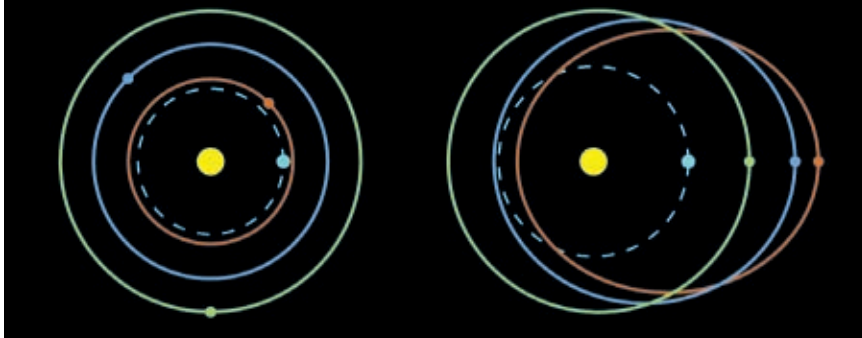
in the Kuiper belt — but also puts it on par with rocky bodies that fill the asteroid belt, located between the orbits of Mars and Jupiter.

In an article now in press in *Chemie der Erde*, Erik Asphaug of the University of California, Santa Cruz offers an intriguing explanation for the new finding. His solution not only fits with existing evidence that the Kuiper belt was once a more crowded place, but also could explain other formation scenarios.

He envisions that Quaoar was originally covered by a mantle of ice that made it 300 to 500 kilometers bigger than it is today, and that it collided with another Kuiper belt body about twice its size — an object roughly the diameter of Pluto, possibly Pluto itself.

In this scenario, Quaoar is a bullet,

Planetary migration As Neptune (dotted circle) migrated toward the Kuiper belt, scientists suggest, it would have disrupted the orbits (solid circles) of other belt objects (before migration on left, after on right). Studying the relative numbers of objects in two particular orbits may help scientists determine how quickly Neptune moved.





striking a bigger body in the belt at a speed a few times higher than the escape velocity of that object. At that speed, Quaoar wouldn't have stuck to the object but would have ricocheted off it. The bigger body would have emerged from the collision pretty much unscathed, but the encounter would have gravitationally and mechanically stripped Quaoar of most of its icy mantle, leaving only its denser, rockier core intact.

If Asphaug is right, the belt must have been rife with millions of Quaoars sev-

eral billion years ago. That's the era when Quaoar-sized objects were coalescing to make larger bodies like Pluto. A large number of Quaoars are required so that after most of these bodies were either ejected from the belt or accreted onto bigger bodies, there would still be enough left over to make a hit-and-run collision likely. A few other Quaoars might still lurk somewhere in the belt, awaiting discovery by future surveys, Asphaug suggests.

Anytime a small body has a much higher density than bigger bodies in the

same region of space, this collision scenario may apply, Asphaug says. Indeed, hit-and-runs are by no means limited to the outer solar system.

Asphaug's interest in such collisions was first piqued by puzzles closer to the sun. In the inner solar system, the dense, iron-rich planet Mercury stands out like a sore thumb. He speculates that a fluffier, bigger Mercury with a lot of mantle collided with Venus, the next-largest planet in the neighborhood, ridding Mercury of its lower-density, outer layers while leaving Venus relatively undisturbed. And in the asteroid belt, an exotic population of about 100 dense, iron-rich asteroids may be the remains of hit-and-run collisions with larger rocks.

In the standard picture of evolution in the solar system, Asphaug says, bodies of similar size were thought to collide and merge, and then a few chunks might be whacked off during a subsequent impact. In contrast, the hit-and-run model "gives a whole new pathway for planetary evolution," Asphaug says. Understanding how such impacts occurred may indicate how crowded the early solar system was.

All this activity—formations, migrations, collisions—took place some 4 billion years ago, soon after the solar system's birth. Today, Brown says, "we are left with this junk on the floor, the Kuiper belt objects, to try to reconstruct what might have happened." ■

Explore more

- More information about the Kuiper belt, from NASA: <http://bit.ly/4nT5XY>
- Planetary scientist Mike Brown's blog: www.mikebrownplanets.com
- Information on Eris: <http://bit.ly/6vnQFq>
- And on Pluto and other dwarf planets: <http://bit.ly/7G2mL2>

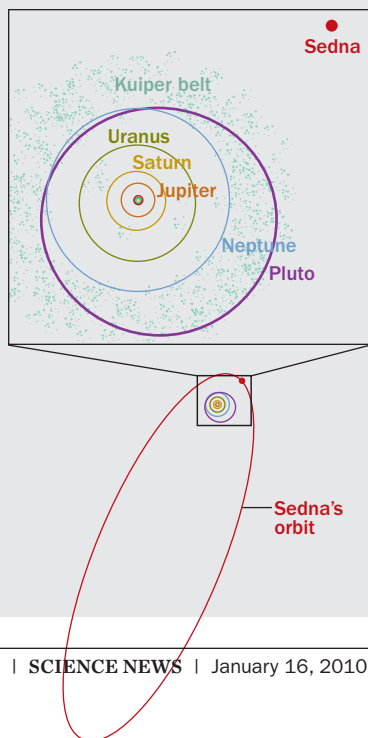
Solitary puzzle beyond the belt

Discovered by Mike Brown of Caltech and colleagues in 2004, an object called Sedna is the most distant body known in the solar system. Residing beyond the Kuiper belt, Sedna approaches as close to Earth as 76 times the Earth-sun distance (or 76 astronomical units) and travels as far away as 1,000 times that distance during its highly elongated, 10,500-year orbit (illustrated below).

Sedna's very existence is a puzzle, Brown says. The body lies too far from the Kuiper belt to have been affected by any migration of Neptune but too close to the sun to have been pulled outward by a passing star. If Sedna were one of a group of objects in similarly remote orbits, it would indicate that the

sun was born within a cluster of stars, long since dispersed, that tugged on these now-remote bodies and pulled them into their current orbits.

But a survey of the edge of the solar system has failed to turn up any other single object like Sedna. Meg Schwamb of Caltech, who collaborated with Brown, reported these findings in October at a planetary science meeting in Fajardo, Puerto Rico. The survey searched a sizable patch of sky—about 220 times the apparent area of the full moon—and was sensitive enough to detect large objects as far as 1,200 astronomical units from the sun. Sedna's seemingly solitary status makes it "one of the strangest objects in the solar system," Brown says. —Ron Cowen



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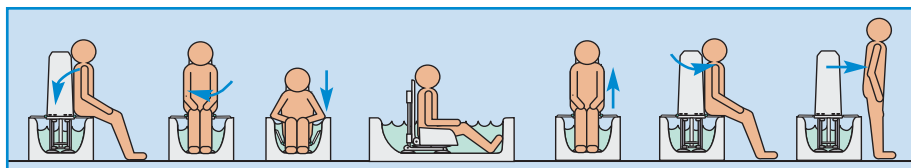
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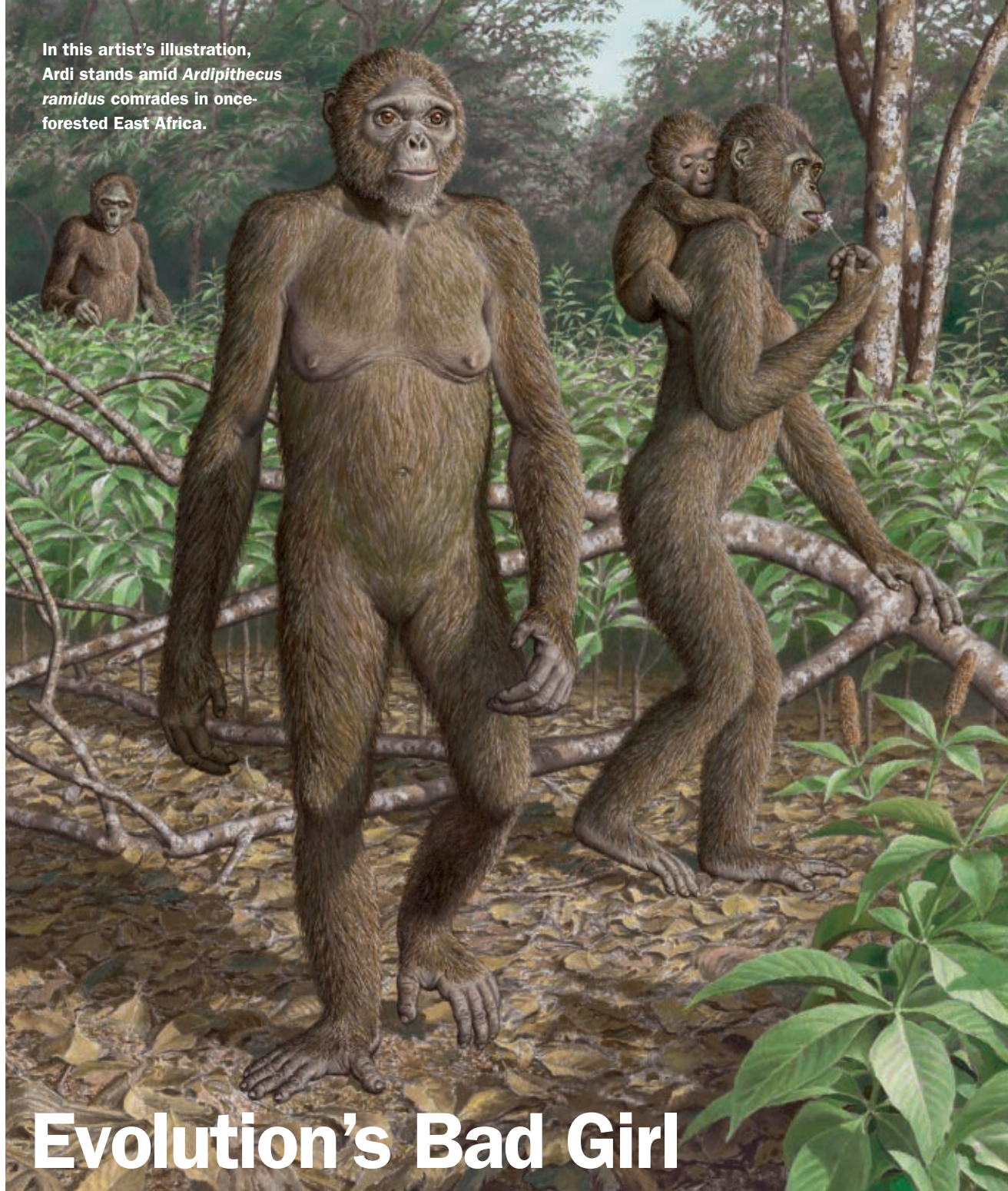
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In this artist's illustration, Ardi stands amid *Ardipithecus ramidus* comrades in once-forested East Africa.



Evolution's Bad Girl

Ardi shakes up the fossil record **By Bruce Bower • Illustrations by Jay Matternes**

She's the ultimate evolutionary party crasher. Dubbed Ardi, her partial skeleton was unearthed in Ethiopia near the scattered remains of at least 36 of her comrades. Physical anthropologists had known about the discovery of this long-gone gal for around 15 years, but few expected to see the 4.4-million-year-old hell-raiser that was unveiled in 11 scientific papers in October.

Like a biker chick strutting into a debutante ball, Ardi brazenly flaunts her nonconformity among more-demure members of the human evolutionary family, known as hominids. She boasts a weird pastiche of anatomical adornments, even without tattoos or nose studs. In her prime, she moved slowly, a cool customer whether upright or on all fours. Today, she's the standard bearer for her ancient species, *Ardipithecus ramidus*.

JAY MATTERNES © 2009

And in true biker-chick fashion, Ardi chews up and spits out conventional thinking about hominid origins, according to a team — led by anthropologist Tim White of the University of California, Berkeley — that unearthed and analyzed her fragile bones (*SN*: 10/24/09, p. 9). First, White and his colleagues assert, Ardi's unusual mix of apelike and monkeylike traits demolishes the long-standing assumption that today's chimpanzees provide a reasonable model of either early hominids or the last common ancestor of people and chimps — an ancestor which some scientists suspect could even have been Ardi, if genetics-based estimates of when the split occurred are borne out.

Second, the team concludes, Ardi trashes the idea that knuckle-walking or tree-hanging human ancestors evolved an upright gait to help them motor across wide ancient savannas. Her kind lived in wooded areas and split time between lumbering around on two legs hominid-style and cruising carefully along tree branches on grasping feet and the palms of the hands.

One member of White's team argues for a controversial possibility: that two-legged walking evolved because *Ardipithecus* males had small canine teeth. Many living and fossil male apes fight for mates by wielding formidable canines, but Ardi's male counterparts had to band together and forage over long distances to obtain mates, his thinking goes.

In a third slap at scientific convention, Ardi fits a scenario in which a few closely related hominid lineages preceded the larger-brained *Homo* genus that emerged around 2.4 million years ago, White says. In contrast, many anthropologists think of hominid evolution as a bush composed of numerous lineages that, for the most part, died out.

Each of Ardi's challenges draws plenty of fire. While lauding the new finds and the painstaking reconstruction of Ardi's bony frame, some critics dismiss White and company's reading of the fossils as incomplete and speculative.

Presentations at the Royal Society of London in October by several members of the Ardi excavation team produced "much sparring," says anthropologist William McGrew of the University of Cambridge in England.

"There's legitimate disagreement," White says. "But Ardi provides a perspective on early hominid evolution that was previously missing. This is a really bizarre primate."

Chimp change

Ardi sports a peculiar skeletal medley that pushes chimps and gorillas out of the evolutionary spotlight, says anthropologist Owen Lovejoy, a member of White's team. Ardi's ancient remains indicate that the last common ancestor of humans and chimps must not have looked much like living chimps, as many researchers have assumed, asserts Lovejoy, of Kent State University in Ohio.

Since a split 8 million years ago or so, chimps and gorillas have evolved along evolutionary paths that eventually pro-

duced specialized traits such as knuckle-walking, he says.

In his opinion, Ardi indicates that a human-chimp ancestor had monkeylike limb proportions and feet, a flexible and unchimplike lower back, and an ability to move along tree branches on all fours, rather than swinging chimp-style from branch to branch and hanging by outstretched arms.

"*Ardipithecus*, not living chimps, offers a remarkably good perspective on the last common ancestor," he says. "We can't modify the truth to make chimps more important."

That conclusion leaves some scientists unimpressed. "It's way too early to claim that we know what the last common ancestor looked like without actually finding its fossils," remarks anthropologist Brian Richmond of George Washington University in Washington, D.C.

Richmond holds that Ardi lived several million years after the last common ancestor, plenty of time for her kind to have evolved substantial skeletal changes.

And those changes may not have been as substantial as White's team claims, adds Richmond. Ardi's curved toes, wide big toe and large body correspond pretty well to chimps, in his opinion.

Other fossil evidence suggests that hominids came from a climbing and knuckle-walking ape ancestor that was unlike Ardi, Richmond argues.

Chimps and other living apes can provide testable ideas about issues such as tool use among early hominids and even the last common ancestor (*SN*: 11/21/09, p. 24), McGrew says. "Ardi is an intermediate hominid form, as is Lucy. So what?" he asks.

Questions remain about whether Ardi had the build for regular upright walking — a clear marker of hominid status — or for primarily moving through trees, with occasional two-legged jaunts on the ground, adds anthropologist John Hawks of the University of Wisconsin–Madison.

Consider *Oreopithecus*, an ape that lived on an island near Italy between 9 million and 7 million years ago. This creature possessed a pelvis, legs and feet that supported tree climbing as well as slow and somewhat stilted walking.

"*Oreopithecus* shows that there are alternate pathways to evolving a ground-based skeleton from the ape body plan," Hawks says.

But *Oreopithecus* differed from Ardi in critical ways, Lovejoy responds, such as having extremely long arms. "Locomotion differed vastly between *Oreopithecus* and Ardi," he says.

If *Ardipithecus* adopted upright walking in a big way and was a precursor of the human lineage, Hawks posits, "it could be the first hominid or perhaps even the common ancestor of humans and chimps — if we take genetic studies seriously." DNA analyses suggest that people and chimps split from a common ancestor between 5 million and 4.5 million years ago, around Ardi's time.

Lovejoy regards those genetic estimates as unreliable. DNA studies rest on doubtful assumptions, he says, such as constant rates of genetic mutation in the human and chimp lineages.

"This is a really bizarre primate."

TIM WHITE

Ardi

Skull Chimp-sized brain was slightly smaller than that of Lucy, a later hominid.

Base of skull A forward-placed opening in the base of Ardi's skull for the spinal cord links her to *Australopithecus* and *Homo*, not chimps or gorillas.

Spine Long enough to curve in, the spine provides crucial support for a two-legged gait. African apes have shorter spinal columns and stiff backs.

Pelvis Broad, enabling upright walking with a straightened hip.

Legs and arms Of about equal length, as in monkeys. Later hominids had short arms and long legs for mobility; knuckle-walkers have long arms and short legs.

Feet Diagonally oriented, grasping big toes and flat feet support a slow-moving, upright gait.



Teeth Accommodate a variety of foods, such as seeds, fruit and insects. Small canines in males compared with modern male chimps.

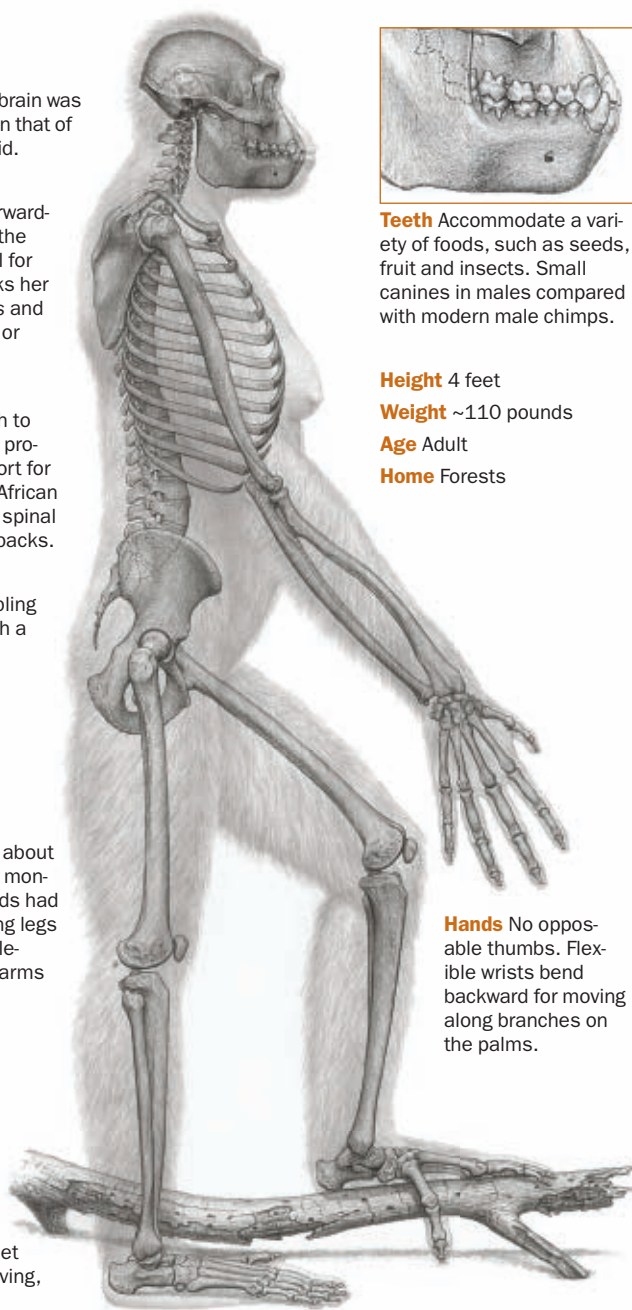
Height 4 feet

Weight ~110 pounds

Age Adult

Home Forests

Hands No opposable thumbs. Flexible wrists bend backward for moving along branches on the palms.



million-year-old partial female skeleton found at another Ethiopian site in 1974. Lovejoy proposed that Lucy's kind possessed traits consistent with what amounted to a sexual revolution in the ape world (*SN*: 6/11/05, p. 379).

In most ape species, males are much larger than females and fight viciously to mate with fertile females, who advertise their availability with swollen red tissue. Females raise offspring on their own.

Lucy's kind upended that arrangement, Lovejoy argued. Males grew only slightly larger than females and had small canines. Adults of both sexes favored long-term relationships as a matter of survival, he theorized. Males supplied food to regular partners with whom they had children, allowing females to spend more time raising their own children.

Monogamy worked, in Lovejoy's view, because female anatomy evolved to mask obvious signs of ovulation that signal sexual readiness to males, instead developing features such as permanently enlarged breasts. Hit-and-run unions stood a good chance of yielding no offspring and thus became unappealing to both sexes.

Lovejoy's evidence for minimal size differences between *A. afarensis* sexes has been sharply criticized. Critics charge that he's underestimated the size disparities. Detractors add that upright males with diminutive canines could have found plenty of ways to pummel one another in mating battles, even if they had to resort to fisticuffs.

With Ardi in tow, Lovejoy has now elaborated on his argument. A transition to monogamous relationships, expanded child care by mothers and hidden female ovulation first occurred before Lucy, in *Ardipithecus*, he proposes. Ardi's kind displays even smaller sex differences in canine size than Lucy's species. "*Australopithecus* represents a more intense version of what was already evolving in *Ardipithecus*," Lovejoy says.

Cooperation among males later expanded in *A. afarensis*, he posits. Male bands scoured forests and savannas for food and worked together to avoid and defend against predators.

A social puzzle

Ardipithecus canines excavated by White's team validate Lovejoy's scenario, remarks anthropologist Robert Tague of Louisiana State University in Baton Rouge. Male canines are slightly larger than those of females, but all the canines are about the size of female chimps' canines, he says.

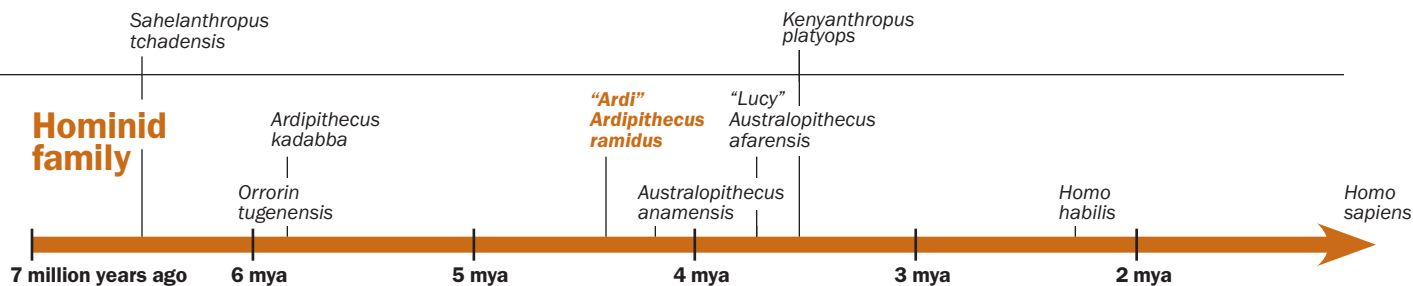
"Although Lovejoy's theory is widely cited and presented in

Fossil evidence places the human-chimp split at more like 8 million to 10 million years ago, in his view.

Hominid family values

Disputes over Ardi's evolutionary relationships to living and extinct apes seem cordial compared with debate over her sexual relationships and their implications for ancient hominid social life.

This fracas goes back to 1981, when Lovejoy published a paper in *Science* about the sex life of what was, at that time, the earliest known hominid species, *Australopithecus afarensis*. The most famous member of that species is Lucy, a 3.2-



Putting down roots The relationships of human ancestors to one other are hotly debated (dates shown indicate a species' earliest appearance in the fossil record). Discoverers of a 4.4-million-year-old partial *Ardipithecus* skeleton think that, for now, researchers should classify earlier finds *Sahelanthropus* and *Orrorin* as members of the *Ardipithecus* genus, and *Kenyanthropus* as a member of the *Australopithecus* genus.

almost all biological anthropology textbooks, it is also widely rejected," Tague acknowledges.

And for good reason, argues J. Michael Plavcan of the University of Arkansas in Fayetteville. Using a different statistical approach, he estimates that Lucy was actually considerably smaller than her male cohorts.

To portray early hominids as a peaceful, monogamous crowd "is phenomenally speculative," Plavcan says. Although large-bodied primate males with fanglike canines usually fight over mates, minimal sex differences can result in any of a variety of mating arrangements, he contends.

What's more, *Ardipithecus ramidus* fossils do display size differences between the sexes sufficient to assume that males mated with several females, as in many other primates with size disparities, McGrew remarks.

"Lovejoy's social hypothesis is an interesting just-so story," Richmond asserts. "He's winning the competition for the title of the Rudyard Kipling of paleoanthropology."

Primatologist Frans de Waal of Emory University in Atlanta doesn't dismiss Lovejoy's social hypothesis but faults him for comparing Ardi's kind with common chimps while ignoring pygmy chimps, or bonobos. Bonobos have small canines relative to common chimps, a largely peaceful social life and a fondness for sexual activity.

"It's high time for a new look at the bonobo," de Waal wrote in a published commentary shortly after the Ardi papers appeared in *Science*. "What if we descend not from a blustering chimplike ancestor but from a gentle, empathic, bonobo-like ape?"

That's doubtful, since bonobos differ in some critical ways from Ardi's kind, Lovejoy responds. In particular, he says, bonobo males display moderately larger canines and body sizes than females.

"*Ardipithecus ramidus* preserves some of the ancestral characteristics of the last common ancestor [of humans and chimps] with much greater fidelity than does any living African ape," Lovejoy says.

Not-so-bushy evolution

If Ardi cuts a singular figure that sets her apart from living apes, she also bolsters an argument for cutting back the expanding number of proposed early hominid lineages, White says. Since 1994, fossil discoveries have led to reports of four new genera from eastern Africa and Chad: 7-million to 6-million-year-old *Sahelanthropus* (*SN*: 7/13/02, p. 19), 6-million-year-old

Orrorin (*SN*: 7/14/01, p. 20), 3.5-million-year-old *Kenyanthropus* (*SN*: 3/24/01, p. 180) and *Ardipithecus*, including fragmentary remains of 5.8-million to 5.2-million-year-old *Ardipithecus kadabba*.

White's team folds *Sahelanthropus*, known only from skull remains, and *Orrorin*, known from fossil teeth and leg-bone pieces, into the better-described *Ardipithecus* genus.

"*Ardipithecus* may represent a long period of stasis in hominid evolution," Lovejoy says.

From about 6 million to 4.2 million years ago, he proposes, *Ardipithecus* evolved as a set of separate hominid groups in East Africa that interbred enough to maintain biological unity.

After that, Ardi's kind possibly evolved into the first *Australopithecus* species. Or, one *Ardipithecus* group may have settled in an isolated area where it alone evolved into *Australopithecus*. It's also possible that *Australopithecus* derived from a hominid lineage that researchers haven't found, relegating *Ardipithecus* to an evolutionary side branch.

Anthropologists, in particular those who have excavated and named other early hominid genera, have not jumped on the *Ardipithecus* bandwagon. Proponents of bushy hominid evolution, such as Richmond, rely on computerized models that divvy up species by distinguishing between shared and distinctive skeletal traits across fossil sets, an approach that White and Lovejoy have criticized (*SN*: 11/25/00, p. 346).

"More time is needed to study Ardi and compare her to living primates," Hawks says. "White's team had 15 years to study this skeleton that the rest of us saw for the first time in October."

Complaints have circulated in anthropological circles over the past decade that White has inappropriately kept outside investigators from studying Ardi's remains. White vehemently denies those charges, saying that he has abided by Ethiopian law by publishing an initial description of the finds before making them available for others to study.

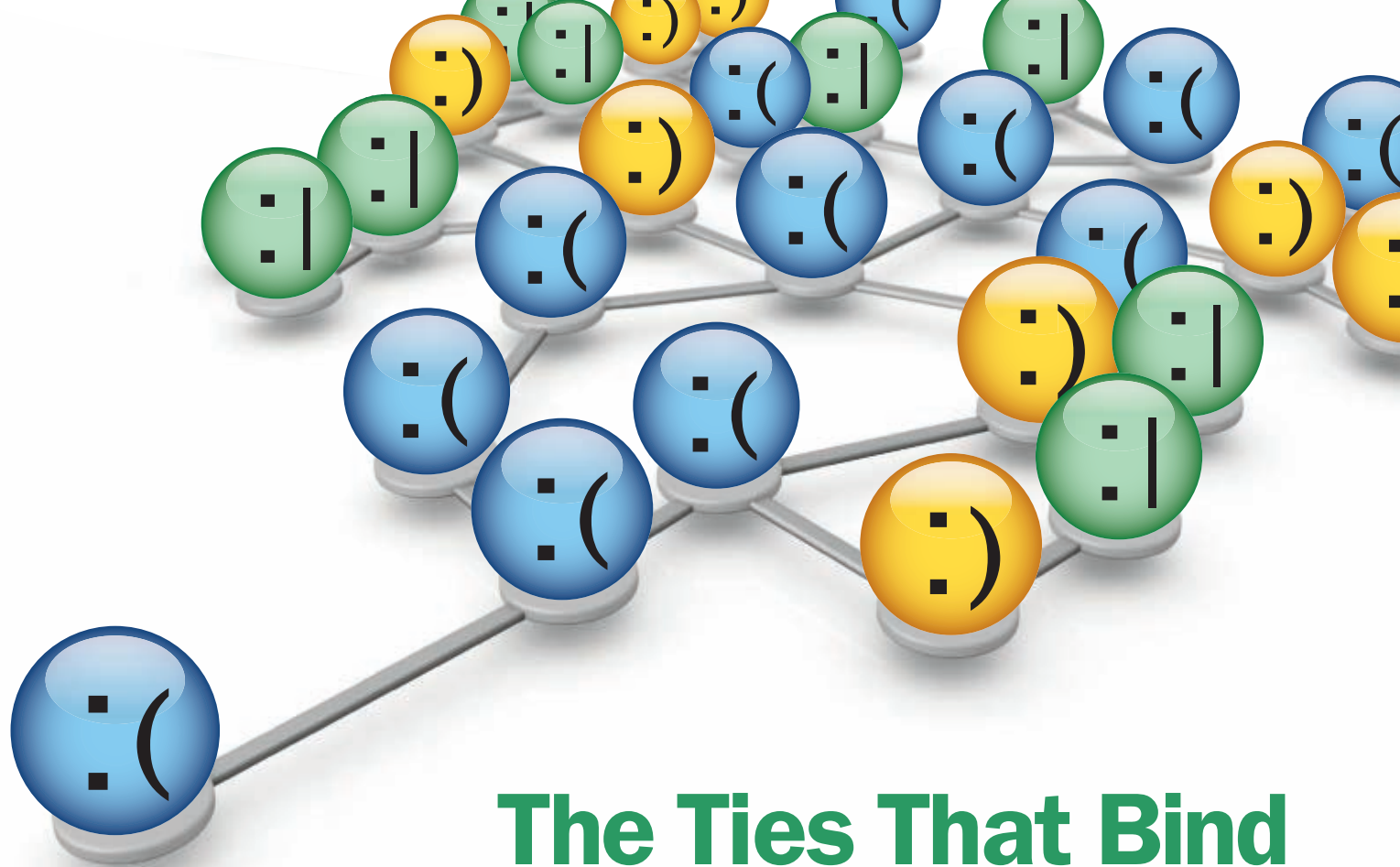
Researchers can now examine casts of the *Ardipithecus* fossils or, in certain cases, the fragile bones themselves, White says.

"These finds are phenomenally important and will keep many of us busy for years to come," says anthropologist Carol Ward of the University of Missouri in Columbia.

In other words, the evolutionary shindig that Ardi crashed has just started. The night is young. Party hearty, Ardi. ■

Explore more

■ Special issue on *Ardipithecus*. *Science*. October 2, 2009.



The Ties That Bind

Studies of human social networks go high-tech

By Lisa Grossman

When John Cacioppo walks around Chicago with his book *Loneliness*, he hides the cover. “Who wants to go around with a big L on their forehead?” he says. Society, he complains, treats loneliness as a disease.

“People think it’s just neuroticism, or it’s people who can’t form relationships,” Cacioppo says. In 15 years of studying social isolation, the University of Chicago psychologist has found that loneliness is just another emotion. “Everybody has the capacity to be lonely, just as everybody has the capacity to feel pain,” he says.

And yet in one sense, his work shows how loneliness *is* very much like a disease: It can spread like the common cold.

That’s the conclusion of Cacioppo’s recent work with James Fowler, a University of California, San Diego political scientist, and Nicholas Christakis, a sociologist and physician at Harvard

Medical School. Fowler and Christakis have made names for themselves studying how unlikely contagions — such as obesity and happiness — spread in social networks. The trio’s study of how lonely people pass on their pain highlights an emerging area of research, which some call computational social science. The field uses new data collection and analytical techniques to understand how people are connected in networks and how influences move through social links. In some cases, the effects that people have on those they know can be startling.

Some researchers hope that, by illustrating large-scale human interactions, this new field could help reduce depression, contain epidemics and generally make the world a better place — not to mention clarify the basics of human nature. “What we’re trying to do,” says Fowler, “is start a revolution.”

That revolution is fueled by a fire hose

of data coming from cell phones, credit cards and the Internet. People leave traces of their place in the social network every time they do a Google search or swipe a subway fare card. Researchers are beginning to use these traces to see how people influence one another. But not everyone believes that these studies show what they claim to. Limitations of data collection and quality leave other interpretations open. Privacy issues can keep data under wraps. And barriers in the social network of academia itself could stunt the growth of the nascent field.

Not only the lonely

To track how behaviors and feelings travel through a network, Christakis and Fowler painstakingly digitized 30 years’ worth of paper records from a long-term health study in Framingham, Mass. The pair constructed more than 50,000 ties among about 5,000 people in the small



town. In a series of studies, the researchers plotted how weight, smoking habits and happiness (as measured on a diagnostic test for depression) changed over time. Each of the three traits appeared to move through the network in clumps, like flocks of birds or schools of fish.

The traits also seemed to spread from person to person as far as three degrees of separation. This finding was widely interpreted to mean that your best friend's roommate's brother can make you measurably happier or sadder, fatter or thinner, even if you've never met.

While many found these results surprising when they first hit medical journals and newspapers, there are intuitive explanations for each trend, Christakis and Fowler argue in their book, *Connected* (Little, Brown, 2009). If all your friends quit smoking, there's social pressure for you to quit, too. If your friends all gain weight, there's less social pressure for you to stay slim. The adage "smile and the world smiles with you" hints that the idea of contagious happiness has some roots in common sense, too.

But loneliness makes a strange virus. Fowler, Christakis and Cacioppo traced loneliness in 5,124 people in the Framingham network using answers from a common screening test for depression. One question explicitly asks how many days in the previous week the participant felt lonely. Cacioppo's earlier research confirmed that this question can measure loneliness as distinct from depression.

Using the same statistical methods as in the earlier studies, the researchers plotted instances of loneliness in Framingham from 1983 to 2001. They found that lonely people tended to cluster at the edges of the network, and that loneliness—like happiness, smoking and obesity—seems to spread through the network out to three degrees of separation. Having one lonely friend can leave you 40 to 65 percent more likely to be lonely than if you have no lonely friends. A lonely friend of a friend increases your chances by 14 to 36 percent, and a friend of a friend of a friend contributes between 6 and 26 percent to your loneliness—whether you know each other or

not. For anyone further away in the network, the effect disappears.

While conventional wisdom may say loneliness is a symptom of having few social connections, not a cause, Cacioppo says that lonely people are found at all levels of popularity. It doesn't matter how many social ties you actually have, only how satisfied you are with them.

The feeling starts as a sense that the world is unfriendly, that those closest to you might not back you up in a crisis. Cacioppo thinks this feeling could have evolutionary roots. If human ancestors faced a greater risk of becoming prey when alone, an emotional early-warning signal that not all was well in their social network could have been lifesaving.

Thinking the world is unfriendly can become a self-fulfilling prophecy. "Lonely individuals expect social threats,"

Cacioppo says. "If you think others around you are going to be nasty to you, you see more nasty behavior." Feeling under fire, lonely people alternately lash out and withdraw in self-defense. This erratic behavior pushes friends away, but it also makes the friends more likely to mistrust the world and start the cycle over again.

This could explain how loneliness might be catching. But the idea that people are not alone in their isolation could have troubling implications for society.

"We think of society like a crocheted sweater," Fowler says. "If one thread becomes loose, the whole sweater can become unraveled."

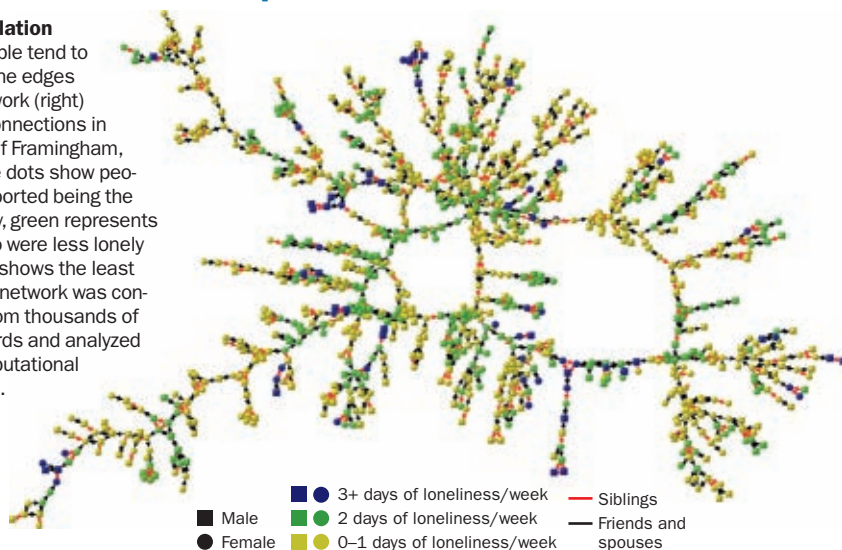
A tangled net

There are two other reasons why people with certain traits might be clumped together in a network. One is that similar

Social network and reported loneliness

Linked isolation

Lonely people tend to cluster at the edges in this network (right) of social connections in residents of Framingham, Mass. Blue dots show people who reported being the most lonely, green represents people who were less lonely and yellow shows the least lonely. The network was constructed from thousands of paper records and analyzed using computational techniques.

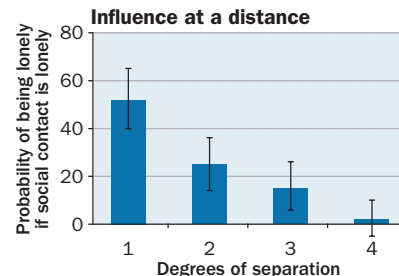


Loneliness and social contacts

Days felt lonely last week	Mean number of social contacts	Standard error
0-1 days	4.03	0.05
1-2 days	3.88	0.11
3-4 days	3.76	0.21
5-7 days	3.42	0.28

SOURCE FOR ALL: CACIOPPO ET AL./J. PERSONALITY & SOCIAL PSYCH., 2009

An analysis of the Framingham social network found that, not surprisingly, self-reported loneliness is related to how many friends and family members a person named (above, left). As was found in studies of smoking and obesity in the network, the tendency to feel lonely spread as far as three social contacts away (above, right)—a lonely friend makes you more likely to be lonely than does a lonely friend of a friend, but a friend of a friend of a friend still has a measurable effect.



people tend to like each other — happy people have happy friends, smokers befriend other smokers. The other is that some outside factor influences everyone in a network equally — say, a fast-food place opens just before everyone in the neighborhood gains weight.

To try to control for people choosing similar friends, Christakis and Fowler's studies all looked at snapshots of the network at different points in time. If a group of smokers had all quit during a certain period, researchers assumed it probably wasn't a result of people's fondness for those like themselves.

To account for outside influences, the team also looked at the direction of the ties. If Alice named Bob as a friend but he didn't name her back, for example, Bob has more of an influence on Alice than she has on him. The strongest influence occurred between mutual friends — those who named each other. If a change was caused by the environment, such a directional effect shouldn't be there.

Some scientists doubt that these control measures are enough, though. Jason Fletcher of Yale School of Public Health used Fowler and Christakis' methods on a network of adolescents and found that acne, height and headaches seem to be contagious, too. "If we can find these effects in height, it seems like we can find it in anything. And I think their findings are, 'Yes, we find it in everything,'" Fletcher says. "It's hard to tell if their model is strong enough to detect no social effects when they actually don't exist."

Fowler responds that acne, height and headaches can all be influenced by diet,

especially in adolescents, and peers can certainly change each others' eating habits. But he admits that the methods are "still not foolproof."

Others have complained that the data are incomplete: People in the Framingham study named only a few friends, and some of those friends weren't in the study. So there could be people influencing the Framingham participants whose effects are invisible to researchers.

That's also a fair criticism, Fowler says. "I don't think there's ever going to be a network study where we can say the results of one study are automatically generalizable to all 6 billion people on the planet," he says. "Each part of the network is inherently incomplete."

Networks 2.0

The Framingham studies offer a glimpse of what social scientists could do if they could only collect enough information. Fortunately, there is a place where scientists can collect near-complete large-scale data on social networks and even run experiments: the Web.

"Historically you couldn't really do large-scale network studies with data," says Duncan Watts, a physicist-turned-sociologist who has studied networks for over a decade. "Now we can."

Watts is perhaps most famous for a network model, codeveloped with mathematician Steven Strogatz of Cornell University, that showed how many real-world networks lie somewhere in between completely ordered and completely random. Watts and Strogatz called them "small world" networks because the

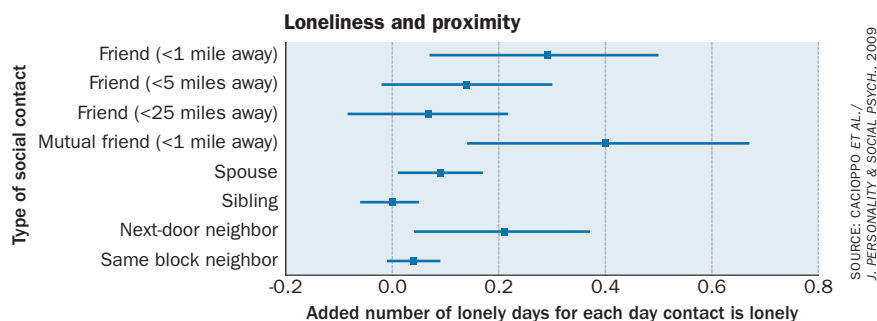
average path from any one spot in the network to another was short. Networks with these properties show up everywhere, from the neural networks of nematodes to the power grid of the United States to networks of actors costarring in films.

E-mail let Watts test the small world model on a global scale. In 2003, he and two colleagues replicated the famous experiment that produced the phrase "six degrees of separation." The team asked more than 60,000 online participants to forward e-mails to a far-away target through networks of acquaintances. The e-mails, the majority of which originated in North America, reached their destinations — including an archival inspector in Estonia and a veterinarian in the Norwegian army — in five to seven steps.

Watts now works at Yahoo! Research in New York City, where he uses specially designed websites and applications on social networking websites such as Facebook to ask specific questions about group behavior. His recent work, presented at meetings and appearing in *Social Psychology Quarterly* and *Management Science*, has shown that people will like unpopular songs more if others seem to like them (but not as much as they like songs that are actually popular), that the choice to cooperate with or mooch off an opponent in an online game can cascade through a network, and that people think they and their friends are more similar than they really are.

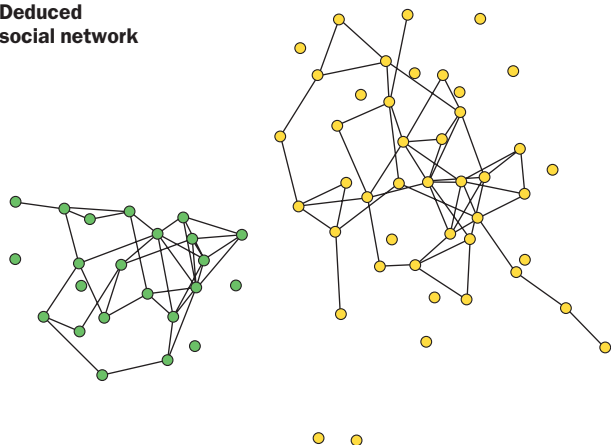
Other studies examine blogs as indicators of political climate or national mood. Lada Adamic of the University of Michigan in Ann Arbor plotted online links among political blogs in the months leading up to the 2004 presidential election. Her results, which she presented in 2005, showed a sharp split between the liberal and conservative "blogospheres."

Peter Dodds and Christopher Danforth of the University of Vermont in Burlington tracked emotionally charged words in blog posts. In a 2009 paper in the *Journal of Happiness Studies*, the two suggest that the method could be used as an emotional barometer, giving researchers a bird's-eye view of how moods clump and spread. By this measure, the happiest

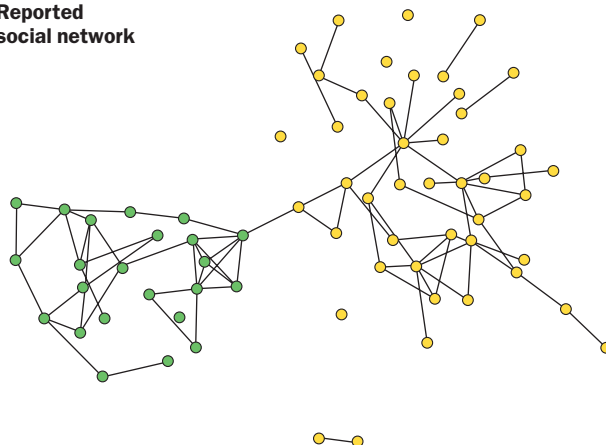


Too close for comfort Lonely pals can increase your number of lonely days per week — but only if they live nearby. Close-by friends and neighbors had a bigger effect than spouses, and siblings had no effect at all in the study of loneliness in the Framingham social network.

**Deduced
social network**



**Reported
social network**



SOURCE: N. EAGLE ET AL./PNAS, 2009

High-tech friend finder Social network researcher David Lazer and colleagues inferred which people in a study were friends based only on cell phone call logs and the volunteers' physical proximity to one another over nine months. The deduced friendship network (left) accurately predicted

95 percent of the friendships that volunteers named themselves (right). The colors distinguish between two groups, first-year business school students (green) and people who work in the same building (yellow). Here, technology both supplied the data and analyzed it.

day in the past four years was Election Day, 2008; among the saddest: the day Michael Jackson died.

Using mobile phones to track people's movements and activities is another example of how technology is being used to better understand social networks. David Lazer, now at Harvard University, and his colleagues gave students and faculty mobile phones that tracked the participants' calls and proximity to other phones in the study. Lazer's team compared phone data with the volunteers' own reports of their friends and habits. The researchers were able to identify 95 percent of friendships based on the phone data alone, the team reported in the Sept. 8 *Proceedings of the National Academy of Sciences*.

This predictive power could be useful in tracking phenomena from political leanings to the spread of the flu, Lazer suggests. Knowing where and when students congregate could help university officials decide whether it would help to cancel class in the case of an H1N1 outbreak, for example. And pinpointing a person's place in the network could help in designing customized health programs.

"Until recently you could only think of these things theoretically," Watts says. "What's so tantalizing about the Web is that you can really do this for real. You can get inside the black box of society and see how it really works."

But opening the black box isn't easy. Social data are hard to obtain without putting personal information at risk.

"It doesn't take too many signals to uniquely identify someone," Lazer says. "The trick there is, how do you de-identify the data and not completely destroy the insights that they provide?"

The data are also noisy and hard to work with. "I think we will need new and better methods," Fletcher says. "We're almost saturated in data, but we're not saturated in methods yet."

Two cultures

Computational social science, as a cross-disciplinary field, could overcome weaknesses in its progenitor fields. Traditional social science research is usually limited to snapshots of small groups and often relies on questionable self-reported data. Physicists and mathematicians borrowed methods from statistical mechanics and computational biology, which produce nice visualizations of how a group can act as a unit. But to reliably reflect human behavior, the models need to be grounded in how people really behave.

And yet the new field's scholars may be culturally and, on some campuses, physically distant. "Sociologists felt miffed when you had these physicists come in the 1990s repackaging ideas that had been around a long time," Fowler says. While there's more cross-talk now than a decade

ago, researchers still sometimes step on each others' toes or talk over each others' heads, "and everyone just winces."

One of social network research's own tools demonstrates the divide. A plot of Twitter usage from a recent conference shows attendees lumped neatly into two groups: physicists and math types on one side, social scientists on the other.

How to bridge this gap? "The same way we've always done it: We get them in the same room together," Fowler says. "We promote real-world social relationships, and then utilize the technology to stay in touch after the conference is over."

Similar strategies could reach out to people on society's fringe, too. A November 2009 Pew Internet Survey found that, contrary to popular suspicion, people who spend a lot of time on mobile phones and Facebook socialize more in person than people who don't. "If you use the Internet to promote face-to-face relationships, it makes them richer, higher quality," Cacioppo says. Virtual networks may be more than just treasure troves of data. They can also thread lonely people back into the social crocheted sweater. ■

Explore more

- Ramsey M. Raafat et al. "Herding in humans." *Trends in Cognitive Sciences*. October 2009.
- J. Cacioppo and W. Patrick. *Loneliness*. W.W. Norton & Co. 2008.

Megadisasters: The Science of Predicting the Next Catastrophe

Florin Diacu

To describe “the science of predicting,” Diacu ends up taking a comprehensive look back. The result is an excellent history of natural disasters and of the science behind understanding and mitigating those disasters. For a who’s who of volcanic eruptions, major earthquakes, big hurricanes, asteroid near-hits or historic pandemics, this book is the place to go.

Diacu, a mathematics professor at the University of Victoria in Canada, proves an excellent storyteller. The fluid writing and tidbits of science history prepare the reader well for what caps each chapter: an assessment of how well scientists can predict each type of disaster. But Diacu often goes beyond discussing whether or not prediction is possible and suggests that prevention is a better goal. For example, scientists can forecast the when and where of hurricanes, Diacu notes, but predictions of intensities remain elusive — complicating decisions on evacuations. The way to

prevent tragedy, he contends, is to keep coastal communities small.

Asteroids colliding with Earth are a different matter, having potential consequences of Armageddon-like proportions. The best bet is to track and follow asteroid paths in detail decades ahead, Diacu says, which scientists are starting to do. Ultimately, the key to preventing



an asteroid-induced disaster will be to change the object’s course — an ability that Diacu suggests could be realized in the coming decades.

Diacu even tackles economic crises.

The current situation, which was in its early stages as Diacu finished this book, is similar to the financial disasters of 1929 and 1873 — but not completely, he argues. “The prediction and prevention of stock market crashes is likely to remain a big challenge for many years to come.” — *Kristina Bartlett Brody*
Princeton University Press, 2009, 195 p., \$24.95.

Danger to Self: On the Front Line with an E.R. Psychiatrist

Paul R. Linde

What most people know about the psychiatric emergency room is that they don’t want to end up there. In Linde’s latest book, the veteran psychiatrist and writer draws on more than a decade of experience at San Francisco General Hospital’s psychiatric E.R. to show what life is really like behind the locked doors.



A gripping, and at times unsettling, account unfolds. In each chapter, Linde plays a slightly different role: de-escalating a homicidal sociopath, evaluating whether

a suicidal young man can be safely allowed to go home, or consulting on whether a recovering drug addict might make a good organ donor candidate.

Linde candidly describes his reactions to both the personalities and personal hygiene of his patients, lending a sense of reality and complexity to the story. He writes just as openly about his frustrations with the public mental health system. His tone carries an off-putting bravado at times but generally conveys the passion Linde feels toward his work.

While Linde’s own experiences practicing psychiatry make an interesting read, it’s the descriptions of his patients that make this book truly compelling. People from all different backgrounds pass through the psych E.R. There are addicts, trauma survivors, psychotics and many high-functioning people who are simply “having one of the worst days of their lives,” as Linde writes. *Danger to Self* personalizes what it means to have acute mental illness in the United States. — *Rachel Zelkowitz*
University of California Press, 2010, 253 p., \$24.95.



The Double Helix and the Law of Evidence

David H. Kaye

A legal scholar describes the history and future of DNA-based evidence in the American justice system. *Harvard University Press, 2010, 330 p., \$45.*



Toward the Healthy City: People, Places, and the Politics of Urban Planning

Jason Corburn

City planners could increase health equity by considering environmental and public health issues during urban redevelopment. *MIT Press, 2009, 282 p., \$24.*



Engineering Invention: Frank J. Sprague and the U.S. Electrical Industry

Frederick Dalzell

The inventor and entrepreneur worked for Edison before coming up with the electric railway and electric elevator. *MIT Press, 2009, 288 p., \$30.*



Life Along the Inner Coast

Robert L. Lippson and Alice Jane Lippson

Southeast waterways host tremendous diversity, described in this field guide by two naturalists. *University of North Carolina Press, 2009, 454 p., \$35.*



Jump into Science: Active Learning for Preschool Children

Rae Pica

Science education starts early through experiments that keep kids moving. *Gryphon House, 2009, 131 p., \$14.95.*

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Well-tooled apes

The fascinating article “Aping the Stone Age” (*SN*: 11/21/09, p. 24) led me to wonder whether researchers who work with chimps or other higher apes have ever introduced them to the modern tools used by humans, such as saws, axes, hammers or pliers. If so, it would be interesting to know whether the apes could grasp the tools’ purposes, employ them productively and/or demonstrate their utility to ape kin.

Jack J. Friedman, Fort Lauderdale, Fla.

Andrew Whiten of the University of St. Andrews in Scotland replies: An interesting question. Some studies have involved giving apes humanlike tools, as when Sue Savage-Rumbaugh and colleagues tested whether one chimpanzee could request the correct tool from another chimpanzee to open one of several boxes and share the food contents (as Savage-Rumbaugh describes in her book Ape Language, Columbia, 1986).

However, these were specially designed tools, not regular human tools. Anecdotally, I know of chimpanzees who see a lot of human behavior, who on managing to purloin something like a screwdriver will attempt to undo the screws holding their cage together — which may partly explain the limits on this kind of inquiry! This implies that apes will appreciate the utility of certain tools from watching humans, consistent with what we have shown of apes’ ability to learn particular forms of tool use from others. See, for example, A. Whiten et al., “Transmission of multiple traditions within and between chimpanzee groups,” Current Biology, 2007.

Speedy issues

I enjoyed Laura Beil’s piece “Breaking the Speed Limit” (*SN*: 12/5/09, p. 26) and learned some fascinating things. But as a bicyclist since the 1950s, I would like to point out a shortcoming

in her comparison of [Oscar] Pistorius’ running with a cyclist: When the cyclist gears down, he pedals faster with less force without losing speed. Pistorius steps faster with less force than other runners to maintain the same speed, like a cyclist gearing down. Saying that switching to a lower gear permits a rider to pedal less without losing speed is simply wrong.

Conrad F. Nuthmann, Deland, Fla.

As an old relay anchor, I’d expect Usain Bolt’s top speed to be even faster on the home stretch of a 200-meter race or the back stretch of the 400. Top running speed depends more on length of stride and coordination than on “pounding the pavement,” and you can’t “hit your stride” in a race as short as 100 meters.

Karl Staubach, Benicia, Calif.

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Eric D. Isaacs



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Powering the national labs as engines of discovery

In May 2009, University of Chicago physicist Eric D. Isaacs took the helm of the Department of Energy's Argonne National Laboratory near Chicago. Earlier in his career, Isaacs spent 13 years at Bell Laboratories, where he directed semiconductor and materials physics research. Recently, Science News senior editor Janet Raloff spoke with Isaacs about ways to reinvigorate research, especially on energy.

You've described corporate research centers such as Bell Labs as engines of discovery and as potential models for national labs. How so?

Bell Labs conducted pioneering research in support of a mission. Even its basic research and open-ended science was connected through an internal grapevine and people to real problems. And that's an important role that government labs need to fill. It's what the Department of Energy refers to as needs-driven science.

Some of it will be high risk, which is not to say you try anything and everything. You choose intelligently and surround yourself with a community working on the same focus, always judging quality. Bell Labs had its own internal and external peer-review communities. And the internal one could be brutal, with someone always looking over your shoulder and asking, "Are you doing something really good?"

Along these lines, Argonne is organizing, more than ever, around a few big ideas, big challenges. The key is to have a mission that's very clear. And ours is energy. One focus is energy storage, where we're pulling together a very powerful, multidisciplinary effort with theorists, computational scientists, materials scientists and chemists to collectively address a major challenge.

You also need sufficient funding. Ours is still not at the level we need. Our president has done a lot, investing

Recovery [Act] money in science budgets. We'll also be collaborating closely with industry.

Finally, we need a staff of committed young people. And here, too, we need more. For instance, in programs like energy storage, I envision tripling our effort over the next few years, from maybe 30 or 40 people working on a \$20 million effort to between 100 and 150 people working on a \$50 million to \$100 million program.

The Recovery Act phases out in a year. What then?

I can't predict what will happen in the post-Recovery period. There will be a big deficit, and there will be other things competing for investments, like health care.

It's always tempting at times like this to do what industry has done and reduce the science investment. But I would argue now is not the time to do that because our long-term problems are not going to go away. If we can continue to invest in research even in tough economic times, then we have the opportunity to recruit really great people. Remember, if science isn't looking like a good career, young people won't sign on. And without them, you won't get the next wave of innovations — and you're certainly not going to solve the energy problem. It'll happen in China.

My worry is that our nation is running out of our "seed corn" — the great ideas to pursue in the future. Those ideas are coming out of academia and the government labs. But if we don't continue to invest in these idea centers, we're going to lose out — big.



If science isn't looking like a good career, young people won't sign on. And without them, you won't get the next wave of innovations.

You said the "ecosystem" for this is challenging. What do you mean?

In the past, monopolies like AT&T could develop everything from soup to nuts. Venture capitalists brought technologies to market another way: They bought small start-up companies, some

to do the research and development, others to make products.

Today we need to achieve the same thing — do the science, technology development and product delivery — by piecing together elements from different organizations that together work as an ecosystem. From a structural point of view, this ecosystem consists of academia, government labs and industry. They have somewhat different missions: Universities do research and education, government labs do research and development, and industry

delivers a product and makes a profit. Building such an ecosystem and keeping it productive and healthy will be a challenge. But we can do it.

You've talked about a need for retaining ownership of our energy technologies. What does that mean?

As estimated by the National Science Foundation, some 20 to 50 percent of our gross domestic product is based on innovative technologies, like the transistor and computer. But at some point these become commodities. Will we retain ownership of these technologies?

Ownership is not just intellectual property. IP is good, but if we don't own the manufacturing of that technology, then we won't own the full economic benefits. ■

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 reading.

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 feel about your living and work spaces. It brings the benefits of natural daylight indoors, simulating the full spectrum of daylight.

The **Balanced Spectrum's** 27-watt compact bulb is brighter than a 100-watt ordinary light bulb. With the lamp's sharp visibility, you will see with more clarity and enjoyment in close tasks such as reading, writing, sewing, and needlepoint. It is especially helpful for aging eyes.

Experience sunshine indoors at the touch of a switch. This amazing lamp is not only easy on the eyes, it is easy on the hands as well, featuring a special "soft-touch, flicker-free" rocker switch that is easier to use than traditional toggle or twist switches. And its flexible gooseneck design enables you to get light exactly where you need it. The high-tech electronics, the user-friendly design, and a bulb that lasts 10



You don't need the sun to get the natural benefits of daylight

- See with clarity and enjoyment
- Creates natural, glare-free light
- Provides sharp visibility
- Flexible gooseneck design
- Instant-on, flicker-free light
- Pays for itself in energy savings over the life of the bulb

This light can change the way you live and work

It provides excellent lighting which is very close to true daylight. The lamp itself is light enough to be moved easily around a room and an office. The glare-free characteristics provide a very non-stressful illumination for prolonged reading.

—Stanley G., M.D.

As soon as I turned on the lamp and began to read the newspaper I could see the wonderful difference. This lamp is just what I needed. Thank you so much.

—Donna E.

Your lamp has been a wonderful help to me in reading my newspaper and magazines. I would hate to be without this lamp, it's made such a difference in my life.

—Kenneth K.

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Results may vary.

Technology revolutionizes the light bulb

- Save almost \$61 over the life of the bulb
- 8,000 hours bulb life
- Energy efficient
- Shows true colors

times longer than an ordinary bulb—all these features make the **Balanced Spectrum® floor lamp** a must-have.

Try the Balanced Spectrum® floor lamp for the best value ever! Now more than ever is the time to spread sunshine all over the room in your home at this fantastic low price! The **Balanced Spectrum® floor lamp** comes with **firstSTREET's** exclusive guarantee. Try this lamp for 90 days and

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