Long Life in a Pill | Network Math for Control Freaks | Giant Ants

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JUNE 4, 2011

Strange Stars

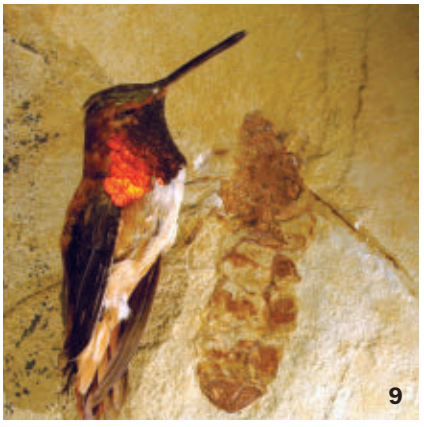
Beyond exoplanets, Kepler spots the wild and wonderful

When Investing, Gut Trumps Equations

Stem Cell Setback

Top Honors for Student Scientists

JUNE 4, 2011 • VOL. 179 • NO. 12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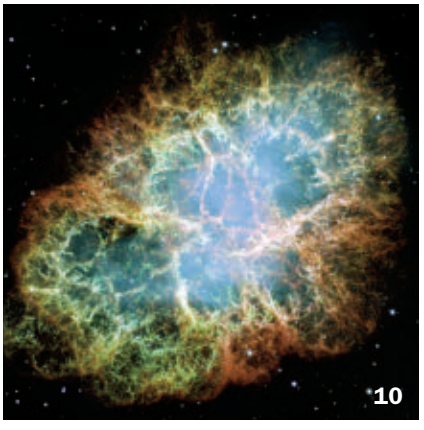
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ScienceNews

In The News

Features

Departments

COVER The space-based Kepler telescope detects strange stars, including flaring dwarfs similar to the one illustrated here, that seem wacky compared to Earth's quiet sun.
Casey Reed, NASA

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FROM THE EDITOR

Textbook science defers to supremacy of Science

There's science, and there's Science.

The real Science (with the capital *S*) is an abstract, idealized, Platonic-perfection conceptual process of finding truths about life and nature. Textbook science (small *s*) is the practical product of this endeavor: the contents of textbooks and the current conceptions of what life and nature are like.

Supposedly, science is a reliable guide to navigating the world and making sound judgments. And most of the time it is. When science comes under attack, its critics are typically enemies of reason, the deniers of fact, logic and history. But every now and then, science comes under attack from Science.

At least that might be one way you could interpret some current controversies in economics, where new research (Science in action) is challenging the textbook prescriptions for making many business and investment decisions. It turns out that textbook science often does no better (and may do worse) than informed rule-of-thumb guesses, as behavioral sciences writer Bruce Bower reports in this issue (Page 26).

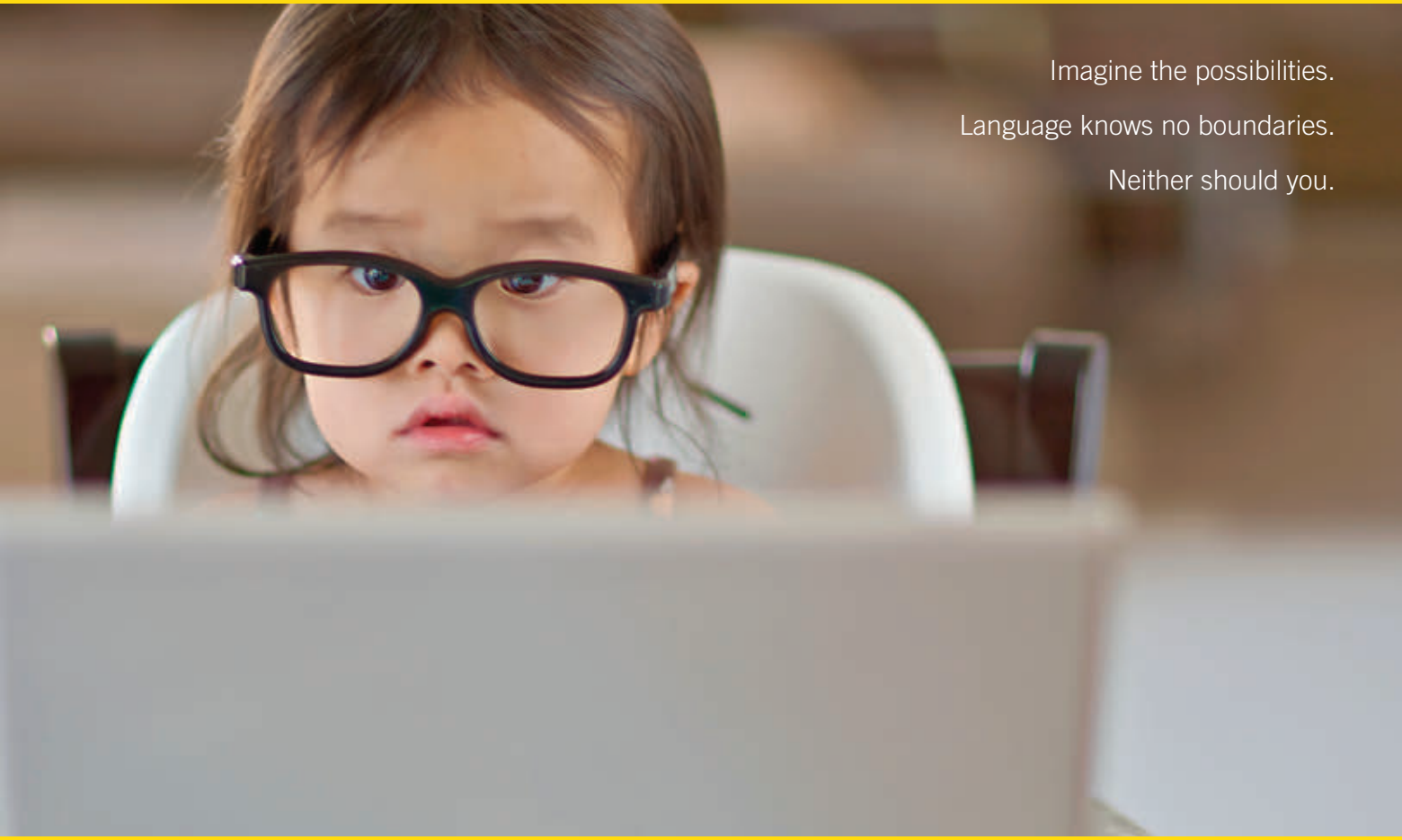
Among experts, disagreement remains about some of these findings, and whether they actually invalidate the economics-textbook science. But suppose they do. It would be wrong to infer that established science is inherently often invalid or unworthy of respect. Or that guesswork beats science-based analyses for assessing optimal courses of action. It's just that Science sometimes produces counterintuitive conclusions that defy the conventional wisdom of science.

All this is simply another sign that the practice of Science by humans is imperfect. Consequently textbook science is never completely correct. A large part of reporting news from the world of research is identifying instances where Science suggests the need for textbook revisions.

When controversy erupts, though, science and Science can seem to be at odds; the desire to verify old verities often competes with the quest to uncover new understanding. In such situations, textbook conclusions properly rooted in sound Science should not be dismissed lightly, but neither should science impede the assimilation of new evidence. Rewriting the textbooks to accommodate such evidence reflects the prime reason for science's strength: When Science speaks, science listens.

—Tom Siegfried, Editor in Chief

More than words.
Potential.



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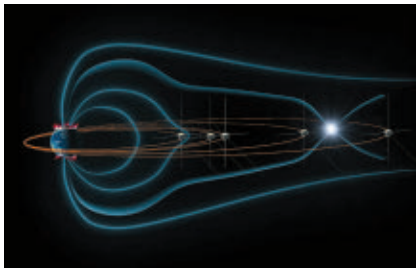

Say What?

betatron acceleration \BAY-tuh-trahn ak-seh-leh-RAY-shun\ ***n.*** Acceleration of particles by a changing magnetic field. The changes give particles, such as electrons, an energy boost and send them corkscrewing through space at high speeds. Researchers led by Maha Ashour-Abdalla of UCLA reported online January 30 in *Nature Physics* that electrons in a type of space storm that forms on Earth's night side appear to build up most of their energy via betatron acceleration caused by strong, shifting magnetic fields close to Earth—and not from the rubber band–like snap of outlying terrestrial magnetic field lines (shown in blue) that first sends the electrons hurling toward the planet (*SN Online: 2/15/11*). The study may help scientists understand auroras and other space weather phenomena.

SN Online

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BODY & BRAIN

Broken neural loops distinguish vegetative states. Read "Gravely damaged brains have 'bottleneck.'"

MATTER & ENERGY

Bird plumage inspires a new laser design. See "New laser is from the birds."

HUMANS

Depression may boost individuals' analytical skills. Read "Thinking better with depression."

LIFE

Ancient fungi finally found. See "New fungi the dark matter of mushrooms."

CLOCKWISE FROM TOP LEFT: NASA; LTSHEARS; GEOATLAS/GRAPH-OGRE, ADAPTED BY T. DUBÉ; JSC/NASA

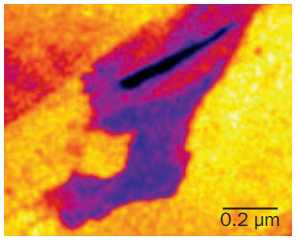
Science Past | FROM THE ISSUE OF JUNE 3, 1961

ATOMIC ENERGY SEEN BEST FOR ROCKET POWER — Atomic energy is the most feasible source for powering rockets into the far reaches of outer space. A refined model of a nuclear

power system now being developed could be used to propel space probes to Mars and Venus, [said] Dr. Glenn T. Seaborg, chairman of the Atomic Energy Commission.... Already it is feasible to put an "atomic generator" in a satellite whirling around the earth to supply electric power. This generator, weighing four pounds, could produce electricity, equivalent to thousands of pounds of batteries, over a five-year period.... Atomic energy can also be used in a worldwide network of television satellites or weather stations.

Introducing...

An international team of researchers has discovered a new mineral buried deep inside a meteorite. Dubbed "Wassonite" after the UCLA meteorite specialist John Wasson, the mineral is made of sulfur and titanium and has a crystal structure unobserved in minerals until now, NASA scientists and their colleagues announced April 5. The team found the streak of Wassonite (dark slash in



the X-ray image at left) in a meteorite recovered in Antarctica in 1969, in which the mineral's width spans about a thousandth the thickness of a sheet of paper. It's also surrounded by other unidentified minerals.

Science Future

June 27

Go behind the scenes of Houston's Cockrell Butterfly Center. Go to https://store.hmns.org

July 15–17

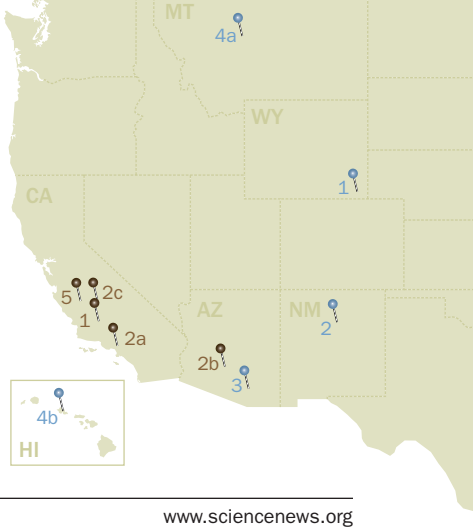
Swim with the world's largest fish at the fourth annual Whale Shark Festival in Isla Mujeres, Mexico. More information at www.whalesharkfest.com

Science Stats | BREATHE FREELY

The top five cleanest and top five dirtiest U.S. cities—as far as year-round air pollution from particles such as exhaust goes—all lie west of the Mississippi, according to the American Lung Association.

Top five least and most polluted U.S. cities

Rank	Location
Least polluted	
1	Cheyenne, Wyo.
2	Santa Fe/Espanola, N.M.
3	Tucson, Ariz.
4a	Great Falls, Mont.
4b	Honolulu, Hawaii
Most polluted	
1	Bakersfield/Delano, Calif.
2a	Los Angeles/Long Beach/ Riverside, Calif.
2b	Phoenix/Mesa/ Glendale, Ariz.
2c	Visalia/Porterville, Calif.
5	Hanford/Corcoran, Calif.



SOURCE: *STATE OF THE AIR* 2011

“The iPS cell phenomenon is so new and so hyped up that it’s good we’re taking a step back to ask what they can really do.”
—CHAD TANG, PAGE 13

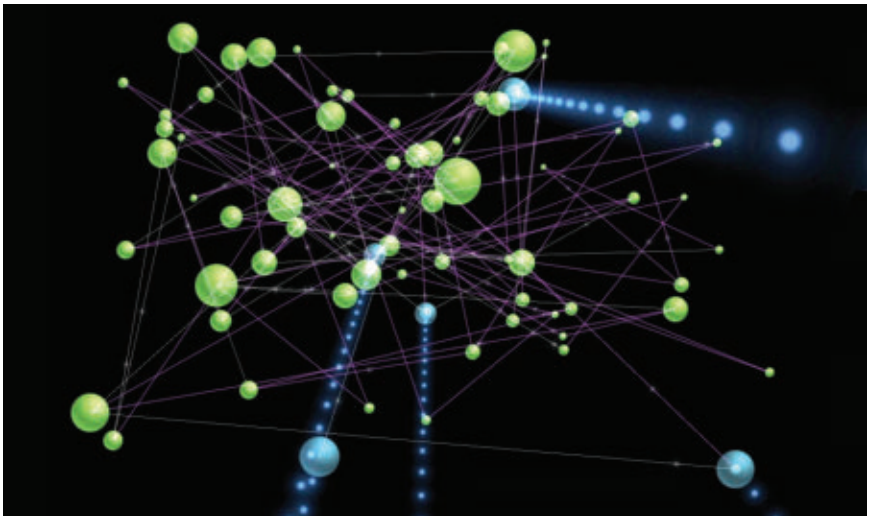
In the News

STORY ONE

A few master switches can rule a network

Social sites like Facebook especially easy to control

By Rachel Ehrenberg



MAURO MARTINO

A new algorithm identifies the subset of nodes that must be manipulated in order to dominate a network. In this illustration, exerting control requires interfering with a handful of “driver nodes,” in blue. Dense networks are generally easier to control.

It’s like a Hollywood political thriller come true: A handful of people lurking in the shadows control the minds of millions. New research reveals that it’s possible for a few individuals to enslave an entire network, even if they aren’t highly connected themselves.

Scientists have figured out how to identify the nodes (points that link to other points in a network) that when tweaked can influence an entire network. The research, published in the May 12 *Nature*, might lead to more secure power grids, tricks for controlling the metabolic processes of cells and marketing campaigns that spread like the plague.

If you wanted to nudge people on a social network into trying a new product or get a biochemical system to turn compound A into compound B, you could just push your product or compound into every entry point in the network. But that’s sort of a silly approach, says study coauthor Jean-Jacques Slotine of MIT. A much more efficient tactic would be to target just the nodes needed to get the desired outcome.

So, along with colleagues Albert-László Barabási and Yang-Yu Liu of Northeastern University in Boston, Slotine developed an algorithm that calculates the minimum number of these driver nodes and finds them. Then the researchers asked how much this minimum number depends on the architecture of the network (be it a tidy grid or a convoluted web) and its connectivity (whether each node is linked to a lot of other nodes or just a few).

Oddly, a network’s shape barely matters. The number of nodes needed to control a whole network mostly depends on the average number of connections per node, the researchers found. Sparse networks, such as the regulatory system controlling genes in a yeast cell, are pretty resistant to control; roughly 80 percent of the nodes need to be influenced to get the desired outcome. Dense networks, on the other hand, such as many social networks like Facebook, are much easier to control: Influence roughly 20 percent of the nodes and the whole network responds.

“I found that very shocking,” says Magnus Egerstedt, director of the Georgia Robotics and Intelligent Systems Laboratory at Georgia Tech. “Social networks, which seem to be these random, ad hoc collections of people freely expressing information and sharing their thoughts — those were much easier to control than other networks.”

Another counterintuitive finding had to do with where those power nodes lie. The nodes to tweak aren’t the hubs with many, many connections, but unassuming nodes off to the side.

“It’s a little scary,” says Slotine. “Do we really want large groups of people whose opinions are going to be controlled by just a few? And not the obvious people?”

Knowing that highly connected nodes aren’t the power players is a big step toward understanding why complex systems often behave nonsensically, says Dirk Helbing of the Swiss Federal Institute of Technology Zurich. “They

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SN Today at **www.sciencenews.org**

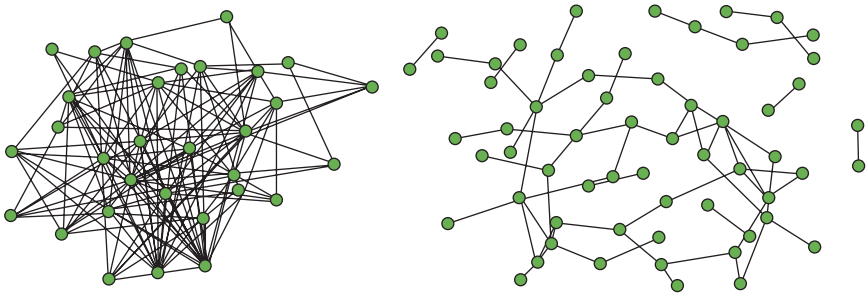
often behave in a counterintuitive way. Making sense of complex systems and managing them requires thinking out of the box and using new tools," he says.

The new math also allowed the researchers to determine a network's robustness and its vulnerabilities. Removing some links between nodes has little effect, while knocking out others drastically alters the flow (of whatever is being spread) through the network. The ability to pinpoint crucial links might help researchers find an infectious bacterium's Achilles' heel or help engineers shore up power grids.

"It gives us a better idea how to tame complex systems, particularly where we face serious coordination failures," says Helbing. Take traffic, for example. "Traffic light optimization is a damn hard problem, which cannot be perfectly done in real time today, not even with supercomputers. Knowing which nodes we must focus on will allow us to fight traffic congestion more efficiently."

Others aren't so sure that the math can be applied so widely. While the findings may hold for viral marketing in a social network, some networks are more complicated, and maybe the same broad brush can't be used, says Ali Jadbabaie, a networks expert at the University of Pennsylvania. There's more detail in a power grid than in a social network, he says. "Sometimes low-level details don't matter, but sometimes they do," says Jadbabaie. "This is interesting, with caveats."

But researchers generally agree that the work advances understanding of how networks behave, a problem that humans, who often think hierarchically, seem to have a hard time with.



Dense networks like the one on the left can be controlled by relatively few nodes compared with sparse ones like the one on the right. Surprisingly, researchers find that a network's shape has relatively little influence on how easy it is to control.

"We have very poor intuition about dynamic networks," says Egerstedt, a control theory expert whose projects include how to manipulate swarms of robots for environmental monitoring or intelligence gathering. "We are still so bad at driving lots of robots into a formation. I was trying to think of one thing in life where we have that kind of control, and the only thing I could think of is sheepherding. We have sheepherder dogs — driver nodes which are pretty good at controlling the herd with the help of a few leader female sheep. But that's about as far as our intuition goes." ■

An automated army invades a conference room at Georgia Tech. Researchers there are investigating ways of creating networks to control swarms of robots.

Controlling whole swarms of robots is one of the great challenges of robotics — and one that researchers have not yet mastered. Much of the difficulty stems from the complexity of the situation: many individuals, each with their many gears and parts, acting according to their own dynamics and connected to other agents that are all doing the same. To get a swarm to act in a coordinated way, the individual robots need to be linked in networks.

But just as everybody on a conference call can't talk at once, the network has to be configured so the most valuable information gets distributed widely while meaningless chatter is swept aside. Imagine a squadron of drones flying over enemy terrain — a single human operator can't direct dozens of aircraft simultaneously. The network has to be set up so that some drones can order their compatriots into action in the most effective way. In other words, it needs driver nodes.

Using an algorithm developed by researchers at MIT and Northeastern University, a dense network might be controlled by 20 percent of its nodes. But to coordinate a swarm taking incoming fire, you'd have to do way better than that. Today, says Magnus Egerstedt of Georgia Tech, a single drone flying over Afghanistan might have four or five human operators: "We want to invert that," Egerstedt says.

TOP: E. FELICIANO; BOTTOM: JEAN-PIERRE DE LA CROIX

★★★★★

"This watch looks AWESOME!!! Just got this big beautiful time piece and man is it worth every penny. The pictures do not do it justice.

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This watch doesn't do dainty. And neither do I. Call me old-fashioned, but I want my boots to be leather, my tires to be deep-tread monsters, and my steak thick and rare. Plenty of folks around here appreciate the softer side of life. Monet, Shakespeare, whoever. They're all great, but I don't want to wear anything inspired by pastel water lilies or a 400 year-old sonnet. Inspiration should come from things like dirt and axes. Firefighters and belt sanders. And if you want to talk beauty, let's discuss a 428 cubic inch V8. Things that can't help being tough. That's exactly how I'd describe this watch. In fact the only thing that's not tough about it is being able to afford it. The Stauer ***Centurion Hybrid*** is **only $79!**

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Humans

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‘Nutcracker Man’ preferred grazing

Despite name, huge-jawed human relative ate grass, sedges

By Bruce Bower

A jut-jawed, peg-toothed member of humans’ evolutionary family has chemically vetoed its 50-year-old nickname — Nutcracker Man.

Far from eating nuts, seeds and other hard foods seemingly suited to its viselike jaws, this now-extinct hominid mainly munched grasses and flowering plants called sedges, which include papyrus, says a team led by geochemist Thure Cerling of the University of Utah.

Nutcracker Man, a species known formally as *Paranthropus boisei* that lived from around 2.3 million to 1.2 million years ago, competed for food in swampy parts of East Africa with grazing animals such as ancestral zebras and pigs, Cerling’s team proposes in a paper published online May 2 in the *Proceedings of the National Academy of Sciences*.

The new study elaborates on previous investigations suggesting that Nutcracker Man said “nuts” to nuts. Archaeologist Nikolaas van der Merwe of the University of Cape Town in South Africa and his colleagues reported in 2008 that two *P. boisei* teeth from Tanzanian sites contained chemical signatures of a diet rich in grasses and sedges. Analyzing the proportions of certain forms of carbon in animals’ teeth can distinguish between a taste for tree-based items such as fruits and nuts or for tropical grasses and sedges.

“I don’t think *P. boisei* ate much grass,” van der Merwe says. “Sedges, particularly papyrus, get my vote.”

Cerling and his colleagues take no position on Nutcracker Man’s favorite food, emphasizing only that the ancient species was partial to grazing. Carbon measurements showed that among the 24 *P. boisei* teeth tested, the proportion of the diet consisting of grasses and sedges ranged from 61 percent to 91 percent.

Cerling plans to probe the carbon content of teeth from hominids between 3 million and 4 million years old for signs of previously unappreciated grass and sedge eating.

Stone Age cold case wide open

With no bodies, inhabitants’ identity remains mysterious

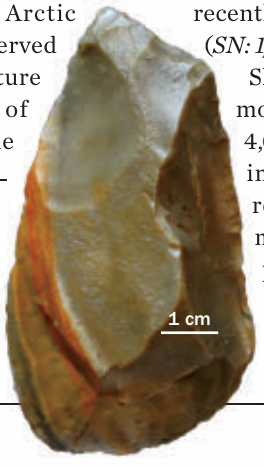
By Bruce Bower

In Asia’s northern hinterlands not far from the Arctic Circle, Stone Age toolmakers left an evolutionary calling card that’s hard to read.

Artifacts found in this desolate region imply that the toolmakers adapted to frigid temperatures and dark winters, says a team led by archaeologist Ludovic Slimak of the University of Toulouse in France. Around that time, groups of modern humans in Europe and southwestern Asia underwent pivotal cultural changes. Some groups even reached Arctic spots near the new finds and left behind artifacts associated with that human cultural transition.

The new discoveries present a much tougher call. There are no human or Neandertal remains at Byzovaya, a site in Russia’s Ural Mountains; stone implements found there — manufactured between 34,000 and 31,000 years ago — resemble scraping and cutting tools associated with 130,000- to 30,000-year-old European Neandertals, Slimak and his colleagues report in the May 13 *Science*. To complicate matters, groups of *Homo sapiens* that lived in northern Africa and southwestern Asia between 200,000 and 45,000 years ago made the same kinds of tools.

If Neandertals held court at Byzovaya, then these stocky members of the human evolutionary family lived near groups of modern humans who reached the Russian Arctic by 36,000 years ago (*SN: 9/22/01, p. 187*). If modern humans made the distinctive Byzovaya tools, “it would imply that Arctic *H. sapiens* groups preserved an older Stone Age culture after the expansion of modern societies in the rest of Eurasia,” Slimak says.



This tool found near the Arctic Circle could have been made by *Homo sapiens*, Neandertals or a recently proposed Neandertal relative.

HUGUES PLISSON, *SCIENCE*/AAAS

Stone tools attributed to anatomically modern human societies, which date to as early as 45,000 years ago in southern Russia, include small, rectangular blades and spear points. Such implements haven’t been found at Byzovaya.

Human-made, old-school tools at Byzovaya would support the idea that stone blades and other cultural signatures of modern societies emerged in Europe, where people migrating from Africa competed for resources with native Neandertals, suggests archaeologist John Shea of Stony Brook University in New York.

It’s also possible that Byzovaya tools were the handiwork of a third species — a recently identified Neandertal relative (*SN: 1/15/11, p. 10*), Shea says.

Slimak and his colleagues studied more than 300 stone artifacts and 4,000 animal bones. The artifacts include cutting tools and large rocks from which these implements had been removed with pounding stones. Nearly two dozen mammoth, reindeer and brown bear bones at the site display butchery marks.

Life

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Giant ants once roved Wyoming

First full-body specimen of its kind from North America

By Susan Milius

It's not a bird or a plane; it's an ant the size of a hummingbird.

A winged ant queen fossilized in 49.5-million-year-old Wyoming rock ranks as the first body of a giant ant from the Western Hemisphere, says paleoentomologist Bruce Archibald of Simon Fraser University in Burnaby, Canada.

The new species, *Titanomyrma lubei*, is related to fossil giant ants previously found in Germany, bolstering the notion that the climate of the time had hot blips that allowed these warmth-loving giant insects to spread from continent to continent, Archibald and a U.S.–Canada team propose online May 4 in the *Proceedings of the Royal Society B*.

An ancient ant wing from Tennessee had hinted that big ants lived in North America during this time, says Torsten Wappler of the University of Bonn in Germany. "But complete preserved specimens were not known until Bruce came up with this beautiful preserved fossil."

The new fossil caught Archibald's eye as he and coauthor Kirk Johnson poked around storage drawers at the Denver Museum of Nature & Science, where Johnson works. The spookiest thing about the Wyoming ant may be that even at 5.1 centimeters long, she is not the largest ant ever found. A German fossil is slightly longer, as are queens of a living African driver ant, *Dorylus wilverthi*.

For the ants to have moved between continents meant taking ancient land bridges through Greenland or Iceland. During much of the ants' time those northern routes were merely temperate. But brief hot spells were possible, Archibald and his colleagues say. Climate scientists have already suggested there were several such episodes around 50 million years ago.

That idea of tropical moments of opportunity fits the interpretation of other fossils from the far north, says paleoclimatologist Appy Sluijs of Utrecht University in the Netherlands. Findings in northern regions of preserved hippo predecessors, tropical plankton and pollen from tropical palms support the idea.

At 5.1 centimeters long, a 49.5-million-year-old fossil ant queen from Wyoming is the size of a rufous hummingbird.

© BRUCE ARCHIBALD

Marine animals moved upriver early

Fossil worm burrows suggest rapid colonization of freshwater

By Alexandra Witze

Earth's early animals moved upstream not long after conquering the seas, newly discovered fossils show.

Rocks in eastern California preserve traces of tiny worms that squiggled through river mud some 530 million years ago. That's roughly 80 million years earlier than other freshwater animal fossils, paleontologists report online May 4 in *Geology*, and not long after the first appearance of diverse animal forms in marine environments.

Changing salinity can make it tough to evolve from living in the ocean to living in rivers and lakes, says Mary Droser, a paleontologist at the University of California, Riverside. The new work shows that "clearly animals had crossed that physiological barrier very early on," says Droser, who made the find with Martin Kennedy of the University of Adelaide in Australia.

The scientists stumbled across the fossils in the Wood Canyon Formation, parts of which were deposited under a salty sea and other parts under a river. In the freshwater layers the paleontologists spotted squiggly traces of U-shaped burrows in which two wormlike species once lived.

Animals apparently worked their way from the sea through brackish water and into freshwater by the time the rocks formed, Droser says. If so, freshwater environments were a fairly hospitable place to live early in animal history — a time well before plants colonized land about 450 million years ago. Some scientists think that early land plants helped stabilize river landscapes enough for animals to thrive there. Other paleontologists, she says, might now start finding earlier and earlier evidence for this key freshwater step in animal history.

But not all are convinced. Knowing which rocks were truly deposited in a river, as opposed to the ocean or along the coast, is difficult, says paleoecologist Molly Miller of Vanderbilt University in Nashville. A study published earlier this year in *Sedimentology*, for instance, argues that the Wood Canyon rocks may have lain quite close to the coast and thus have been flooded with both freshwater and saltwater. "The fact that these are sandwiched between rocks deposited in marine environments raises the bar of evidence required," Miller says.

Atom & Cosmos

"Everything that you would hope would be there, if it's dark matter, is basically there." —DAN HOOPER

New evidence for WIMPs reported

Minnesota experiment finds possible signs of dark matter

By Ron Cowen

An experiment in Minnesota is the first to bolster a long-contested claim that detectors a continent away have found evidence of particles called WIMPs.

WIMPs (for weakly interacting massive particles) are theorized particles and leading candidates for dark matter, invisible material believed to make up more than 80 percent of the universe's matter. In the Minnesota experiment, called COGENT, a hockey puck–sized chunk of germanium deep in a former iron mine attempts to record rare collisions with WIMPs.

In 15 months' worth of data, COGENT researchers detected a seasonal variation in the collision rate — higher in summer and lower in winter — similar to that seen for 14 years by a larger experiment in Italy that uses different detectors. Researchers with that experiment, DAMA/LIBRA, have attributed the results to the Earth's motion through a cloud of WIMPs (*SN: 5/10/08, p. 12*). But many physicists have doubted that interpretation because, until now, no other experiment had found similar results.

COGENT team leader Juan Collar of the University of Chicago presented the new findings May 2 in Anaheim, Calif., at a meeting of the American Physical Society.

"Everything that you would hope would be there, if it's dark matter, is basically there," theorist Dan Hooper of the Fermi National Accelerator Laboratory in Batavia, Ill., says of the evidence. The finding does not constitute a discovery of dark matter, however, because the likelihood of such results appearing by chance is too high to qualify for what physicists consider proof, notes Hooper.

Crab Nebula's behavior confounds

Latest outbursts send theorists skittering for an explanation

By Ron Cowen

The latest and greatest outbursts from the Crab Nebula, long known for its steady high-energy glow, are challenging theories about how the heavens accelerate charged particles to high energies.

Only last year, scientists were astonished to find that the nebula — a giant cloud 6,500 light-years from Earth with the spinning cinder of an exploded star at its center — had spat out gamma-ray pulses that fluctuated on time scales of only a few days (*SN: 1/1/11, p. 11*).

This spring, however, the nebula outdid itself, says Rolf Buehler of the SLAC National Accelerator Laboratory in Menlo Park, Calif. The Crab hurled gamma-ray flares, more energetic and five times brighter than any previously recorded, that fluctuated over just one to three hours. Buehler announced the findings, based on observations with the Fermi Gamma-ray Space Telescope, on May 11 in Rome at the annual Fermi symposium. A second team observed the April fireworks with AGILE, another orbiting telescope.

The Crab Nebula, shown in this Hubble Space Telescope image, was formerly known for its steady gamma-ray output.

NASA, ESA, JPL, ARIZONA STATE UNIV.

The earlier outbursts had already suggested that the Crab is producing gamma rays by accelerating electrons and positrons to energies around a quadrillion, or 10^{15}, electron volts — about 100 times higher than the maximum energy of protons at the Large Hadron Collider, the world's most powerful atom smasher. Because no signal can travel farther than light can in a given period of time, the rapid variation of the April flares indicates that the charged particles were revved up within a tiny region of the vast Crab no bigger than the solar system.

Although the Crab's gamma-ray flares are believed to be generated by electrons or positrons gyrating around magnetic fields, the energy of the observed radiation is several times higher than such a process can normally produce, says theoretical astrophysicist Mitchell Begelman of the University of Colorado at Boulder.

In a theoretical model proposed by Begelman and Boulder colleagues, the charged particles are accelerated near the nebula's center. Magnetic fields are violently rearranged, unleashing enormous amounts of energy in the presence of a strong electric field. Charged particles get sucked into the region, and the field enables them to form a higher-energy beam than they normally would. The researchers posted their work online at arXiv.org on May 5.

Regions where magnetic fields are violently rearranged generate turbulence and undulations, which may result in wiggles in the beam of energetic charged particles and the gamma rays it produces. The fluctuations may occur simply because a wiggling beam could be seen only during the short time it swept across Earth's line of sight.

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Metal light show follows fertilization

Massive outpouring of zinc kicks off embryonic development

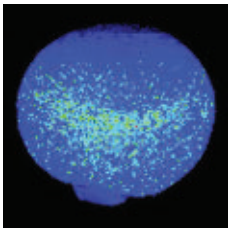
By Rachel Ehrenberg

Sex is often associated with metaphorical fireworks, but there's a real shower of sparks at the moment of conception. Scientists have witnessed mammalian eggs explosively releasing zinc atoms just after fertilization in a series of brief, intense outbursts that appear to jumpstart embryonic development.

The research, reported online April 28 in *ACS Chemical Biology*, reveals new details about how a single cell eventually becomes a full-blown organism and highlights that metals such as zinc can orchestrate major cellular events. In living things, zinc is better known for supporting roles, such as stabilizing a protein's conformation or assisting enzymes that spur chemical reactions.

"This really shows that elements, that chemistry, is in control of biology in a way we haven't thought about," says reproductive biologist Teresa Woodruff of Northwestern University in Chicago.

Before being released from the ovary, an egg has about 12 hours to prepare for fertilization. The egg must reduce its genetic material by half; the basic choreography of the ensuing chromosomal dance, known as meiosis, is well understood. But scientists are still working out exactly how an egg prepares its genetic material for fertilization.



Zinc atoms ejected by a mouse egg reveal preparations for embryo formation.

It's now clear that zinc plays an important role. Near the end of the 12-hour window, a mouse egg takes up more than 20 billion zinc atoms. This seems to signal the egg to sit tight, and the cell becomes quiet. But once a sperm hits its mark, the zinc bursts out of the egg.

With colleagues at Northwestern and Argonne National Laboratory, Woodruff saw the eggs of mice and two kinds of monkey releasing zinc "sparks" in one to five explosive bursts during the 90 minutes after fertilization. The release, which is linked to fluctuating levels of calcium, appears to signal the fertilized egg's readiness to grow into a multicellular blob, and eventually an embryo.

The research hints that zinc may play a much broader role in biology than it's given credit for, says developmental biologist Stephen Stricker of the University of New Mexico. "Who knows? Perhaps there's a whole new zinc-signaling story out there," he says. "This is exciting work and a really beautiful study."

Sickle-cell trait blunts malaria

May lessen severity of illness rather than prevent infection

By Tina Hesman Saey

Sickle-cell hemoglobin may gas malaria into submission, a new study proposes.

Carriers of a mutation that deforms the oxygen-carrying protein in red blood cells are well known to be protected from malaria. Scientists used to think the mutation prevented the malaria parasite from entering blood cells. But researchers led by Miguel Soares at the Gulbenkian Institute of Science in Oeiras, Portugal, now suggest another mechanism.

The sickle-cell mutation bumps up production of a protein called heme oxygenase-1, which helps make carbon monoxide gas. The gas can reduce inflammation and protect against death in mice with malaria infections in their brains, the team reports in the April 29 *Cell*.

Using mice genetically engineered to make human hemoglobin with the sickle-cell mutation, Soares and his colleagues discovered that the mutation primes the body to deal with the red blood cell–shredding activities of the malaria parasite.

Hemoglobin breaks down more easily in people with the sickle-cell mutation, Soares says, releasing a toxic compound called heme. To compensate, the body makes more heme oxygenase-1, leading to more carbon monoxide production. The carbon monoxide latches on to hemoglobin and prevents heme from popping off and causing more trouble.

The extra carbon monoxide also prepares cells for the effects of the malaria parasite. The parasite can still infect cells, but the host doesn't get as sick, allowing more time for the immune system to deal with the infection.

Mice infected with malaria fared well when kept in a chamber with a tiny bit of carbon monoxide, while infected mice kept in a chamber with regular air died, the team found. That finding suggests that very low doses of carbon monoxide could help treat malaria, Soares says.

Although the study carefully teases apart the mechanism, researchers don't know how well heme oxygenase-1 works against malaria in people.

"Humans may not react as uniformly as mice do," says Michael Walther, formerly a senior immunologist at the United Kingdom's Medical Research Council Unit, The Gambia.

This new mechanism may be one of several ways sickle cell protects against malaria, says Rick Fairhurst, an immunologist at the National Institutes of Health in Rockville, Md. But he thinks other immune system factors may be more important for keeping malaria in check in people with the mutation.

A. M. KIM *ET AL*./*ACS CHEMICAL BIOLOGY* 2011

"This really shows that elements, that chemistry, is in control of biology in a way we haven't thought about." —TERESA WOODRUFF

Lab-made stem cells fail a test

Mice raise immune attack on reprogrammed transplants

By Tina Hesman Saey

Stem cells made by reprogramming adult cells from a patient's own body can come under attack by the immune system, a new study in mice suggests.

The finding may present a major barrier to using induced pluripotent stem cells, or iPS cells, in treatments to repair or replace damaged tissues.

The study introduces a needed note of caution into what had become a headlong race to rush reprogrammed cells into clinical use, says Chad Tang, a stem cell biologist at Stanford who was not involved in the new work: "The iPS cell phenomenon is so new and so hyped up that it's good we're taking a step back to ask what they can really do."

Because reprogrammed cells are derived from a patient's own cells, most researchers had assumed that the immune system would not reject the cells as it does those from another person.

But researchers from the University of California, San Diego found that reprogrammed stem cells transplanted into mice were killed by the same sort of immune attack that occurs when transplanted organs are rejected. iPS cells that had been reprogrammed using viruses provoked a more intense immune reaction than ones created using a virus-free method, the researchers report online May 13 in *Nature*. Embryonic stem cells put into similar mice were not rejected.

Immune cells called T cells led the attack on the reprogrammed stem cells, which were derived from skin cells. The T cells keyed in on certain proteins made in some of the reprogrammed cells. Reprogrammed cells that didn't produce those proteins appeared to be safe from attack.

The researchers don't yet know if stem cells reprogrammed from other types of tissues would prompt the same immune onslaught as those created from skin cells, says UC San Diego's Yang Xu. If rejection is limited only to certain types of reprogrammed cells, then some others might be used safely. But if the problem is more widespread, researchers may have to rethink the goal of transplanting the cells into patients. "It's hard to say how big the hurdle is," Xu says, but improving the reprogramming method to make iPS cells more like embryonic stem cells might solve the problem.

Science & Society

For lists of all the Intel ISEF winners, visit **www.societyforscience.org/intelisef2011**

Top winners of Intel ISEF 2011 are (left to right) Matthew Feddersen, Blake Marggraff, Taylor Wilson, Tanpitcha Phongchaipaiboon, Pornwasu Pongtheerawan and Arada Sungkanit.

Youthful ingenuity rewarded with more than $4 million at Intel ISEF

Students' projects range from killing cancer to nuclear security

By Laura Sanders

LOS ANGELES — Cancer-killing radiation, nuclear threat detection and a fishy new plastic were behind the projects that took top awards at the 2011 Intel International Science and Engineering Fair. All together, hundreds of students took home over $4 million in prizes following the May 13 awards ceremony.

The weeklong science competition, a program of Society for Science & the Public, drew over 1,500 student finalists from around the world.

"Your innovation will help our global community transition to sustainable energy sources, mitigate the impact of natural disasters and lead to new ways of preventing and treating addictions and disease," Society for Science & the Public president and *Science News* publisher Elizabeth Marincola told the finalists.

The top prize of $75,000, the Gordon E. Moore Award (named for the Intel Corp. cofounder and inventor of Moore's Law), went to two California high school seniors who invented a way to fry cancer cells. Matthew Feddersen, 17, and Blake Marggraff, 18, of Lafayette, Calif., injected tiny particles of tin into a glob of yeast cells designed to simulate a tumor. When hit with X-rays, the tin produced secondary radiation that killed more cells than X-rays alone would. In tests, the tin didn't seem to have any toxic effects. "It's like a chemotherapy drug without the side effects," Marggraff says.

The technique could easily be implemented with existing technologies such as the X-ray machines found in dental offices, say Feddersen and Marggraff, both of whom have had family members with cancer. What's more, the treatment would cost about 60 cents per patient, so the technique would offer an affordable way to combat cancer.

> "It's like a chemotherapy drug without the side effects."
> **BLAKE MARGGRAFF**

Next year, Marggraff plans to attend Washington University in St. Louis, and Feddersen plans to go to the University of Illinois at Urbana-Champaign.

The two top winners were stunned to hear their names called. "It's amazing. I don't know how to describe it," says Feddersen. "We were disappointed when we didn't get fourth, so hearing this was astounding."

Three students from Thailand won Intel's Young Scientist Award, which comes with $50,000, for designing a new type of plastic out of fish scales. Pornwasu Pongtheerawan, 16, of Muang; Tanpitcha Phongchaipaiboon, 17, of Meung district; and Arada Sungkanit, 17, also of Meung district will split the award. The three students wondered whether a gelatinous product that the fish scales produce might be useful. After many experiments, the three hit upon a formula that produced firm, moldable plastic from the scale gelatin. The plastic completely degrades in about 28 days in soil and causes no ill effects on critters there, the team found. So far, the plastic isn't able to hold hot water or go in the microwave, so the team is tweaking the recipe.

Another recipient of Intel's Young Scientist Award — and $50,000 — is Taylor Wilson, 17, of Reno, Nev. Wilson created a sensitive, low-cost way to detect nuclear material such as weapons-grade plutonium and highly enriched uranium.

Two projects won the Dudley R. Herschbach SIYSS Award, which comes with an all-expense-paid trip to Sweden for the Stockholm International Youth Science Seminar and the Nobel Prize ceremonies. Herschbach, a 1986 Nobel laureate in chemistry, is the emeritus board chair of Society for Science & the Public.

One Herschbach award went to South Korean students Jinyoung Seo, 18, of Go-Yang City and Dongju Shin, 18, of Seoul for a material that mimics spider silk. They are building water-harvesting devices with the silk analog to collect usable water in places with fog but little rain.

The other award went to Andrew Kim, 18, of Athens, Ga. Kim explored why some fruit flies are extreme fighters. The more social experiences a male fly has had, the less likely the fly is to be aggressive, Kim found. A gene called *cyp6a20* also seems to influence aggression.

CHRIS AYERS/INTEL

Environment

607 million Average annual global corn production in metric tons, 1998–2002

586 million Average annual global wheat production in metric tons, 1998–2002

Antarctic ozone hole on the mend

Researchers detect healing sooner than they expected

By Alexandra Witze

Scientists may have spotted Antarctica's ozone hole on the road to recovery, at least a decade sooner than they thought healing would be noticeable.

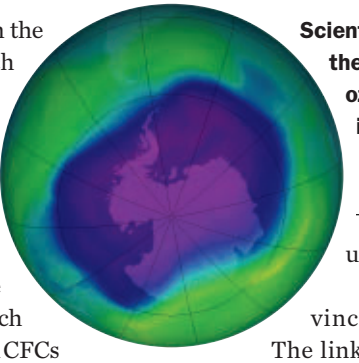
In 1989, an international agreement called the Montreal Protocol began phasing out chemicals that have gnawed away at Earth's protective ozone layer. Most researchers thought it would take until at least 2023 to detect the hole's slow recovery, but researchers in Australia now claim to have seen ozone ticking upward since the late 1990s.

"The key is to account for large year-to-year fluctuations that have obscured a gradual increase in the long-term evolution of ozone," says atmospheric scientist Murry Salby of Macquarie University in Sydney. His team published its findings online May 6 in *Geophysical Research Letters*.

First spotted in 1985, the Antarctic ozone hole was quickly linked to chemicals called chlorofluorocarbons, emitted mainly in the Northern Hemisphere but concentrated over the South Pole by atmospheric circulation. Chlorine atoms from these CFCs react with ozone molecules, seasonally destroying the layer that shields the Earth from cancer-causing and crop-damaging ultraviolet radiation.

Scientists had predicted that ozone loss would bottom out and start recovering by now. They just didn't think they would be able detect that change yet, since complex atmospheric processes cause ozone levels to vary dramatically from year to year, sometimes by as much as the magnitude of the ozone hole itself.

To better understand these year-to-year ozone fluctuations, Salby's team looked at "dynamical" influences such as waves that ripple through the planet's atmosphere much like the ocean's swells. The researchers found that winter dynamical factors closely tracked how much ozone was depleted the following spring. In essence, these processes control how much chlorine breaks away from CFCs each winter, which determines how much ozone will later break down.



Scientists report signs that the annual Antarctic ozone hole, shown here in September 2006, is healing thanks to an international treaty.

Knowing what caused these year-to-year changes, the scientists could then subtract out these effects, unmasking the long-term signal of ozone. After plummeting since the analysis began in 1979, that signal leveled off and began creeping up after 1996, Salby says.

Not all experts are convinced by the new work. The link between year-to-year dynamics and ozone levels seems strong now but could change on further analysis, says Darryn Waugh, an atmospheric scientist at Johns Hopkins University. "I expect Antarctic ozone to be slowly recovering," he says, "but would have thought that we need several more years of data to statistically show this."

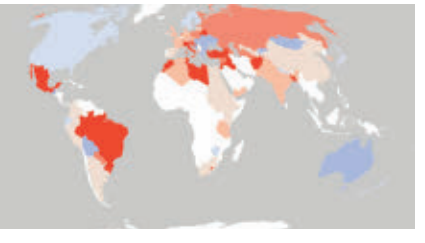
Warming hits corn and wheat yields

Rising temperatures have decreased global grain production

By Daniel Strain

Farms worldwide produced 3.8 percent less corn and 5.5 percent less wheat than they could have from 1980 to 2008 thanks to rising temperatures, a new analysis estimates. These wilting yields may have contributed to recent increases in food prices, a team of U.S. researchers reports online May 5 in *Science*. Climate-induced losses could have driven up prices of corn by 6.4 percent and wheat by 18.9 percent since 1980.

The researchers tracked country-by-country yields of these common foodstuffs over nearly three decades. Harvests of corn and wheat have climbed steadily since 1980 due in part to technological advancements, says David Lobell, a land-use scientist at Stanford University. But based on the team's statistical analysis, farmers could have produced a lot more food if the weather had been cooler. For corn, annual global losses amount to millions of tons — about equal to Mexico's yearly production of the crop.



From 1980 to 2008, hotter weather reduced wheat yields in some nations (red), while in a few countries warming increased production (blue).

This analysis of the last three decades largely falls in line with what other studies have projected, says Andy Challinor of the University of Leeds in England, who studies the impacts of climate on agriculture.

While it's far from a prediction, Lobell says his study identifies a number of problem areas that do need attention — not later but now. "If we really invest a lot in the development of crops that can withstand really high temperatures," he says, "that would potentially change things a lot."

FROM TOP: NASA; IMAGE COURTESY OF *SCIENCE*/AAAS

Body & Brain

0.9 percent Estimated 2006 autism spectrum disorder rate in U.S.

2.64 percent Estimated 2005–2009 autism spectrum disorder rate in South Korea

Autism numbers surprisingly high

South Korea study suggests cases going unrecognized

By Bruce Bower

South Korea just sent autism prevalence rates surging north. Autism spectrum disorders affect an estimated 2.64 percent of the nation's schoolchildren, or about 1 in 38 youngsters, a new study finds.

That's a considerably higher figure than has been reported in the United States, England and elsewhere, where prevalence estimates range between 0.07 percent and 1.8 percent. A 2006 report from the U.S. Centers for Disease Control and Prevention estimated that 1 in 110 U.S. children had an autism spectrum disorder, at that time considered a surprisingly high rate.

South Korea doesn't have an unusually high number of autism cases, says Yale University psychiatrist and study director Young Shin Kim. Previous studies generated prevalence estimates from medical records of children who had been diagnosed with or showed signs of autism spectrum disorders. Her investigation, published online May 9 in the *American Journal of Psychiatry*, screened a representative sample of more than 23,000 South Korean 7- to 12-year-olds regardless of whether they had any record of symptoms.

"It seems that many children with autism spectrum disorders have been here all along but haven't been counted in previous studies," Kim says.

> **"It seems that many children with autism spectrum disorders … haven't been counted in previous studies."**
> YOUNG SHIN KIM

About two-thirds of South Korean children diagnosed with an autism spectrum disorder attended public schools where their condition had gone unrecognized, Kim's team concludes.

Cultural factors, such as South Korean parents and clinicians having especially strict definitions of "normal" child behavior, might have influenced the results, says psychologist Catherine Lord, director of the University of Michigan Autism & Communication Disorders Center in Ann Arbor. Study coauthor Richard Grinker of George Washington University in Washington, D.C., says the study design addressed such factors.

Kim and her colleagues worked from 2005 to 2009 in the city of Goyang, near Seoul. Most participating children attended public schools and had never received special education or psychological services.

A U.S. population survey of autism spectrum disorders needs to be conducted, comments psychologist Geraldine Dawson, research director of Autism Speaks, a private research and advocacy organization in New York City that partly funded the $750,000 South Korea study. "Until then, we won't know the true extent of these disorders here."

Coronary bypasses less common

Use of catheters to clear clogged vessels drops only slightly

By Nathan Seppa

Think of it as bypassing the bypass. U.S. heart patients have been less likely in the past decade to undergo surgery to install a substitute vessel around a clogged coronary artery, with many patients instead getting a less invasive alternative procedure.

Coronary bypass operations decreased by 38 percent per capita in U.S. adults between 2001 and 2008, researchers report in the May 4 *Journal of the American Medical Association*. Meanwhile, angioplasties — in which a doctor threads a catheter to the heart to open a blockage using a balloon — have stayed nearly constant, with the per capita rate dipping only 4 percent over that time. Angioplasties nearly always deliver a coated mesh cylinder called a stent, which props open the vessel from the inside. The study's authors analyzed a national sample of thousands of coronary fixes.

The findings reflect changes since specially coated stents gained U.S. regulatory approval in 2003, says study coauthor Peter Groeneveld, an internist at the University of Pennsylvania School of Medicine and the Philadelphia Veterans Affairs Medical Center. Coatings have made stents less prone to clogging. The new data show the number of stenting procedures in 2008 exceeding bypass operations by 3-to-1, Groeneveld says.

The original guidelines for stents recommended the procedure for people with one or two vessels blocked and neither occluding the left main branch of the coronary artery. But in the past decade, doctors have installed stents in thousands of people with three or more blocked vessels or a blocked left main coronary artery.

In 2009, a U.S.–European team compared stenting and bypass surgery in severe cases and reported that 13.5 percent of patients with stents needed surgery for another blockage within a year. Only 5.9 percent of those getting coronary bypass surgery did. But another look at the same patients, in the March 17 *New England Journal of Medicine,* found that percentages of the patients free of chest pain at 12 months post-procedure were practically the same in the stent and bypass groups — 72 to 76 percent.

"There are quality-of-life issues that are relevant to patients," says Harold Dauerman, an interventional cardiologist at the University of Vermont. "Many patients prefer shorter hospitalization."

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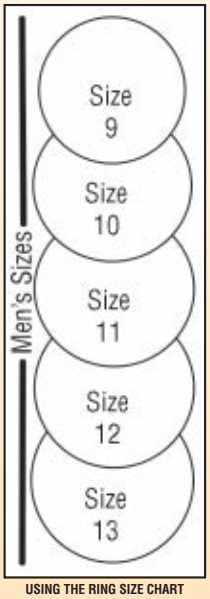

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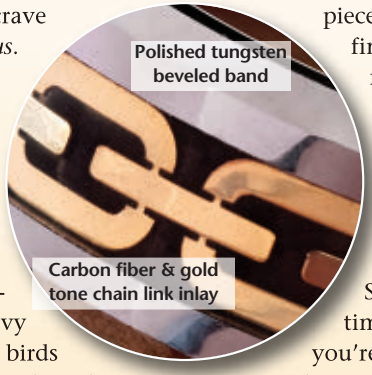
Place one of her rings on top of one of the circle diagrams. Your ring size is the circle that matches the inside diameter of the ring diagram. If your ring falls between sizes, order the next larger size.

Where has this metal been all my life? Named for the old Swedish word for "heavy stone," tungsten is four times harder than titanium and 71% denser than lead. It's so tough that when they need to cut it and polish it they have to use diamonds... the hardest substance on Earth! It's the very same metal that goes into armor-piercing ammunition and the fuel nozzles of skyscraper-sized rockets.

JEWELRY SPECS:



Can it handle a life of luxury? Of course. Even as a piece of jewelry it remains an overachiever. Unlike other fine metals, the spectacular polish and shine will never dull. And you're going to be amazed by how well this ring balances a heavyweight feel with "forget-your-wearing-it" comfort. Added details include a handsome beveled-edge and a carbon fiber and gold tone chain link inlay. The perfect symbol of a relationship built to last. And right now you can **get it for $150 less.** Plus with the Stauer 30-day Money Back Guarantee, you've got time to see if you're ready for the commitment. If you're not satisfied, return it for a full refund of the purchase price. This just might be the easiest "tough decision" you've ever made!

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Smart Luxuries—Surprising Prices

Kepler spacecraft finds much more than exoplanets

By Charles Petit

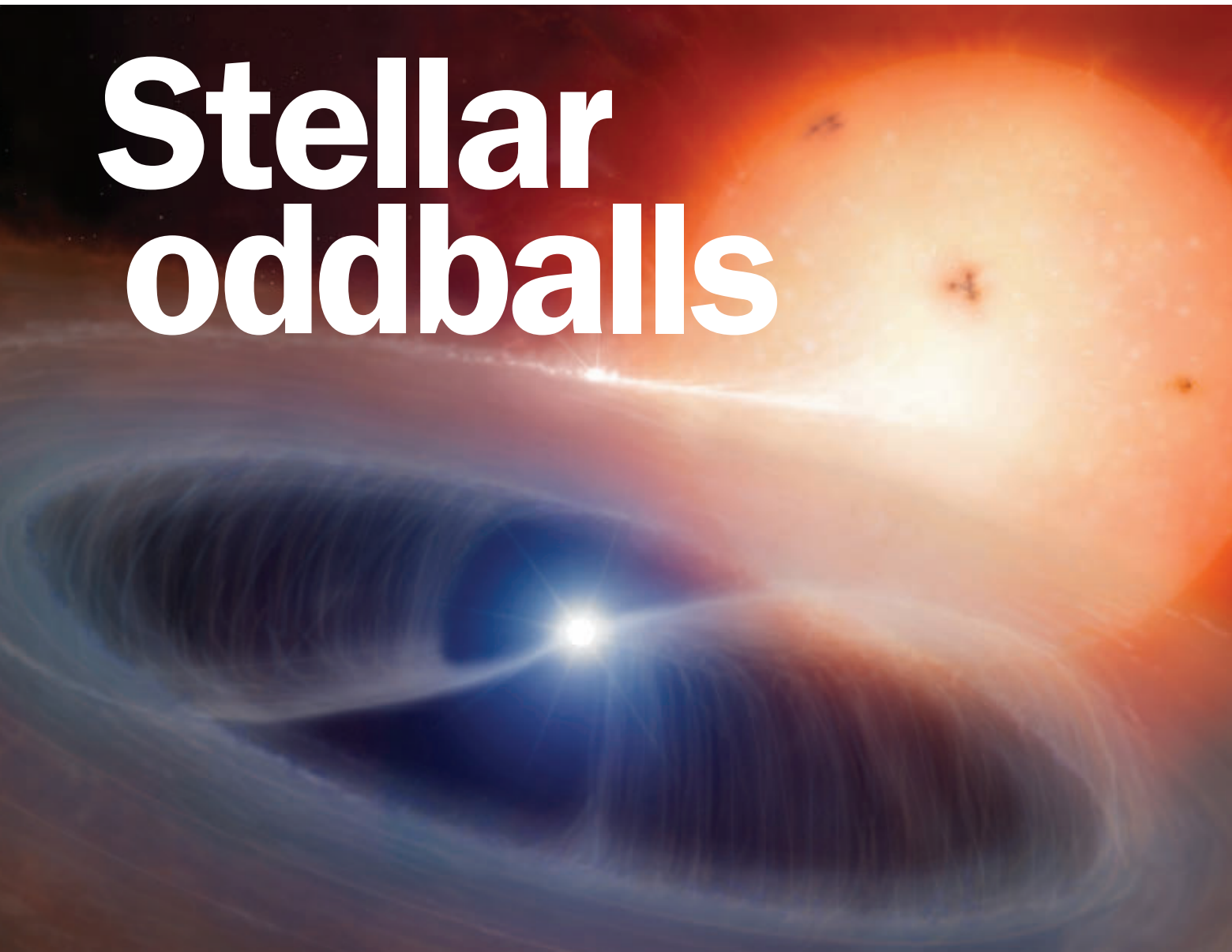
After mind-bendingly precise data and artists' renditions of mysterious stars played across the screen, Martin Still leaned into his lectern at an American Association for the Advancement of Science meeting early this year to deliver a plea to fellow astronomers. In one word: Help!

"We need you guys," said the manager of NASA's guest observer program for Kepler, among the most successful space telescopes ever launched. "Wait a year and it's too late."

Kepler has found a bonus, a treasury of wonders, or one might say a stellar freak show out in space. The result is a predicament: This is not what the space telescope was looking for. Kepler's NASA team has one job that it must, by contract, pursue almost exclusively — hunting for extrasolar planets. In-house researchers must largely ignore other wonders. Hence the call for aid from guest observers, people given access to a telescope's data, but who typically provide their own resources to analyze the results and pursue more.

In science, new instruments routinely discover unexpected things. But Kepler's surprises — which could help astronomers learn far more about the evolution of stars, their internal structures and how the burning balls of plasma die — require fast action if they are to be fully examined.

The telescope honors 17th century German astronomer Johannes Kepler. He was first to realize that planets follow elliptical, not circular, orbits, and he established three laws of planetary motion. "Our mission is to find planets. We hope to find Earthlike planets," says the project's founder and principal investigator, William Borucki of NASA's Ames Research Center in Mountain View, Calif. Borucki spent decades fighting against great skepticism to build an orbiting instrument so sensitive it would



The Kepler team wants outside astronomers to further study strange stars in the craft's data. Here, a white dwarf and red dwarf are depicted in mutual orbit.

detect planets that briefly cross, or transit, their stars' faces.

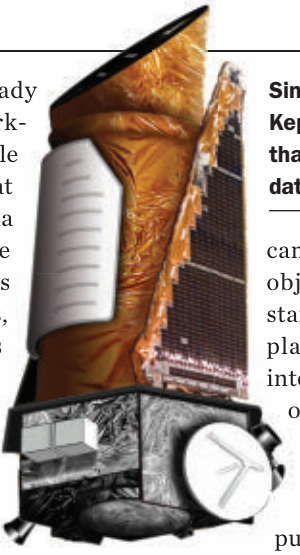
NASA launched the telescope in March 2009 into a "trailing" orbit. Sitting slightly farther from the sun than Earth does, Kepler makes one trip around the sun every 372 days, gradually falling farther behind Earth. In its solitude, the spacecraft keeps its eye on hordes of stars, checking for planets.

It is finding them, too, in scads. There are more than 1,200 entries on Kepler's list of candidate planets (*SN: 2/26/11, p. 18*) betrayed by small, repetitive and distinctively shaped dips in the brightness of their parent stars — the shadow of a planet crossing a star's face as seen by the craft. While further analysis surely will reveal some as false alarms, chances are that 90 percent are real. That will triple the number of known exoplanets. With time, scientists hope to confirm a few with Earthlike size, orbit and other conditions suitable for life as we know it to arise.

But the majority of stars don't have planets lined up to block light headed toward Kepler. These stars too are worthy of study. Still, who is based at Ames, hopes outside astronomers will take a close look at Kepler's new data on stars without signs of planets, plus look at those stars with other scientific instruments while the craft is still operational.

Eye for the weird

"There are so many stars that show bizarre, utterly unexplainable brightness variations that I don't know where to begin," says Geoff Marcy of the University of California, Berkeley. Marcy gained fame in the mid-1990s when he helped pioneer, with ground-based instruments, discovery of extrasolar planets; he joined the Kepler team to help expand the planet-finding toolbox. After the detection of far more than planets began overwhelming the Kepler program, Marcy hired an undergraduate statistics major to scan the plots of varying brightness for tens of thousands of stars. He trained her to spot what Marcy calls the WTF objects, which might politely be rendered "What The Flip is that?"



Since launch in March 2009, Kepler has identified more than 1,200 exoplanet candidates; 15 are confirmed.

Astronomers have already spotted stars with remarkable pulsation modes, double stars orbiting so closely that streams of white-hot plasma flow between them, immense star spots whose movements hint at unlikely rotations, collapsed white dwarf stars in eclipsing orbits around large and seemingly younger stars, and more. "These phenomena have never been seen before, or never with such clarity. This is a gold mine," Marcy says.

Ironically, the bounty comes from a telescope that Borucki has often called, tongue in cheek, the most boring space mission in history. All Kepler does is look, occasionally pausing to realign its solar panels, at one starry patch of sky about as big as a hand held at arm's length. The target is roughly between the Northern Hemisphere constellations Cygnus and Lyra.

About 4 million stars in Kepler's view are bright enough to study closely. Unlike most telescopes, its camera gathers no spectra that directly reveal chemical composition. The main objective is to measure star brightness, an astronomical procedure called photometry. Stellar photometry has never been done before on this scale or with this accuracy. With 42 CCD photo chips, or about 95 megapixels in all, Kepler's camera — the largest ever put in orbit — can detect changes in brightness to well under 0.01 percent, good enough for Earth-sized planets orbiting sun-sized stars. There is capacity on the radio link to Earth for about 6 percent of the data avalanche. "We throw away the rest," Still says. Thus choosing which stars' data to hold onto is essential.

Most of Kepler's attention is on 156,000 stars selected because they appeared from pre-Kepler data to be more or less sunlike, fairly stable in their output. Even among these stars, most light curves are not checked by human eye; computer programs recognize and flag those with the regular, slight dips suggestive of planets. Researchers can request up to 512 extra objects for detailed study: stars already excluded from planet study, perhaps, but interesting for other reasons, or background galaxies.

Already, general astrophysics papers (meaning papers about stars) published from the mission outnumber those dealing with planets. Some papers are on single stars that turned out to be double or triple systems, or stars orbited by — and sometimes consuming — whirling disks of gas, plasma and dust. Such things were already known to exist, but to have so many in such detail is new. Anybody can go to the Kepler website, pick at random one of the 156,000-plus or so stars on the target list, and command the Kepler server to plot and display the star's light curve.

An amateur helps himself

Even amateurs are welcome to try. One such amateur is Kevin Apps, an engineer in Surrey, England. He works days managing natural gas pipeline flows but has published several astrophysics papers with professionals. Shortly after Kepler went into orbit, Apps looked in the telescope's data file for a red dwarf about 120 light-years away that he knew about from star catalogs. To his surprise it had not been included in the list of 156,000 for Kepler's close attention.

From his home computer Apps found that he could retrieve the light curve using data gathered during the telescope's initial commissioning phase. The light curve had four dips spaced 12.71 days apart, suggestive of planet-sized transits. He contacted John A. Johnson, an assistant professor at Caltech whom Apps had worked with before.

Intrigued, Johnson recruited eight other professional astronomers. They obtained spectra with telescopes in California and Hawaii. Analysis revealed

OPPOSITE PAGE: MARK GARLICK/VISUALPHOTOS; THIS PAGE: KEPLER MISSION/NASA, WENDY STENZEL

not, as the catalogs say, a single star but instead a wide-spaced pair, or binary, of red dwarfs (also known as M dwarfs, the most common kind of star in the galaxy). One is about 30 percent and the other 37 percent as massive as the sun. They circle one another every 100 years or so. With an adaptive optics system on the famed 200-inch telescope at Mount Palomar in California, the team even got a fuzzy photo showing two distinct stars.

And the dips in starlight? They are indeed caused by something about the size of a large planet in orbit about the larger of the two dim stars. But it is no planet. Orbital motion betrays a mass 63 times that of Jupiter, Johnson, Apps and colleagues reported April 1 in the *Astrophysical Journal*. That makes it a brown dwarf, or "failed star" in the fuzzy border between planet and star, lacking the internal temperature and pressure to drive hydrogen fusion. The body's transits make it among the least massive for which an exact radius has been determined.

"I'm blown away by the scientific impact of the Kepler mission," Johnson said via e-mail. "It's not often that astronomers get order-of-magnitude gains in precision or sample size, but Kepler has provided both.... My students and I are like kids in a candy store!"

And passionate hobbyist Apps says, "For an amateur to be involved ... and to be published, that is as good as it gets, really." (Apps' successes have led a filmmaker to plan a movie dramatization of his adventures.)

Stellar focus Although Kepler is finding scores of potential planets, papers published on general astrophysics — stars, basically — outnumber planet papers.

Astrophysics papers since Kepler's launch

Time frame	Papers
January–March 2009	2
April–June 2009	1
July–September 2009	2
October–December 2009	5
January–March 2010	29
April–June 2010	6
July–September 2010	28
October–December 2010	9
January–March 2011	32

SOURCE: M. STILL

Ringing like bells

From the start, the Kepler mission recruited hundreds of specialists in the field of asteroseismology to help with the planet search. These scientists look at the flickers of stars to collect key data for deducing the size of an orbiting planet. But the scientists have been astonished at how much else they can tell about stars with Kepler's data. Don Kurtz, an astronomer at the University of Central Lancashire in Preston, England, is coauthor of what he calls the first asteroseismology textbook, published in 2009. Its foreword declares that the pulsations in a star's light due to sloshings of the star's atmosphere are physically similar to low-frequency sound waves.

> "For an amateur to be involved ... and to be published, that is as good as it gets, really."
> KEVIN APPS

Thus modern asteroseismology echoes a theory first put forward by Pythagoras that heavenly spheres make divine music. The vibrations of stars offer details about their internal structures, like a symphony's sound reveals the composition of the orchestra. The introduction to Kurtz's textbook says that just as "you can 'hear' the shape of the instrument, we can use the frequencies, amplitudes and phases of the sound waves that we detect in the stars to 'see' their interiors — to see their internal 'shapes.'"

Kurtz likened the technique to ultrasound exams that tell doctors the health and sex of a developing fetus. In fact, a team reported in the April 8 *Science* measurements from Kepler that reveal pulsations that echo all the way from the center of a star, a red giant.

"Until Kepler, I was doing the best stellar photometry in the business. The very best I could ever do, Kepler is doing it at least 10 or 20 times better, and most of the time it is 100 to 1,000 times better, while looking at 156,000 stars at once."

Kurtz recently examined Kepler's data on one star, known as KIC 10195926. It does something he has never seen: It quivers, or pulsates, on two axes of symmetry at once. The star is roughly twice the sun's mass and has now been classed as an Ap star, for A-peculiar, with a strong magnetic field. A paper by Kurtz and collaborators published online in April in the *Monthly Notices of the Royal Astronomical Society* reported that the star exhibits "torsional modes" in its rotation. Nothing like that has been seen before, either. It means the star's northern and southern halves trade off, one spinning faster than the other and then vice versa — a little bit like a dancer turning and doing the twist at the same time, shoulders and hips moving in opposite sync.

As such discoveries pile up, competition for time on ground-based telescopes in the Northern Hemisphere is already spiking for late summer, the peak of "Kepler Season" when the satellite's target is high in the Earth's night sky. Astronomers want to gather more information on objects that Kepler's data reveal to be interesting, or to make a case for objects that Kepler's handlers should add to their list.

A furious tango

Many of the stars Kepler is looking at have been visible in telescopes for centuries but, like most nondescript-looking stars, got little notice. What standard star catalogs say about seldom-examined stars is often sketchy or wrong. An example is HD 187091, about 1,000 light-years away. The Henry Draper Catalog of 1918–24 lists it as an ordinary A-class star, a type about twice as large and as massive as the sun. It did not seem unusual in any way.

But within just 10 days of operation, Kepler returned an astonishing light curve. Every 42 days the star's brightness rose to a sharp peak and quickly fell, regular as a metronome. The rise was less than 1 percent, "but to Kepler, that is huge," says William Welsh, an astronomy professor at San Diego State University. Furthermore, a complex

forest of secondary brightness variations continued at a lower level in between the dramatic brightness peaks.

One hypothesis was that the star is orbited by a black hole, its strong gravity lensing the star's light into a beam that briefly aims at Earth once every orbit. A platoon of astronomers got time on NASA's Swift telescope to seek signs of a black hole's telltale X-rays, but no luck there. A spectroscopic examination with half a dozen ground-based telescopes solved the puzzle.

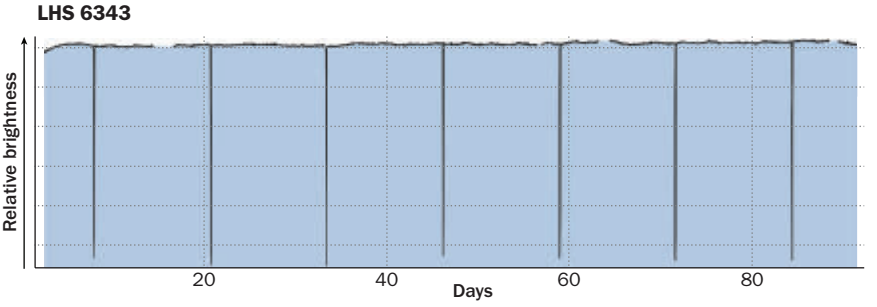
HD 187091, now known as KOI-54 for "Kepler Object of Interest No. 54," is not one A-star but two of nearly the same size, one 2.19 and the other 2.33 times the sun's 1.39-million-kilometer diameter. They are in a wildly stretched-out, elliptical orbit. Every 41 day, 19 hour orbit sends them racing nearly toward each other and zipping around one another at a separation equal to only about three times each one's diameter, and then flings them almost 120 million kilometers apart.

The brightening occurs as the stars, tidally warped by their gravity at closest approach into slight egg shapes, roast one another on their facing sides and heat up. And that explains the spike in brightness, the team reported online in February at arXiv.org. The more surprising revelation of Kepler's data is that one, and perhaps both, pulsate furiously at rates that are precise multiples of their rate of close encounters, in some cases pulsing exactly 90 and 91 times for each orbit. "Nobody had ever seen, or even thought, something like this could happen," Welsh says. Discovering that a star's rapid pulsations are not always driven by internal processes, but can be paced by a tidal metronome from a partner star, offers a new window into stellar dynamics and structure.

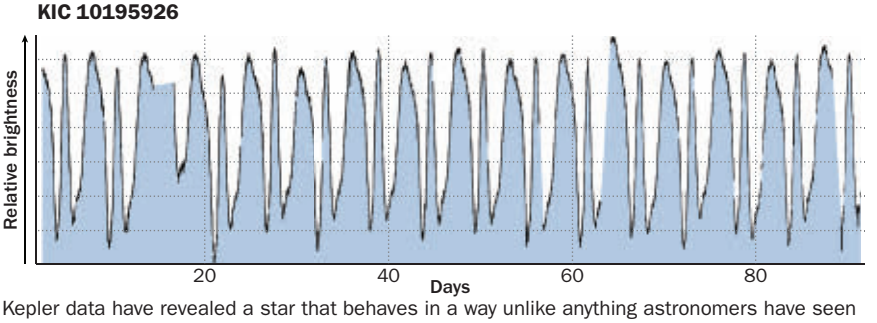
Stay tuned

In the next year or two, and longer if the Kepler mission is extended, myriad more discoveries like these are likely. Eventually the craft will go out of commission; at the outside it could keep working for four or five years, says deputy Kepler project scientist Steve Howell, also at Ames.

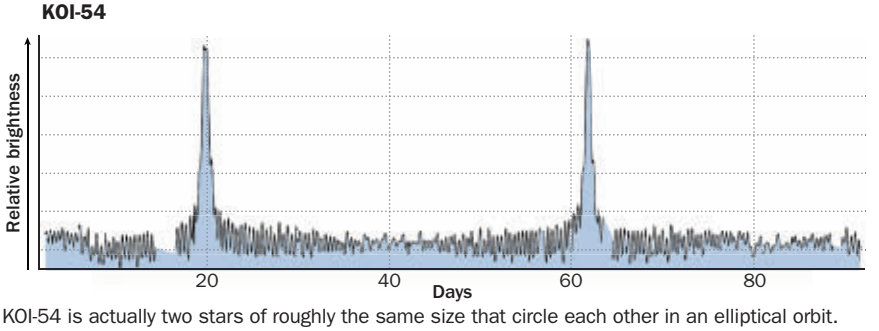
Unexpected curves Kepler tracks changes in the brightness of light emitted by stars over time, generating what are called light curves. Telltale dips in a star's light curve offer evidence that a planet is orbiting and passing in front of the star. But binary star systems, nonplanetary bodies and internal pulsations can also create signature light curves (as shown for the sources below).



Amateur astronomer Kevin Apps helped researchers discover that LHS 6343 is actually a pair of stars. Abrupt dips in light (thin vertical lines) are caused by an orbiting brown dwarf.



Kepler data have revealed a star that behaves in a way unlike anything astronomers have seen before, pulsating on two axes and exhibiting torsional modes in its rotation.



KOI-54 is actually two stars of roughly the same size that circle each other in an elliptical orbit. The two stars heat up when they face each other, explaining the brightness spikes.

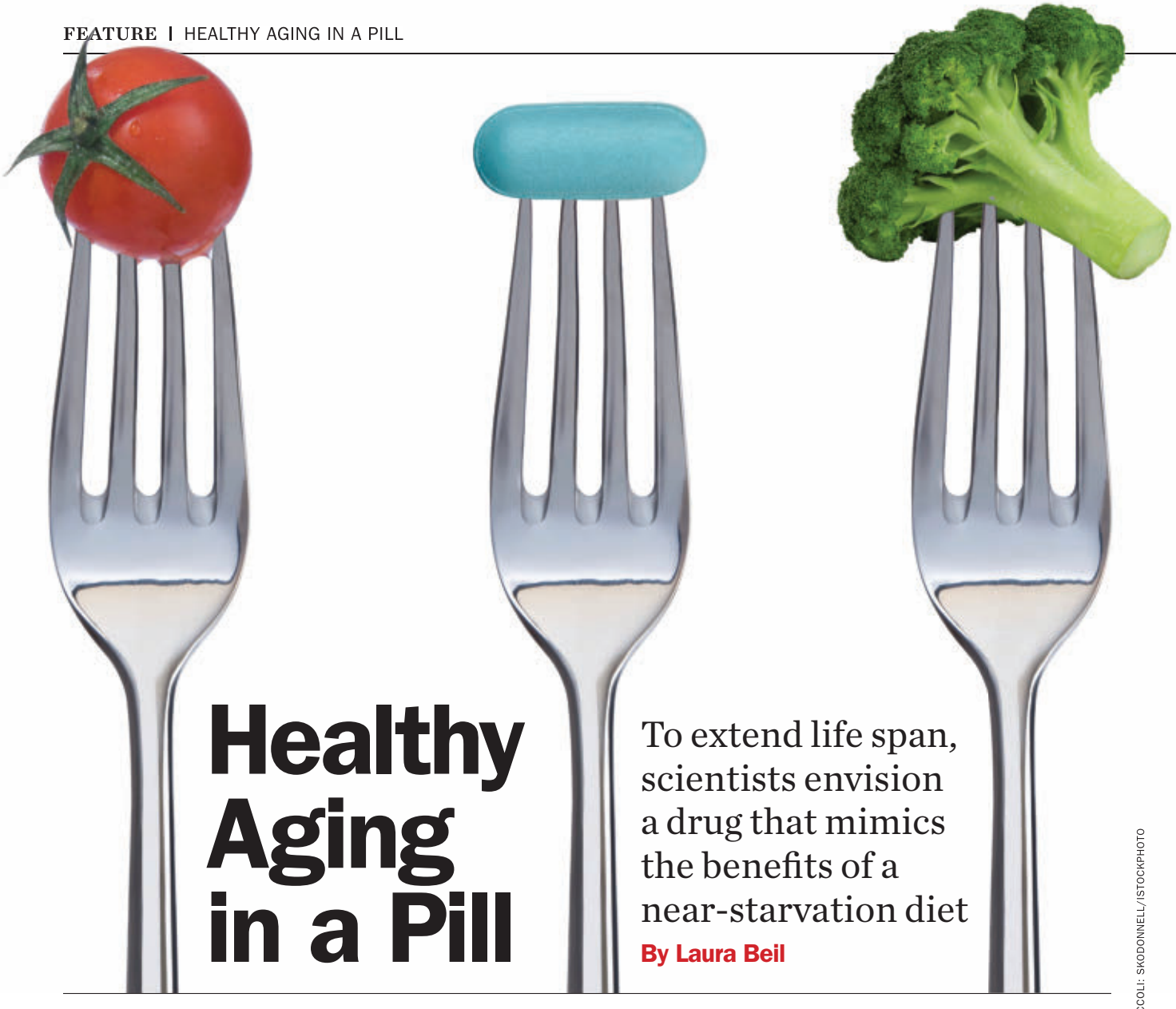
SOURCE: M. STILL

But the telescope's abilities may be surpassed by another in the works. The European Space Agency is considering a mission called Plato, for Planetary Transits and Oscillations of stars. It could go up sometime between 2015 and 2025 with a prime mission much like Kepler's — to study stars with planetary systems. The craft is to be parked in a libration point, a sort of kink in the sun's and Earth's combined gravity that will hold it hovering near Earth but far enough away to be able to stare constantly for long periods at one region.

But unlike Kepler, Plato will be able to swivel around and look at different parts of the sky, and will use bundles of telescopes to stare at larger pieces with even greater precision. Undoubtedly it, too, will find yet more stars whose wonders have nothing to do with planets. Who knows: It may even be able to check on some that Kepler found first, just to see how they're doing. ■

Explore more

- Visit Kepler's guest observer website: keplergo.arc.nasa.gov



Healthy Aging in a Pill

To extend life span, scientists envision a drug that mimics the benefits of a near-starvation diet

By Laura Beil

Animals live long and prosper when eating from a menu that puts them just this side of starvation. So far, experiments with yeast, worms, flies, spiders, fish and rodents all have shown the antiaging power of severely restricting calories. And research in rhesus monkeys suggests similar benefits in primates: One study found that monkeys eating 30 percent less than their cage mates appeared to be protected from age-related diseases and had lower mortality 15 to 20 years later. At this moment, human volunteers at three different U.S. sites have given up 25 percent of normal daily calories to test whether the less-food, longer-life phenomenon applies to people as well.

Yet even if the human experiment confirms that it's possible to diet your way to a 120-year life span, a society accustomed to supersizing probably isn't going to replace an order of fries with a stick of celery. So scientists are looking for shortcuts that people could use to achieve the antiaging windfall of calorie restriction without actually having to do it—a way to eat your cake and survive it, too.

A drug that postpones aging could also have profound health benefits, since most common diseases (such as cancer, heart disease and dementia) accompany old age. "That's what's driving us," says Donald Ingram, head of the nutritional neuroscience and aging laboratory at Pennington Biomedical Research Center in Baton Rouge, La. "We would like to see some kind of a product that would promote healthy aging."

So far, scientists have singled out a handful of synthetic and natural compounds that appear to trigger the same biochemical mechanisms that kick in when cells are partially starved of nutrients, part of a coping mechanism that protects against stress. Some, such as resveratrol (a substance found in red grapes and wine), have already reached an almost pop-star status because of their antiaging potential. Others are lower profile but similarly promising. It's still too soon to

FORKS AND TOMATO: UGURHAN/ISTOCKPHOTO; PILL: MILOSLUZ/ISTOCKPHOTO; BROCCOLI: SKODONNELL/ISTOCKPHOTO

know whether any of the compounds will work at all, much less work safely.

Interestingly, the race to put time in a bottle has not been deterred by the fact that the mechanism of growing old is still largely a mystery. So too is the way that a drastic drop in calories pushes the slow-motion button.

"I've been in the field 15 years now, and it's amazing how theories come and go very quickly. There isn't a central agreed theory about what aging is at the moment. But I think in the next decade we'll know," says David Gems, a biologist at the Institute of Healthy Aging at University College London. When it comes to caloric restriction, "the thing you have to understand is that we don't really know how it works." Much of the research is housed at universities and government research labs, but a small antiaging biotech industry (populated largely by current and former academics) has also sprung up.

When food is scarce

Many leaps into the antiaging market seek to mimic biochemical reactions that occur naturally in cells when eating slows way down. While the script remains incomplete, research has uncovered some key molecular players — such as the family of enzymes known as sirtuins, which are the target of resveratrol. When food intake plummets, emergency alarms go off inside a cell. "There are energy sensors somewhere that turn on some genes and turn off other genes," says George Roth, formerly at the National Institute on Aging and now the CEO at GeroScience, a Maryland-based biotech firm trying to develop an antiaging drug. This genetic fire drill appears to protect tissues from normal wear and tear. To scientists, each gene switched off or on offers a possible antiaging bull's-eye.

"A lot of compounds have come down the pike," says Ingram, who helped found GeroScience. Some approaches have already lost favor, such as the idea of short-circuiting aging solely through antioxidants, chemicals that neutralize damaging molecules called free radicals. Many "were built around the antioxidant hypothesis, and just have gone nowhere."

The antioxidant approach probably didn't pay off because it was too simple an answer for a complex problem. The body ages for many reasons, and more than one are tied to calorie intake. During times of plenty, the body doesn't seem to protect itself as much from the harmful by-products shed during the business of daily living. When food is scarce, protection matters most.

Overeating probably also fuels disease in indirect ways, by inciting inflammation or raising insulin levels, which in turn helps stoke energy-hungry tumors. Ingram and Roth wrote in the February-March *Experimental Gerontology* that any antiaging drug must have a global impact on chemical reactions in the body, just as calorie restriction does. "Our perspective has always been that aging operates on multiple mechanisms," Ingram says.

The GeroScience research focuses on the processing of glucose, the body's source of energy. Of special interest is mannoheptulose, a compound which occurs naturally in avocados, though Roth says it degrades quickly once the fruit ripens. Mannoheptulose partially turns off hexokinase, an enzyme that ignites a series of chemical reactions, known as the glycolytic pathway, when glucose enters a cell. Starving a cell of hexokinase is like sending a chemical memo that less energy is coming in. At a meeting in 2009, Roth reported unpublished data showing that mice fed mannoheptulose lived about 30 percent longer on average than normal mice, even though the groups consumed the same number of calories.

Products based on mannoheptulose may be years away from use in man, but maybe not in man's best friend. Roth and colleagues reported at the 2010 Experimental Biology meeting that mannoheptulose appears to be biologically active in dogs. The team won't discuss further details because GeroScience has now joined with Procter & Gamble's pet food division to explore commercial use.

FROM LEFT: BIOPHOTO ASSOCIATES/PHOTO RESEARCHERS, INC.; ET_ENGINEER/ISTOCKPHOTO; GLOBALP/ISTOCKPHOTO (MOUSE AND MONKEY)

Longer life for all Drastically reducing daily calorie intake has successfully slowed aging in many organisms. Now scientists are finding out whether drugs and genetic tweaks that mimic this dietary restriction have similar life span–extending potential.

Organism	On caloric restriction	Using drugs or genetic modifications
Yeast	Lives three times as long as normal.	Inhibiting the TOR nutrient-sensing pathway by deleting *TOR* and related genes produces a several-fold increase in life span.
Fruit fly	Lives two times as long as normal.	Reducing activity of the insulin/insulin-like growth factor signaling (IIS) pathway through genetic deletions extends life. So does using rapamycin, a drug that acts via the TOR pathway.
Mouse	Lives 30 to 50 percent as long as normal.	Mutations that reduce activity of the IIS pathway or the TOR pathway, called mTOR in mammals, increase life span. So do rapamycin and the diabetes drug metformin. Mannoheptulose, which slows metabolism of glucose, may extend life by 30 percent.
Monkey	Less age-related disease and lowered age-related mortality after 15–20 years.	No published results of experimental drugs.
Human	Long-term study of 25 percent reduction in calories is ongoing.	Not yet determined. Some researchers have hopes for rapamycin and mannoheptulose, among others. Studies of resveratrol and SIRT1 activators, which both stimulate sirtuins, and metformin are ongoing.

SOURCE: ADAPTED FROM L. FONTANA *ET AL/SCIENCE* 2010

An antiaging dog food wouldn't just allow people to keep their canine companions longer. Since dogs have shorter life spans than people, an antiaging effect would be evident sooner in dogs. "We think that a compound like mannoheptulose or a glycolytic inhibitor is going to be superior to any of the products that are out there, because of the fact that it does work somewhat similarly to true caloric restriction," Ingram says.

But mannoheptulose isn't the only natural substance that appears to mimic a state of calorie restriction. The most headline-grabbing compound of the bunch has been the sirtuin-targeting resveratrol.

Celebrity compounds under fire

In cells, sirtuins have a day job of stripping acetyl groups (small carbon-rich chemical bunches) from proteins. Most important, the enzymes are particularly busy during times of mild stress, such as when calorie intake drops. Somehow, for reasons that are still being worked out, cells awash in sirtuins are more protected from damage.

"When we are obese, the body gets lazy and turns those protections off," says David Sinclair, who studies aging at Harvard Medical School in Boston. A decade of research has suggested that sirtuins may help shield the body from a number of afflictions, including diabetes, stroke and even neurodegenerative diseases such as Alzheimer's and Parkinson's.

Sirtuins' path to stardom began in 2003 with a report in *Nature*, in which Sinclair and his colleagues announced that resveratrol could artificially stimulate sirtuins. Thus began the quest to develop an artificial, more potent incarnation of resveratrol. In 2004, Sinclair helped form the company Sirtris with this goal. (The pharmaceutical giant GlaxoSmithKline bought Sirtris in 2008 for $720 million.) Although seven different forms of sirtuins exist in humans, most antiaging research has zeroed in on one called SIRT1.

Caloric restriction exists at the twilight between health enhancement and outright starvation.

The role of sirtuins in aging is still highly debated, so much so that in August of last year *Science* featured a pointed letter volley over whether it was justified to omit sirtuins from a review of the biology of aging published a few months earlier. The problem is that resveratrol and the sirtuins haven't convincingly shown that they can lengthen life, as opposed to simply protecting against diseases that shorten life prematurely. The distinction may sound trivial, but in antiaging research, the two concepts are very different.

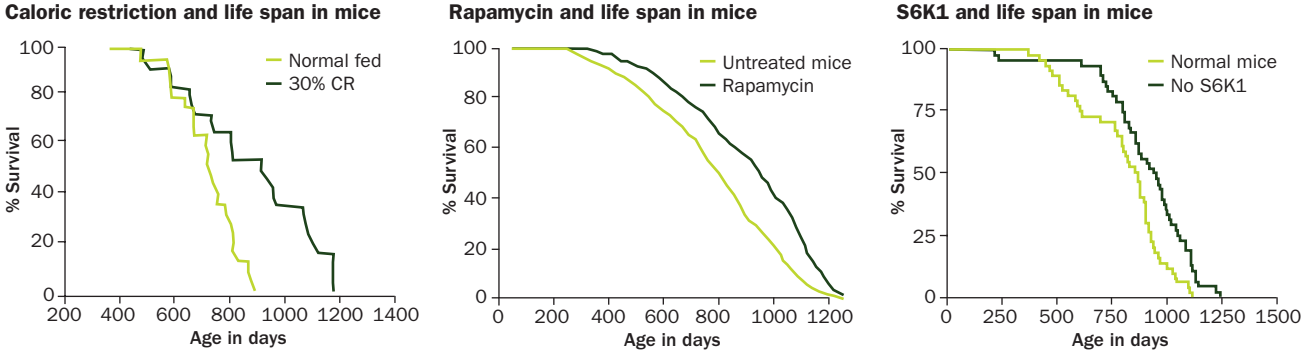
Adding to resveratrol's woes is the fact that some scientists have raised doubts about whether the results seen in studies of resveratrol and its experimental cousins are valid. For example, in 2010 in the *Journal of Biological Chemistry*, researchers from Pfizer Global Research and Development described experiments questioning whether the effect was a testing artifact or resveratrol and three other Sirtris compounds actually activated SIRT1. "Our present data are significant for the field as we provided strong evidence that neither the Sirtris series nor resveratrol are direct SIRT1 activators," the team wrote.

Sinclair points to a follow-up study published in the same journal in October 2010 from Sirtris scientists that reached the exact opposite conclusion. So at Sirtris, the research continues undaunted. Last December, the company abandoned a study of one SIRT1 activator called SRT501, but testing of other activators is continuing in human trials. SRT501 was being tested in patients with multiple myeloma, some of whom developed kidney problems.

Targeting cell growth

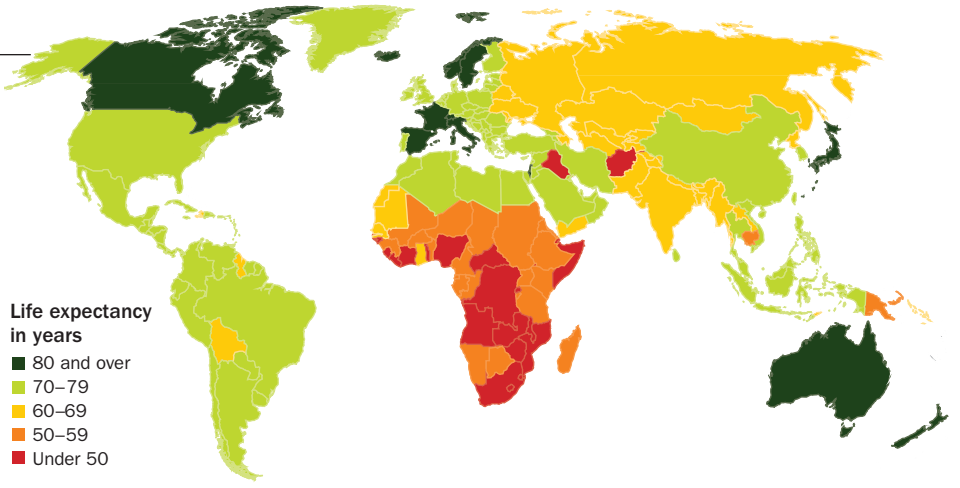
Less controversial, but toting its own baggage, is the drug rapamycin. It has the advantage of already being on the market and having an almost undisputed record of lengthening life span in animals. The drug has long been prescribed to transplant patients because it helps guard against rejection. It has also been investigated in cancer treatment because it has the capacity to starve tumors of nutrients — and indeed, transplant patients taking rapamycin appear to have a lower cancer risk.

Gaining more days In a classic caloric restriction study, mice fed a normal amount died younger than those receiving 30 percent fewer calories (left). Older male mice given the drug rapamycin starting at 600 days of age (middle) and mice genetically engineered without a functional S6K1 protein (right), a crucial player in nutrient sensing and cell growth, also tended to live longer.



SOURCES, FROM LEFT: A. BARTKE *ET AL/NATURE* 2001; D. HARRISON *ET AL/NATURE* 2009; C. SELMAN *ET AL/SCIENCE* 2009

JANEL KILEY



Averages and outliers Jeanne Calment of France was 122 when she died in 1997, making her the longest-lived person known. That a small percentage of people live beyond 110 raises the possibility of extending average human life span and motivates scientists' search for antiaging drugs. For 2009, global average life span was 68. But substantial differences exist: The map shows average life expectancies for people born between 2005 and 2010, broken down by country.

SOURCES: GUINNESS WORLD RECORDS; WHO WORLD HEALTH STATISTICS; UN WORLD POPULATION PROSPECTS: THE 2006 REVISION

Rapamycin inhibits a series of reactions in a cell that begins with a protein called (in a practical bit of nomenclature) "target of rapamycin," or TOR. The TOR chemical pathway is one of life's fundamental processes; it exists in some form from yeast to mammals, where it is designated mTOR, and helps regulate cell growth, the production of ribosomes (cellular protein factories) and protein turnover. mTOR, in turn, activates a protein called S6K1.

In 2009, a team led by British researchers reported in *Science* that mice with mutations that left them without any functional S6K1 lived longer. Just as significant, genes in the mice were switched off and on in patterns consistent with calorie restriction. A study in *Nature* in 2009 reported that rapamycin could extend life span in mice, even when the drug was given during older age. Last year, writing in *Cell Metabolism*, European researchers reported that rapamycin also extends the life span of flies, while another report in the *American Journal of Pathology* described an extension of life span in cancer-prone mice.

"As far as rapamycin goes, it works," says Luigi Fontana, a physician and calorie restriction researcher at Washington University in St. Louis. "By giving rapamycin, you are telling the cells that there is not enough energy." But rapamycin has its drawbacks. Most notably, the drug is given to transplant patients because it suppresses the immune system. This hasn't been an issue in mice because the animals are housed in pathogen-free environments. "Human beings are not living in pathogen-free facilities," Fontana says. "I would never take rapamycin."

The immune system concerns will probably keep the drug, at least in its current form, off the antiaging market. "It will not be prescribed to healthy people because it is labeled as an immunosuppressant," says Mikhail Blagosklonny, a scientist studying cell stress biology at the Roswell Park Cancer Institute in Buffalo, N.Y. "This is enough to make people scared." Blagosklonny (who has helped form a company, Tartis-Aging, to develop rapamycin as an antiaging drug) believes that in the smaller doses that would be given to healthy people, rapamycin would not dampen the immune system. Writing last year in *Cell Cycle*, he even went so far as to say that "taken together with its ability to suppress cellular aging and to increase life span, this may call to re-label rapamycin from immunosuppressant to aging-suppressant (gerosuppressant)."

If that doesn't happen, the body's biology offers plenty of other targets for drugs. Acting on the body's system of glucose detection and insulin production, the diabetes drug metformin has also been an attractive antiaging candidate. And in the future, scientists may be able to capitalize on the signals from mitochondria (a cell's energy factories) that affect life span independently of calorie restriction. In January, researchers from the Salk Institute for Biological Sciences and the Scripps Research Institute, both in La Jolla, Calif., announced in *Cell* that they had pinpointed a chemical distress signal put out by mitochondria that lengthened the life span of worms. In the experiment, the signal was produced only in the intestine and nerve cells, yet affected the entire organism.

Should any new compound reach commercial development, scientists acknowledge that the resulting antiaging drug would still face hurdles to reach the aging public. A drug that might be taken in otherwise healthy people, perhaps for years, would need to demonstrate it was safe beyond doubt.

Calorie restriction exists at the twilight between health enhancement and outright starvation, so a compound would have to be precisely calibrated. If the body gets too strong a signal that energy is low, organs may fail. Scientists have known since a study in 1950 that people who reduce calories by 50 percent can experience depression, apathy, slower movement and other detrimental effects.

It's also clear that tinkering with the aging mechanism might have unexpected side effects. Ingram and colleagues identified one promising glycolytic inhibitor more than a decade ago, while he was still at the National Institute on Aging. Called 2-deoxyglucose, it fared well in early tests but was later found in animal studies to be toxic to the heart and to increase mortality.

So for now, people are left to protect their aging bodies the old-fashioned way, by exercising enough and not eating too much. In the battle against aging, it remains to be seen whether the future will offer a bigger menu. ■

Explore more

■ L. Fontana *et al*. "Extending healthy life span—from yeast to humans." *Science*. April 16, 2010.

GEOATLAS/GRAPHI-OGRE, ADAPTED BY JANEL KILEY

Simple Heresy

Rules of thumb challenge complex financial analyses

By Bruce Bower

Harry Markowitz won a 1990 Nobel Prize in economics for efficiently passing the buck — make that bucks. He was honored for developing a mathematical formula that helps investors maximize profit and minimize loss in their portfolios. After an exhaustive analysis of financial information, Markowitz's procedure allocates a person's stash of cash to an array of assets, with more money going to better bets.

Many banks rely on this or similar investment approaches, warning customers to avoid picking investments intuitively. Yet Markowitz, now at the University of California, San Diego, followed a hunch in 1952 when he split paycheck contributions to his retirement account equally between stocks and bonds.

Economists call this simple approach "1 over N," distributing money evenly among the number of available investment options, the Ns. The 1/N strategy is also called "naïve diversification," a presumably second-rate alternative to crunching the numbers and calculating gain and loss probabilities for each potential investment. Nonetheless, many people with stock-and-bond retirement accounts opt for an even split.

As a young economist, Markowitz just wanted to avoid future regrets about fouling up his nest egg. "I thought, 'You know, if the stock market goes way up and I'm not in it, I'll feel stupid. And if it goes way down and I'm in it, I'll feel stupid,' " he recalls. "So I went 50–50."

Still, the gut-level appeal of that uncomplicated tactic hasn't stopped him from investing nonretirement funds according to a modified version of his more complex, Nobel-winning formula.

Welcome to the two-sided world of economics, where complexity and simplicity, like star-crossed lovers, can't get along and can't leave each other alone — even within the same person. In the wake of worldwide financial turmoil that blindsided most financial specialists, economists' mathematically brawny decision formulas now face a determined challenge from 1/N and other upstart rules of thumb. If David's scrawny tactics fell the academic Goliath in this brawl, economics could fundamentally change.

Markowitz and other traditional economists want to harness huge amounts of information to find optimal solutions to problems such as how to invest money. These academic prophets of profit regard people as members of a logically consistent, selfish species dubbed *Homo economicus*. From this perspective, people try their darndest to solve complex risk-benefit equations in their heads when making money decisions. Mental shortcuts are often used to avoid such high-level math, but the shortcuts usually mean less money.

Lobbing a conceptual grenade into the ring are champions of *Homo heuristicus*, a harried creature who makes quick, surprisingly effective choices with sparse information (*SN: 7/5/08, p. 22*). Such "fast and frugal" tactics are now giving

STEPHEN F. HAYES/GETTY IMAGES

traditional economists' sophisticated decision models a run for their money, research suggests.

From investors vying for a financial edge, to business managers trying to target loyal customers, to high-powered entrepreneurs looking for profitable business locations, new studies celebrate the efficiency and power of mental shortcuts. In uncertain economic situations where time is precious and information incomplete (of which there are a lot these days), heuristics can quickly narrow down a bunch of choices to a few good bets, says economist Nathan Berg of the University of Texas at Dallas.

"The economic environment constantly changes, and the whole menu of choice options that economists traditionally study isn't immediately visible," he asserts. "People can make better economic decisions by using simple rules of thumb to limit the number of choices they consider."

"People can make better economic decisions by using simple rules of thumb."

NATHAN BERG

Keep it simple

A major international insurance company found that lesson out the hard way. The head of the firm's investment department attended a recent lecture about the power of distributing money evenly among assets, given by psychologist Gerd Gigerenzer, director of the Max Planck Institute for Human Development's Center for Adaptive Behavior and Cognition in Berlin. Skeptical but intrigued, the insurance honcho returned home and reanalyzed his company's investments from 1969 to 2009.

To his surprise, a 1/N portfolio would have made more money in that time than any of the complex strategies that his department had employed. Naïve diversification requires periodic reassessments of which stocks and other assets to include in a portfolio. Yet regardless of how the insurance official realigned the portfolio, 1/N came out ahead.

He told Gigerenzer about the results, asking that his identity and his company's name be kept secret.

Many firms pay dearly for complex investment packages that calculate risks and benefits of an array of potential assets based on each one's previous performance. Others devise secret investment formulas. "These approaches do well at predicting the past," Gigerenzer says. "But they have problems predicting the future."

In an economic world in perpetual flux, elaborate investment models that explain a bevy of historical trends can identify some genuine moneymaking opportunities but mistake many accidental and random financial patterns for good bets, Gigerenzer argues. By ignoring past financial information, 1/N misses some profitable buys but rebounds nicely by spreading out investment risks without throwing money at a lot of illusory prospects.

Gigerenzer was inspired by a 2009 study led by economists Victor DeMiguel of the London Business School and Lorenzo Garlappi of the University of Texas at Austin. Using 40 years of data from the U.S. stock market, DeMiguel and Garlappi found that 1/N portfolios consisting of either 25 or 50 stocks usually generated greater returns than 14 complex models for investing in the same stocks.

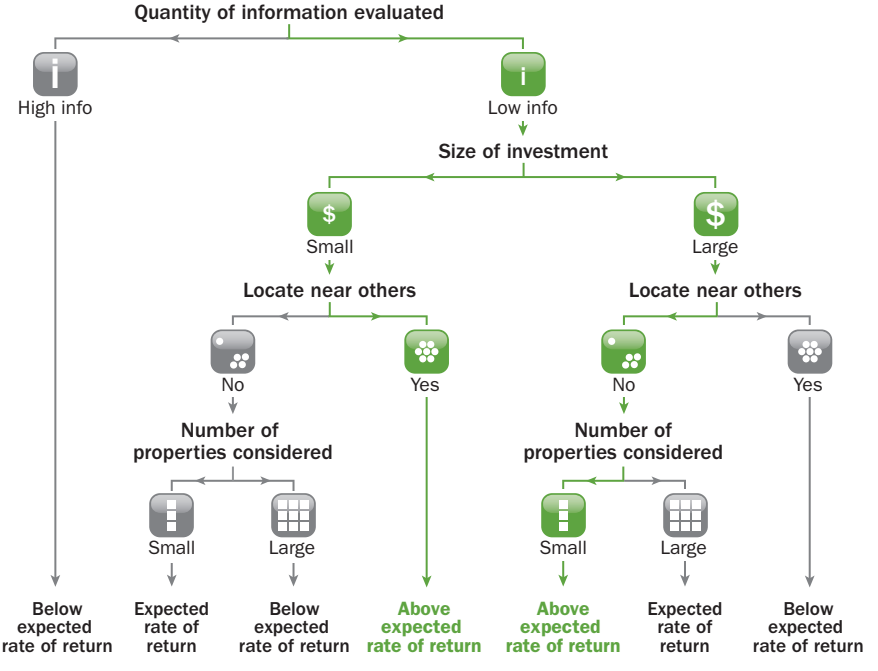
Given a portfolio of the same 50 stocks, an investor would need to wait 500 years before Markowitz's Nobel-winning formula yielded superior returns to 1/N, the researchers estimated.

Markowitz remains skeptical of the findings and plans to closely evaluate the team's calculations.

Naïve diversification works well for large portfolios but often backfires when applied to a few assets, says Richard Thaler of the University of Chicago, a leading behavioral economist and critic of Gigerenzer's approach. Financial disaster looms when people put equal amounts of their life savings into a handful of stocks, especially if those people invest in a company they work for, Thaler says. Think Enron or Bear Stearns.

Thaler, who advises a British govern-

Maximizing returns Dallas entrepreneurs choosing locations for a new business report that they rarely do the exhaustive research that traditional economic theory calls for, instead relying on rules of thumb. The event tree (below), which agrees well with interviews with 49 entrepreneurs, shows bigger returns for investors who put in a little money and imitate others' locations and for those who put in a lot of money, locate away from others and consider few properties. SOURCE: N. BERG



T. DUBÉ

ment agency that provides economic policy suggestions to Prime Minister David Cameron, says that simple rules of thumb such as 1/N lead to thinking blunders.

"In many cases, individuals make pretty bad decisions that they would not make if they paid full attention and possessed complete information, unlimited cognitive abilities and complete self-control," says Thaler, coauthor of *Nudge*, a 2008 book arguing that institutions and governments should steer people's choices in directions that would boost personal health and wealth.

Less effort, more money

Yet when given the opportunity to peruse a lot of financial information before choosing investments, affluent customers of an Italian mutual bank say "no, grazie." These savvy investors consider only a few key pieces of information when buying assets, Berg and his colleagues contend. In their view, Italians seeking a good return on the euro need a complex investment analysis like they need a plate of overcooked pasta.

"If rationality means you have to assess all possible trade-offs before making an investment decision, then that's a nuts definition of rationality," Berg says.

His team randomly recruited 15 bank customers who completed computer-administered investment tasks at mutual bank branches in and around Trento, Italy. Participants held bank deposits of at least 40,000 euros and consulted with bank-employed financial advisers.

Investors rank three or four investment features that, based on experience, can be used to pick the better of two potential assets, his team found. A pair of investment possibilities gets compared on the top-ranked feature first and, if possible, a choice is made. If not, the second-ranked feature gets considered, and so on.

In a typical case, an individual will choose the asset deemed least risky, because risk of possible losses represents that person's most valued investment characteristic. If neither choice is excessively risky, the investor will select based on characteristic No. 2, taking the asset considered likely to yield returns more quickly. If that doesn't produce a clear winner, feature No. 3, the asset with lower brokerage fees, receives consideration. If fees are comparable, the choice is random.

In another computer task, participants similarly considered risk and a few other investment features when deciding how to allocate money to six investment categories, including stocks and government bonds.

Bank clients said that brief, nontaxing deliberations informed their real-life investment verdicts as well. No one tried to calculate probable profits and losses for every potential asset when putting cold, hard euros on the line.

Customer managers in large businesses take a similarly straightforward approach to crucial money decisions, apparently for good reason. Rules of thumb guide forecasts of which customers will remain loyal and which won't. That's a big deal, since flyers, special offers and other expensive marketing efforts are targeted at customers who are "active," meaning likely to buy more products.

One popular forecasting tactic in the business trenches is called the recency-of-last-purchase, or hiatus, heuristic. Managers tag a customer who hasn't made a purchase within a certain time window, say the past nine months, as inactive.

Researchers have developed complex statistical models, fed by exhaustive data on customers' purchase patterns, to improve on managers' intuitions. Yet customer-finding formulas in the business world have proven about as popular as pay cuts.

Customer managers have every right to hold on tight to their heuristics, says marketing researcher Florian von Wangenheim of Munich Technical University. To von Wangenheim's

Decoding choice

By studying consumers' rankings of phones, researchers recently tried to determine what rules of thumb the buyers used. The scenarios outlined below portray hypothetical rankings based on two features: brand and operating system.

By brand In this example, brand is the most important feature. Blackberry beats out Nokia, which beats out Samsung, which beats out Sony. Operating system further refines choices within each brand, with Microsoft considered preferable.

	Blackberry	Nokia	Samsung	Sony
Microsoft	1	3	5	7
Palm	2	4	6	8

Take the top In this example, the consumer has a preferred brand. Blackberry is selected first, regardless of the operating system. But after that first brand is chosen, operating system becomes more important, with Microsoft preferable. Within that preference, phones are again ranked by brand, with Nokia beating Samsung beating Sony.

	Blackberry	Nokia	Samsung	Sony
Microsoft	1	3	4	5
Palm	2	6	7	8

Elimination In this case, consumers make a decision by ruling out disliked phone characteristics. The consumer does not want a Sony, but after that a Palm operating system becomes least desirable. Among the remaining Microsoft-based systems, Samsung and Nokia are the least liked, leaving the buyer with the Microsoft-based Blackberry as the first choice.

	Blackberry	Nokia	Samsung	Sony
Microsoft	1	2	3	7
Palm	4	5	6	8

SOURCE: M. YEE *ET AL*/*MARKETING SCIENCE* 2007

COBALT88/SHUTTERSTOCK

surprise, he and a colleague found that the hiatus heuristic predicted a range of customers' buying practices for three large businesses at least as well as, and sometimes better than, two complex models did.

In a 2008 paper, the two investigators called the hiatus heuristic's unexpected power "a devastating result" for purveyors of complicated forecasting methods.

"It's important to understand when speedy, simple heuristics are the right way to go," von Wangenheim says.

Gut decisions

Situations infused with uncertainty that require original thinking bring out the best in heuristics, Berg suggests. Dallas business entrepreneurs offer a prime example. In a pressure-packed milieu where millions of dollars ride on determinations of where to build a high-rise office building or a new grocery store, the entrepreneurs hitch their wagons to heuristics.

When searching for locations suitable for development or expansion, major business players could scan all affordable properties in Dallas, or even the world. Standard economic theory calls for assessing potential costs and benefits of every possible choice, meaning that low property prices or enticing amenities could compensate for erecting a new mall somewhere other than Dallas.

In interviews with 49 Dallas business owners and senior managers in charge of locating new building spots, Berg heard nothing about exhaustive property searches. Most business people considered no more than three possible sites, and often only one, in the Dallas vicinity before signing off on a project. Locations were usually discovered by chance, Berg reports in an upcoming *Journal of Business Research*.

In one case, a real-estate developer driving to a suburban golf course noticed an undeveloped tract of land that struck him as promising. He took a detour and drove around to get a feel for the area. His entrepreneurial radar went off. Over the next few days, the developer determined that a building project on the vacant land would produce at least a 20 percent annual return on initial cost within two or three years. That financial prospect sealed the deal.

Looking ahead Complex models (such as multiple regression) are good at "fitting" to past performance, but better predictions of future success often come from simpler rules of thumb. Tallying merely counts good characteristics, and take-the-best relies on the first cue that distinguishes between two options.

SOURCE: G. GIGERENZER AND H. BRIGHTON/*TOPICS IN COGNITIVE SCIENCE 1* 2009

Performance of decision-making approaches

Investment approach	Accuracy	
	Fitting	Prediction
Take-the-best	75%	**71%**
Tallying	73%	69%
Multiple regression	**77%**	68%

Nearly all business owners chose expansion sites using a version of the simple real estate formula: "If I can get at least *x* percentage of return on my initial expense within *y* years, then I'll do it."

New ventures that resulted from this limited search-and-analysis strategy tended to be profitable, participants said. A smaller number of failures provided valuable lessons for evaluating new expansion sites.

Berg's sample of entrepreneurs scoffed when asked whether they weighed costs and benefits of many potential sites to calculate the best possible choice. No one has the time or data to do that, the business people replied. In a volatile business environment, there's no way to know whether such a determination would hold up in six months or a year, they added.

Like Dallas business big shots, experts in any endeavor tune out tons of informational noise and focus on a few powerful but imperfect cues to get the job done, Gigerenzer proposes. For them, rationality consists of creative experimentation that leads to the discovery of useful shortcuts, in his view.

Dropping an econ bomb

Gigerenzer and a colleague, Nobel laureate economist Reinhard Selten of the University of Bonn in Germany, took that sacrilegious argument to a high cathedral of financial orthodoxy last year. The two were invited to speak, along with a pair of business entrepreneurs, at a prestigious annual gathering of the economics and business departments at Germany's Bielefeld University.

Gigerenzer and Selten bluntly told the assembled professors and marketing researchers to scrap their curriculum. Trash their textbooks, too. Start teaching about how people in the real world make successful, profitable decisions based on informed shortcuts, without having to consult mathematical formulas dropped out of ivory towers.

"You should have seen their faces," Gigerenzer says.

Although the audience reacted as if a couple of drunken longshoremen had crashed a faculty mixer, the entrepreneurs invited to speak at the event defended Gigerenzer and Selten's heresy. Everything the two businessmen learned as MBA students was of no use to them, they insisted. Each had amassed a fortune by trusting gut decisions that often worked but were difficult to explain.

At other lectures on investment heuristics, heads of large firms have told Gigerenzer the same thing. Often, he says, masters of the business universe sheepishly acknowledge having hired a staff member to generate complex mathematical covers for their heuristic-based choices, so that clients and investors wouldn't worry.

Equally troubling, Gigerenzer adds, is a tendency for complex forecasting formulas to encourage corporate complacency. Many businesses aim to predict financial crises with these tools rather than prepare to react flexibly to the next unforeseeable calamity, he says.

It remains to be seen whether *Homo heuristicus* triggers an unforeseeable calamity for economics-as-usual. David used a slingshot to floor Goliath, but shortcuts for taking down academic giants are hard to come by. ■

Explore more

- For Nathan Berg's website, including access to his past publications, visit www.utdallas.edu/~nberg/

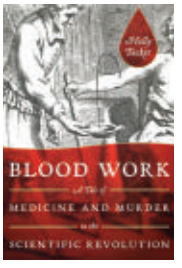
Blood Work: A Tale of Medicine and Murder in the Scientific Revolution

Holly Tucker

It's hard to believe now, but Copernicus worked out that the Earth revolves around the sun decades before scientists figured out that blood circulates through the human body. An English physician, William Harvey, announced in 1628 that the heart pumps blood through the arteries and veins, only to be denounced for decades by conservative doctors. It was against this backdrop in 1665—a time when pocket sundials were all the rage—that the first blood transfusions were carried out.

Tucker, a historian of medicine, paints a vivid portrait of the first transfusionists and their experiments. Physician Richard Lower went first, transferring blood between dogs to the amazement of scientists at London's Royal Society. In 1667, a young physician named Jean-Baptiste Denis transfused lamb's blood into a boy to cure his fever. With no understanding of blood types or species differences, the first patients probably survived only because the crude equipment transferred so little blood.

Denis' second patient died days after a transfusion, and Tucker unearths historical documentation strongly suggesting the man was poisoned by Denis' detractors to end the experiments. True or not, the French parliament banned the procedure, and human transfusions were halted until the 1800s.



The tale raises questions about science that are as relevant today as in the 17th century. Society then feared that transfusions would create man-beast monsters, and lest anyone scoff, Tucker notes that in 2006 George W. Bush called for a ban on research "creating human-animal hybrids." Today's fights over embryonic stem cell research and transgenic organisms reveal that every era must grapple with moral taboo and, ultimately, what it means to be human. —*Erika Engelhaupt*
W.W. Norton, 2011, 304 p., $25.95.

Is the Internet Changing the Way You Think?

John Brockman, ed.

The Internet has grown into a social network, political forum, marketplace and entertainment source. In a series of essays, some noted thinkers opine on the Web's effect from the neck up.

"The Internet has become an extension of my memory," writes Daniel Everett, a college dean. "It combats the occasional senior moment, helping me to find names, facts, and places nearly instantly. It gives me a second, bigger brain."

But the addition of bloggers makes the Internet more than a library, says computer scientist Jon Kleinberg. "The online world is one where human beings and computational creations commingle," he writes. The result is like a Lewis Carroll character, "the giant creature who has memorized everything ever written and will repeat excerpts back to you (mainly out of context) in response to your questions."

It's distracting. "I now do the bulk of my reading and researching online," writes author Nicholas Carr. "And my brain has changed as a result.... I have experienced a steady decay in my ability to sustain my attention."

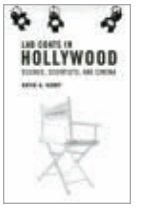
It can be creepy, too, writes Kleinberg. "There are the diaphanous forms, barely visible at the right-hand edge of your field of vision, who listen mutely as you cancel meetings and talk about staying home in bed and then mysteriously begin slipping you ads for cough medicine...."

The book would be an ambitious undertaking for any individual. By breaking up the task into more than 100 essays, Brockman gets witty treatment from a diverse crowd. —*Nathan Seppa*
Harper Perennial, 2011, 408 p., $14.99.

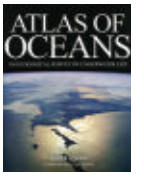
Dream Life
J. Allan Hobson
A candid memoir of the author's career studying the neurobiology of sleep and dreams. *MIT Press, 2011, 296 p., $29.95.*

The Theory That Would Not Die
Sharon Bertsch McGrayne
The history of Bayes' theorem and its controversial role in science's use of statistics. *Yale Univ. Press, 2011, 336 p., $27.50.*

The Darwin Archipelago
Steve Jones
A surprising look at Darwin's lesser-known works uncovers the foundations of entire fields of biology, from soil science to early inklings of hormones. *Yale Univ. Press, 2011, 248 p., $27.50.*



Lab Coats in Hollywood
David A. Kirby
A behind-the-scenes peek at how science consultants have helped movies such as *2001: A Space Odyssey* and *A Beautiful Mind* try to present science realistically. *MIT Press, 2011, 265 p., $27.95.*



Atlas of Oceans
John Farndon
This richly illustrated survey of marine life introduces basic principles of oceanography and highlights the hazards of environmental degradation. *Yale Univ. Press, 2011, 256 p., $50.*

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Nuclear recycling

In all I've read in the popular press about spent nuclear fuel, including "Natural catastrophe begets nuclear crisis" (*SN: 4/9/11, p. 6*), all that is written about is on-site storage or burial. Why is reprocessing of the fuel never seriously considered? I understand that the French have done it successfully for years. Are they so much smarter than everyone else?
Paul Baker, Browns Valley, Calif.

Given the political problems in disposing of nuclear waste, the U.S. Department of Energy has proposed reprocessing spent nuclear fuel, which involves separating radioactive elements for reuse in new fuel rods. France, the United Kingdom, Japan, Russia and others do reprocessing for civilian reactors. But it's expensive and raises terrorism risks. After the incident in Fukushima, it's unlikely that the United States will move forward on such reprocessing anytime soon. —Alexandra Witze

Cell phone on the brain

I read with interest the study of the effects on the brain of cell phone use ("Cell phones turn up brain activity," *SN: 3/26/11, p. 13*). Are more studies planned? What if the phone is active but not receiving messages? Does the technology matter? The work is a good start at getting real information to counter hype and scare tactics, but it's not sufficient. We also have to find out whether this brain activity is harmful or neutral.
Ted Grinthal, Berkeley Heights, N.J.

A cell phone call appears to boost activity in brain regions near the phone's antenna. No one knows if this effect is harmful, neutral or even beneficial. Nora Volkow's team plans further experiments to answer such questions. —Laura Sanders

Primate lefties

Right-side (left-hemisphere) dominance for specialized hand function shows up in primates, and the orangutans that appear to be left-handed ("Apes show handedness," *SN: 4/9/11, p. 11*) may nonetheless be right-handed. Chimps, bonobos and gorillas move about using all four limbs and tend to use the right hand for handling objects. Orangutan locomotion is primarily with the arms, so these primates may use a dominant right hand for hanging on (crucial in a tree) while handling objects with the left.
Don Burnap, Rapid City, S.D.

William Hopkins' team suggests that orangutans really do tend toward left-handedness because they often use right arms and hands to maintain balance and stability while moving upright along tree branches, so the left hand gets used for grabbing objects and carrying out fine manipulations. —Bruce Bower

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Marketplace

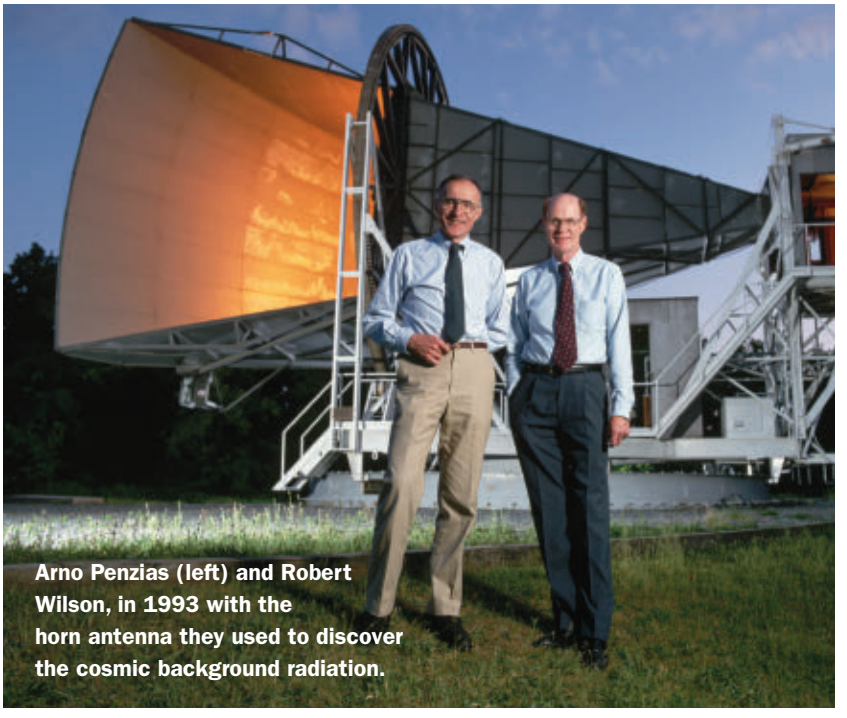
From the Archive

To read the full 1959 article, visit
www.sciencenews.org/archive_grandjury

Discuss Origin of Universe

THE WORLD'S top astronomers do not agree on the origin of the universe. Of 33 participating in a SCIENCE SERVICE Grand Jury on this subject, there was a virtually equal division on whether or not the universe started with a "big bang" several billion years ago. To this question, 11 (33.3%) voted "Yes," and 12 (36.4%) voted "No," while 10 (30.3%) were counted as "Not Voting." Concerning the more recent theory that matter is being continually created and destroyed, opinion was more sharply divided among the 33. More than half of those responding, 18, or 54.5%, said they did not agree. Eight, or 24.2%, replied they did believe matter is being continually created, and seven, or 21.2%, did not vote. Of the 33 experts, 23, or 69.7%, showed high hopes that one or the other of these opposing theories would be proved right within the next 41 years, while three, or 9.1%, thought they would never be solved.

Besides answering questions, the 33 astronomers polled were given an opportunity to make any comment they desired, with assurances of anonymity for their remarks. Not all astronomers agreed with the idea of a poll. One said, "I do not believe that polls such as this one serve any useful scientific purpose and in fact are apt to be misleading. I prefer, therefore, not to participate." Another astronomer said that much of the "fun of astronomical research" would be removed if a sure answer to the question of the origin were ever found.



Arno Penzias (left) and Robert Wilson, in 1993 with the horn antenna they used to discover the cosmic background radiation.

PENZIAS AND WILSON: ROGER RESSMEYER/CORBIS; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

Big Bang wins despite hung jury

Even the most respected scientists can't always tell what's coming. A "grand jury" conducted by *Science News* in 1959 polled 33 top astronomers to get their take on the origin of the universe. More than half of those who took a stab did not agree that the universe began with a "big bang" — a phrase previously defined in the magazine as "the creation of the universe with a finite past of only five to ten billion years."

The answer came as an accident just five years later. In 1964, Arno Penzias and Robert Wilson picked up a persistent microwave "noise" on an antenna intended to detect radio waves. Over subsequentdecades, study of that radiation helped establish today's consensus that the universe began with a bang about 13.7 billion years ago. But like turtles on the backs of turtles, bigger questions await; there is still fun to be had. Today, scientists are looking to the very same signal — the cosmic microwave background — for clues to what came before the Big Bang, a start before the start.

Perhaps potential jurors who opted out ("I do not believe that polls such as this one serve any useful scientific purpose ...") had the right idea all along. This time around *Science News* will pass on sending out the summons, instead waiting for the new evidence that inevitably comes as a surprise as science runs its course.

— Elizabeth Quill

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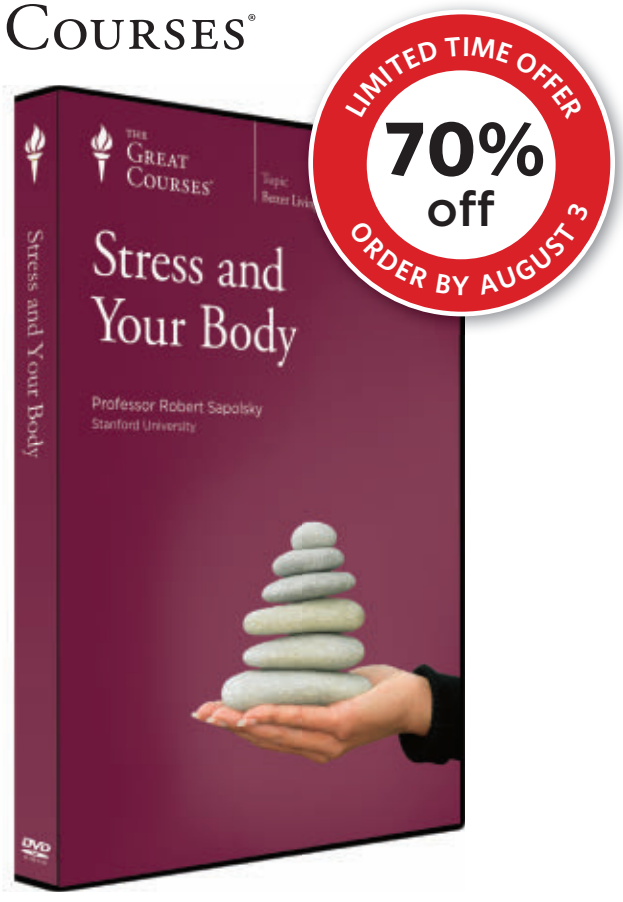

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