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Cosmic Ripples

The Perils of Protein

Exoplanet Bonanza

Extreme Heat Keeps Rising

Tragic losses

The controversy over sudden death in student athletes

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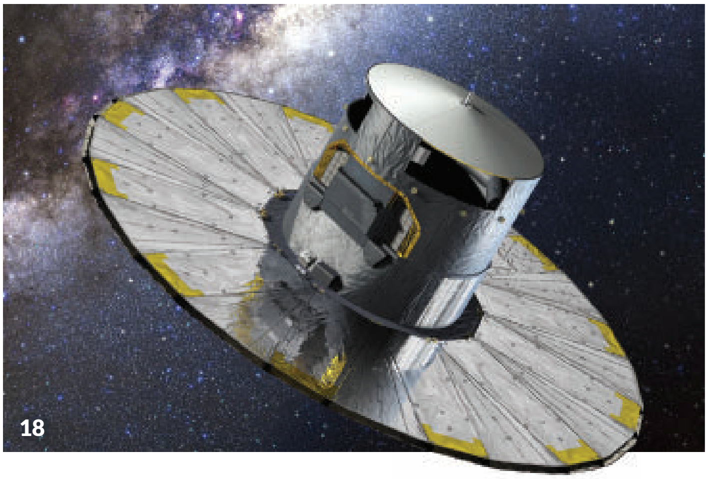
ScienceNews



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COVER Wes Leonard died of cardiac arrest after sinking the winning basket in the final game of his high school team's undefeated 2011 season. *AP*

CLOCKWISE FROM TOP LEFT: MILKY WAY: SERGE BRUNIER/ESO; GAIA: D. DUCROS/ESA; DONALD E. HURLBERT/SMITHSONIAN; IVAN PAVLOV/SHUTTERSTOCK

Gravitational wave detection a big day for the Big Bang

SANDY SCHAEFFER

On a snowy St. Patrick's Day, our offices officially shut down by a late-winter storm, the *Science News* staff was abuzz over the biggest thing since the Higgs boson. On March 17, scientists announced the first direct evidence of the theory of cosmic inflation: primordial gravitational waves. The news spread fast, even rippling out to the front page of the *New York Times*.

Cosmic expansion was one of the most important discoveries of the 20th century; before Einstein and Hubble, people assumed the universe was static. Explaining the universe's expansion led to the idea of the Big Bang and later to inflation (*SN: 7/28/12, p. 20*): a moment of explosive, exponential growth in the moments after the Big Bang that accounts for the uniformity of the visible universe, among other things. The universe grew from a speck smaller than a proton to something more akin to a softball in a tiny fraction of a second. Soon after, the theory goes, the ballooning universe slowed down to a more leisurely pace.

Working at home and listening in to a glitchy webcast of the press conference, astronomy writer Christopher Crockett reported the biggest science story in months, if not years. As he describes on Page 6, scientists have discovered the signatures of primordial gravitational waves in the cosmic microwave background, leftover radiation from the early universe. This offers the strongest evidence to date for inflation, and suggests a universe more vast than once imagined. The gravitational waves were stronger than expected, which gives some skeptics pause. But, as one of Crockett's sources told him, that will also send theorists running to the blackboard to try to explain the discrepancy. If confirmed by other teams and data from the Planck mission, this could lead to new physics.

Tom Siegfried reports on some other intriguing data from the Planck mission on Page 18. In his Context blog (online at sciencenews.org/context), Siegfried also tackles the latest news by filling in the backstory of the search for gravitational waves and calling the discovery "a landmark in the history of physics." He points out that, in most models, if you have inflation, you also get multiverses. For the starry-eyed, that's news worthy of some big buzz. *—Eva Emerson, Editor in Chief*

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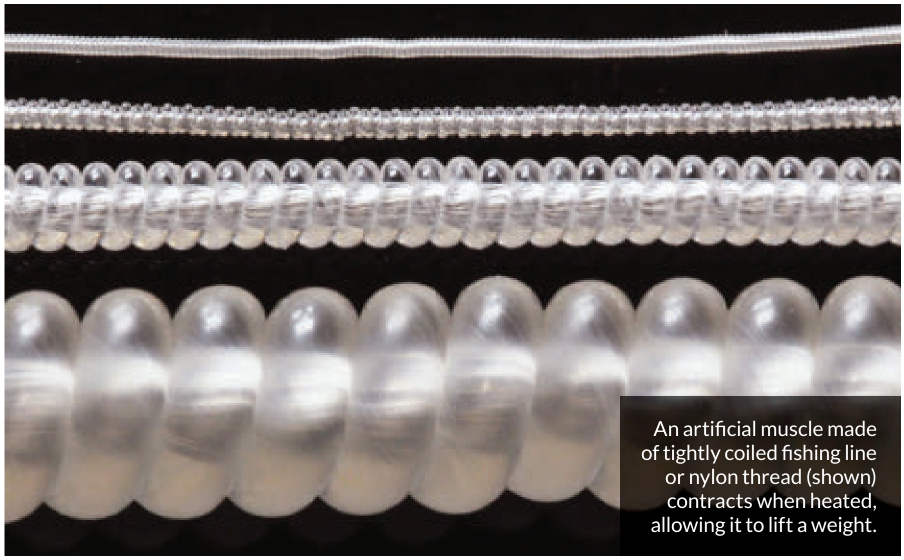
Excerpt from the April 4, 1964, issue of *Science News Letter*

50 YEARS AGO

English Channel Tunnel

When and if engineers build the long-planned tunnel connecting France with Britain under the English Channel, the new U.S. Chesapeake Bay Bridge-Tunnel, about to carry traffic, will receive some of the credit for making it possible. England sent two engineers to work on the mammoth bridge-tunnel, which has been called one of the five future wonders of the world.... The recent agreement between British and French Governments to build the Channel tunnel calls for twin 32-mile-long tubes in which electric trains will speed back and forth.... The ventilation problem of exhaust fumes in such a long tunnel would be too difficult to permit auto traffic.

UPDATE: First proposed in 1802 as a tunnel for horse-drawn carriages, the Channel Tunnel, or Chunnel, was built starting in 1987 and opened in 1994. The tunnel carries high-speed trains and automobiles, with a service tunnel and towers providing ventilation. Chunnel operations have been suspended at times by fires, cold weather and illegal immigration problems.



An artificial muscle made of tightly coiled fishing line or nylon thread (shown) contracts when heated, allowing it to lift a weight.

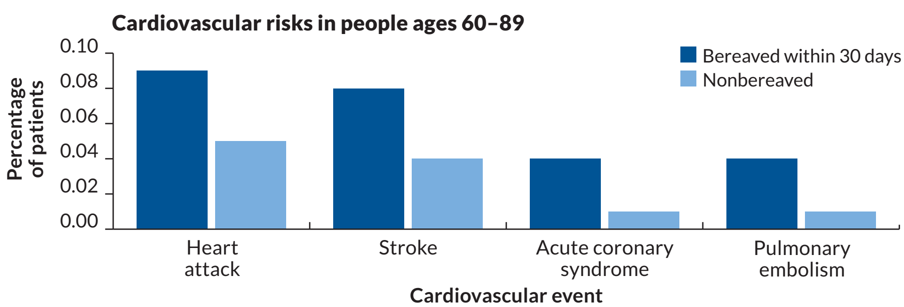
HOW BIZARRE

Making artificial muscles with a spin

Scientists have given ordinary fishing line and sewing thread a new twist. When coiled into tight corkscrews, the fibers can lift loads more than 100 times as heavy as those hefted by human muscles.

Each strand of fishing line and nylon thread contains tiny plastic polymers neatly organized into parallel chains. The chains contract when heated, making the strands plump up and shorten. This change forces already twisted fibers to rotate, which can tighten the corkscrew.

Ray Baughman of the University of Texas at Dallas and colleagues harnessed this tightening movement to lift weights. The researchers raised and lowered the weights just by heating or cooling the coiled strands. Supertwisted fibers could one day form soft, strong artificial muscles for robots, replacing clunky motors. Strands could even be knit into breathable fabrics that open and close their weaves on command, the team reports in the Feb. 21 *Science*. *— Meghan Rosen*



SCIENCE STATS

Grief takes its toll

A person's risk of heart attack or stroke is doubled in the month following the death of a spouse or partner. The increased risk fades in subsequent months. Researchers used a U.K. health registry to compare more than 30,000 people ages 60 to 89 whose partner or spouse had died with a group of 83,000 people who weren't bereaved but who matched the survivors in age and gender. Previous studies have shown that the bereaved have higher levels of inflammatory cells and clotting factors in their blood.

SOURCE: I.M. CAREY *ET AL/JAMA INTERNAL MEDICINE* 2014

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To read more about grief's health effects, visit **bit.ly/SNbereavement**

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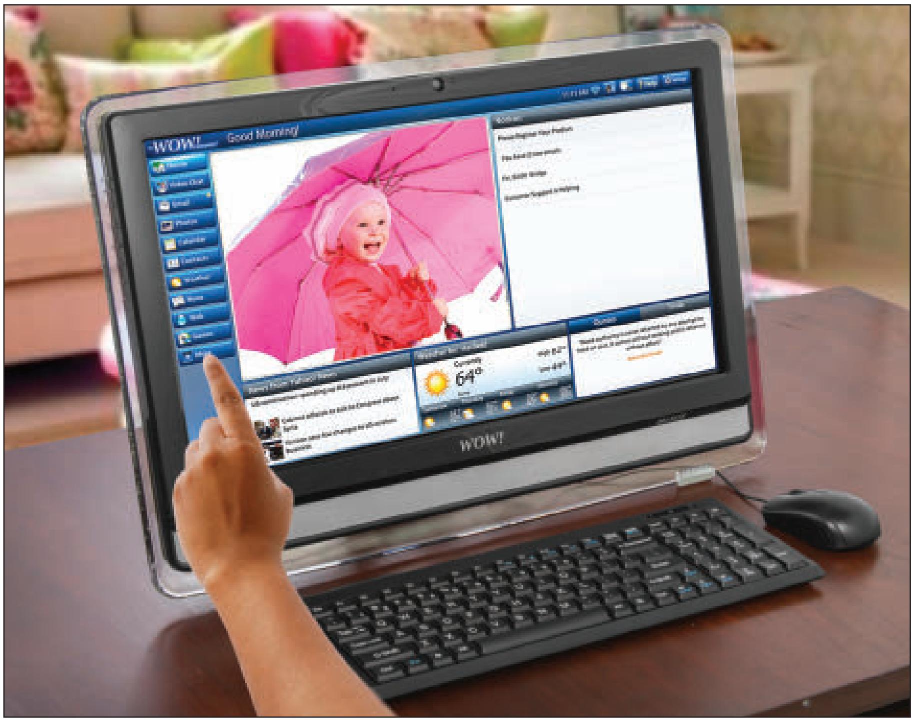

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Have you ever said to yourself "I'd love to get a computer, if only I could figure out how to use it." Well, you're not alone. Computers were supposed to make our lives simpler, but they've gotten so complicated that they are not worth the trouble. With all of the "pointing and clicking" and "dragging and dropping" you're lucky if you can figure out where you are. Plus, you are constantly worrying about viruses and freeze-ups. If this sounds familiar, we have great news for you. There is finally a computer that's designed for simplicity and ease of use. It's the WOW Computer, and it was designed with you in mind. This computer is easy-to-use, worry-free and literally puts the world at your fingertips. From the moment you open the box, you'll realize how different the WOW Computer is. The components are all connected; all you do is plug it into an outlet and your high-speed Internet connection. Then you'll see the screen – it's now 22 inches. This is a completely new touch screen system, without the cluttered look of the normal computer screen. The "buttons" on the screen are easy to see and easy to understand. All you do is touch one of them, from the Web, Email, Calendar to Games– you name it… and a new screen opens up. It's so easy to use you won't have to ask your children or grandchildren for help. Until now the very people who could benefit most from E-mail and the Internet are the ones that have had the hardest time accessing it. Now, thanks to the WOW Computer, countless older Americans are discovering the wonderful world of the Internet every day. Isn't it time you took part? Call now, and a patient, knowledgeable product expert will tell you how you can try it in your home for 30 days. If you are not totally satisfied, simply return it within 30 days for a refund of the product purchase price. Call today.

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News

ATOM & COSMOS

Primordial gravitational waves found

Researchers see traces of cosmic expansion just after Big Bang

BY CHRISTOPHER CROCKETT

Astronomers have detected the earliest echoes of the Big Bang, confirming a decades-old hypothesis that describes the universe's ultrafast expansion during its first moments. The findings provide researchers with the first direct measurement of conditions at nearly the instant that cosmic expansion began, and may have far-reaching implications for physicists' understanding of general relativity, quantum mechanics and the origin of the universe.

"We now have a much stronger belief that we understand the early universe than we did yesterday," says Sean Carroll, an astrophysicist at Caltech.

For decades, astronomers have tried to understand several quirks surrounding the Big Bang, the theory that describes how the universe began and evolved over its 13.8-billion-year lifetime. In the 1980s, MIT physicist Alan Guth suggested that many of the oddities could be explained if the universe underwent a period of hyperexpansion known as inflation (*SN: 7/28/12, p. 20*). During inflation, Guth proposed, the universe's volume grew by a factor of at least 10^{75} in the first trillionth of a trillionth of a trillionth of a second after the Big Bang.

It has long been predicted that inflation, if it occurred, would have left marks on the cosmic microwave background radiation, the flash of radiation released into space about 380,000 years after the Big Bang, when the universe had cooled down enough for light to travel freely. One signature could be found in how the photons align with one another, what physicists refer to as polarization. Gravitational ripples induced by inflation would have set up swirling patterns in the polarization. Up until now, this "B-mode polarization" has been exceedingly difficult to detect.

A detection of B-mode polarization would greatly strengthen the case for inflation: Primordial gravitational waves are the only known source.

On March 17, researchers announced they had found the elusive B-mode. Led by John Kovac, an astronomer at the Harvard-Smithsonian Center for Astrophysics, the team measured subtle variations in the polarization of the cosmic microwave background using the BICEP2 telescope. The telescope, located in Antarctica, houses 512 detectors, each cooled to nearly one-quarter of a degree Celsius above absolute zero. The detectors alternate, half filtering out horizontally aligned light and half vertical light. By regularly scanning a region of the sky above the South Pole, the researchers were able to map a chunk of the cosmic microwave background in polarized light. The team released the

BODY & BRAIN

Eating less protein may extend life

Meat-rich diets could raise the risk of dying young

BY TINA HESMAN SAEY

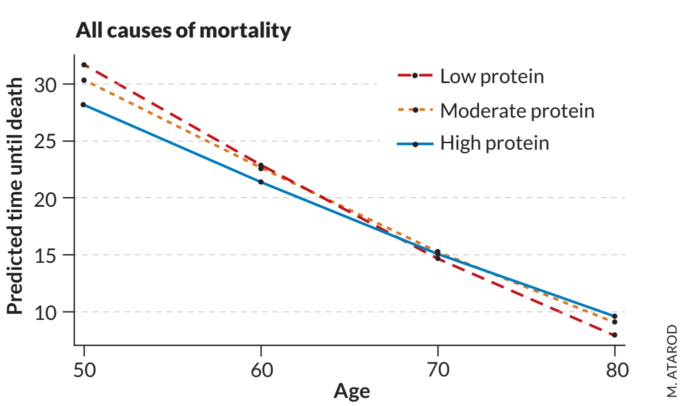
To live longer, two studies suggest, lower your protein intake. In two independent studies, people and mice eating diets low in protein were healthier and tended to live longer than those eating protein-rich diets. Both studies, which appear in the March 4 *Cell Metabolism*, suggest that animal proteins, including those from dairy, are less healthy than plant proteins.

In a study of 6,381 people age 50 and older, those 65 and younger who got less than 10 percent of their calories from protein had lower risks of dying from cancer and diabetes during 18 years of follow-up than those who ate more protein. People who ate moderate amounts of protein — making up 10 to 19 percent of the diet — had, for instance, three times the chance of dying from cancer as those on a low-protein diet. After age 65, though, the pattern reversed with high-protein diets (20 percent or more) carrying lower risks of dying of cancer.

"A high-protein diet is one of the worst things you can do up to age 65," says Valter Longo, a biogeriatrician at the University of Southern California in Los Angeles who coauthored the study. Eating lots of protein, especially protein from animal sources, can be nearly as harmful to health as smoking, he says.

Other researchers aren't ready to vilify proteins. The findings, says Edward Giovannucci, an epidemiologist at the Harvard School of Public Health, "are sort of intriguing, but I would view them

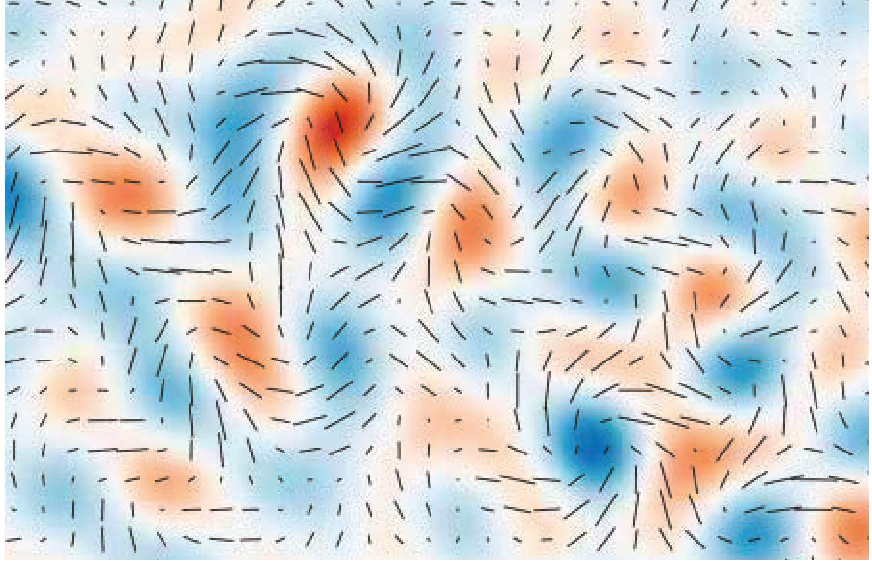
Dead meat Middle-aged people who ate low-protein diets died at lower rates than those on moderate- or high-protein diets. After age 65, the picture changed: Those with low-protein diets had the highest overall mortality rate, while those with high-protein diets were better protected against death.



SOURCE: M.E. LEVINE *ET AL*/*CELL METABOLISM* 2014 results in papers posted online.

The strength of the gravitational waves is significantly higher than researchers had expected. Data from the Planck mission — a space telescope that, from 2009 to 2013, mapped minute variations in infrared and microwave light from the cosmic microwave background (*SN: 4/20/13, p. 5*) — showed little indication that gravitational waves played any role during inflation. The surprisingly strong signal rules out several models for inflation, although it's not yet clear why Planck and BICEP2 disagree.

"This opens up a whole new window, a whole new research area," says Scott Dodelson, an astrophysicist at Fermi National Accelerator Laboratory in Batavia, Ill., who compared the finding's importance to that of the recent discovery of the Higgs boson (*SN: 7/28/12, p. 5*). The high energies seen in the inflationary epoch, he says, make it possible to test some ideas from string theory, which many assumed to be untestable. "This is a playground for everyone to start testing their theories," he says.



Gravitational waves generated during a period of cosmic inflation twirl light from the cosmic microwave background, as seen in this 25°-by-100° sky map from the BICEP2 telescope. The lines trace the alignment, or polarization, of photons released after the Big Bang; the line lengths show the light's intensity. The colors indicate how strongly twisted the polarization is, both clockwise (red) and counterclockwise (blue).

Both Carroll and Dodelson, from preliminary looks at the data, believe that the team has been careful to understand and account for possible statistical sources of error. "It's not a fluke, that's for sure," Carroll says. But he adds that researchers don't know for certain if the signal is really from the early universe or if it's an artifact from the telescope or intervening galaxies. At least eight other telescopes continue to look for B-mode polarization. Their findings should help nail down the true source of the signal.

"People are skeptical, that's what we do for a living," says Dodelson. But before he and others start to scrutinize the data more carefully, he's enjoying the moment. "The main message is one of excitement," he says. "This is a game changer." ■

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as not really definitive at this point."

He finds it particularly puzzling that low-protein diets are healthy before age 65 but become harmful in old age. More studies are needed to confirm the results, he says.

In the other study, protein proved more important than calories for determining health and longevity. Researchers fed 858 mice one of 25 diets that had varying ratios of proteins, carbohydrates, fats and calories. Mice that ate low-protein, high-carbohydrate diets fared the best. As protein content climbed, the mice's risk of dying younger also increased.

In contrast, dropping calories without lowering protein generally did not affect the rodents' life spans. That result seems to contradict previous studies that have shown that cutting calories lengthens life span in organisms such as yeast, fruit flies, dogs and mice. But coauthor David Le Couteur, a biogerontologist at the University of Sydney, says the study may shed light on how caloric restriction actually extends life. "We think that calorie restriction works not by restricting the amount of energy, but by restricting protein," he says.

Previously, researchers have mimicked the health effects of a low-calorie diet in mice with a drug called rapamycin. Rapamycin inhibits a protein called mTOR. That inhibition turns on biological processes that help slow aging, scientists have discovered.

> "A high-protein diet is one of the worst things you can do up to age 65."
> **VALTER LONGO**

In the study, mice eating low-protein, carb-rich diets also had lower mTOR activity in their livers than mice on protein-rich diets did. Particularly important for upping mTOR activity were the blood levels of certain amino acids that are more common in animal proteins than in plant proteins. Lower levels of those amino acids corresponded to lower mTOR activity, better health and longer lives for the mice.

The study's one exception was mice fed low-protein, high-fat diets. Those animals were less healthy and died young.

The results confirm work with fruit flies that showed reducing protein consumption extends life, says Subhash Katewa of the Buck Institute for Research on Aging in Novato, Calif. How changing protein levels affects a person's health will depend on many more factors, he says. "If your body can sustain protein restriction, adults should try it," he says.

There's no downside to eating less protein or to replacing meat with plant proteins, says Longo. "If we're wrong there's no negative side effect. If we're right it means a reduction in cancer and diabetes." ■

BICEP2 COLLABORATION

Read other stories about gravity waves at **bit.ly/SN_inflation**

GENES & CELLS

Giant virus pulled from permafrost

Scientists revive ancient, record-breaking microbe

BY MEGHAN ROSEN

After lying dormant in Siberian permafrost for 30,000 years, the largest virus ever discovered is just as deadly as it was when mammoths roamed the Earth.

The virus targets amoebas rather than humans. But thawing, drilling and mining of ancient permafrost could potentially unleash viruses that infect people, say the discoverers of the oversized microbe.

At 1.5 micrometers long, *Pithovirus sibericum* is 25 to 50 percent longer than the previous record holders and about 15 times as long as a particle of HIV. Though shaped like another type of giant virus, *P. sibericum* has a relatively tiny genome, scientists report March 3 in the *Proceedings of the National Academy of Sciences*.

"It's quite different from the giant viruses already known," says Eugene Koonin of the National Center for Biotechnology Information in Bethesda, Md., who was not involved with the research.

The team was led by Jean-Michel Claverie and Chantal Abergel of Aix-Marseille University in France, who helped discover the world's first giant virus about 10 years ago. Dubbed *Mimivirus*, the microbe was so large that researchers could see it with a light microscope. Before the finding, Claverie says, "we had this silly idea that all viruses were basically very small."

Years later, the discovery of a few viruses resembling *Mimivirus* led researchers to believe that all giant viruses might belong to a single family. But last summer, Claverie, Abergel and coworkers uncovered a second, completely different family that includes the even larger *Pandoravirus*, scooped from the mud of a Chilean river and a pond in Australia (*SN: 8/10/13, p. 19*).

The team has rattled the field once again with the discovery of yet another family of giant viruses.

"Now, with this *Pithovirus*, we are totally lost," Claverie says. "It adds to the confusion."

After reading about a plant revived from 32,000-year-old Siberian permafrost (*SN: 4/7/12, p. 15*), Claverie, Abergel and colleagues went hunting for viruses in Siberia's frozen soil.

The team added samples of permafrost to dishes containing amoebas and then waited to see if the one-celled organisms died. They did. When the researchers looked at the dead amoebas under a microscope, they spotted lots of oval-shaped particles of the virus.

"Either we are very good, we are very lucky or there are many of them," Claverie says.

Now scientists don't know just how big viruses can get, Koonin says. "I would be excited but not terribly surprised if something even larger comes up tomorrow."

Because *Pithovirus* has survived for so long, Claverie says it's not hard to

BODY & BRAIN

Camels are likely source of MERS

Most animals tested in Saudi Arabia had signs of infection

BY BETH MOLE

Three-quarters of dromedary camels in Saudi Arabia have been infected with the virus that causes Middle East respiratory syndrome, or MERS, according to the most thorough survey of the animals there. The finding adds to mounting evidence that camels are a source of the deadly infections in humans.

In September 2012, health experts isolated the first human case of MERS

A dromedary camel stands in the Omani desert.

coronavirus, which was discovered in Saudi Arabia and is related to the SARS virus. Since then, the World Health Organization has reported 189 cases and 82 deaths while researchers have scrambled to identify a source of the infections. So far, scientists have found signs that camels and bats harbor the virus (*SN Online: 8/8/13*; *SN: 9/21/13, p. 18*), which causes severe pneumonia in humans.

Of more than 200 Saudi Arabian camels surveyed in 2013, researchers found that 74 percent showed signs of previous infections and around 25 percent had signs of active infections. In more than 250 archived samples of camel blood dating back to 1992, researchers found high rates of MERS exposure, from 93 to 100 percent, in every year represented.

Several research teams have found evidence of MERS in Middle Eastern camels over the last year. But the new study, published February 25 in *mBio*, confirms that the virus is common in camels in Saudi Arabia, which appears to be the epicenter of the disease. The study is also the first to find signs of the virus dating back to the 1990s.

The study doesn't prove that camels passed the virus to humans, says epidemiologist W. Ian Lipkin of Columbia University. But, he adds, it shows that there doesn't need to be another animal source. Domesticated camels and camel meat are common in Saudi Arabia.

Lipkin and colleagues collected blood samples and nasal and rectal swabs from camels across the country. The team found that 95 percent of adult animals showed signs of past MERS infections, based on antibodies in their blood; only 55 percent of young camels had antibodies. But younger camels were more likely than adults to have fragments of viral genetic material in their noses, suggesting an active infection.

The team speculates that MERS is like the chicken pox of camels, with most animals getting the virus while they're young and then becoming immune. The camels

IVAN PAVLOV/SHUTTERSTOCK

The largest virus ever discovered, the 1.5-micrometer-long *Pithovirus sibericum*, seen in this false-color electron microscope image, was roused from 30,000-year-old permafrost.

imagine that viruses harmful to humans can too.

But Koonin is not too worried about dangerous viruses escaping from the permafrost and infecting humans. "This is a completely far-fetched idea," he says. There's no evidence that long-frozen soil hides greater amounts of unusual viruses than other environments, he adds.

Koonin is more interested in what the find says about giant viruses. Scientists have only just begun to tap into their diversity, he says. ■

don't seem to experience symptoms, so it's hard to spot an infection, Lipkin says.

"Every camel I've ever seen has a runny nose," he says. "It's very difficult to tell if it's unusually runny."

Finding signs of MERS from the 1990s is important, says coronavirus researcher Matthew Frieman of the University of Maryland School of Medicine in Baltimore. "It shows that this virus has been in camels for longer than we expected."

Virologist Chantal Reusken of Erasmus University Medical Center in Rotterdam, Netherlands, agrees. The disease could also have infected people much earlier than the first confirmed case. That theory could be tested using archived samples of blood and nasal swabs from humans, she says, which could clarify how the virus evolved and spread to people.

If studies confirm camels as the virus' source, Lipkin says, the next step might be to develop a vaccine for camels that could curb the virus' spread to humans. ■

FROM TOP: JULIA BARTOLI AND C. ABERGEL/IGS/CNRS-AMU; BRENDA CARSON/SHUTTERSTOCK

HUMANS & SOCIETY

Evolution of dark skin reconsidered

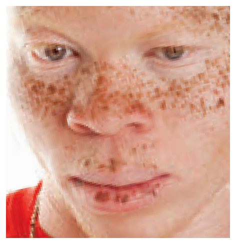
Melanin could have protected early hominids from cancer

BY BRUCE BOWER

Common forms of skin cancer were Stone Age killers that prompted the evolution of dark skin among human ancestors in Africa, a controversial new analysis concludes.

Evidence gathered over the last 40 years shows that albinos in tropical parts of Africa and Central America, where people are constantly exposed to high levels of the sun's ultraviolet radiation, frequently develop skin cancer and die young, says biologist Mel Greaves of the Institute of Cancer Research in London.

Early members of the genus *Homo* in Africa were probably pale skinned and spent a lot of time hunting and foraging in direct sunlight, Greaves asserts. Researchers generally agree that the loss of most body hair helped hominids control body temperature in tropical savannas.



African albinos often develop skin cancer at a young age, studies find.

Nonmelanoma skin cancers probably killed many light-skinned early hominids before they could reproduce, he proposes in the April 22 *Proceedings of the Royal Society B*. Genes that produce dark skin capable of filtering UV radiation would have spread relatively quickly in populations that had much greater sun exposure throughout life than modern groups do.

"Skin cancer could have plausibly been the most potent selective force responsible for the emergence of black skin in ancient hominids," Greaves says.

Other researchers have rejected the idea partly because skin cancer doesn't kill many people today.

Ancient, largely hairless hominids probably had skin more like that of living African apes than like human albinos', remarks biological anthropologist Nina Jablonski of Penn State. Apes' pale skin, when exposed to sunlight, develops enough protective melanin pigmentation to enable tanning similar to that of light-skinned people today. Apes possess a gene variant that makes tanning possible, while human albinos don't. Early *Homo* species probably carried the gene and weren't as prone to skin cancer as Greaves assumes, Jablonski says.

In her view, dark skin evolved in Africa around 1.2 million years ago to keep UV radiation from lowering the body's levels of folate, a B vitamin necessary for fertility and development.

Greaves responds that albinos, despite lacking skin-darkening melanin, can tan with careful sun exposure. So as with African albinos today, tanning wouldn't have deterred fatal skin cancers in pale-skinned hominids, he argues. Albinos represent an imperfect but useful modern analog for ancient hairless hominids living in the tropics, he says.

African albinos in the tropics develop serious or fatal cases of squamous cell and basal cell cancer by their early 30s, Greaves says. Several studies have concluded that less than 10 percent of albinos in equatorial Africa survive beyond their 30s, mainly due to skin cancer. Other investigations have found that nearly all Native American albinos living on islands off Panama develop skin cancers by young adulthood that are fatal without treatment.

Nonmelanoma skin cancer is usually treatable in pale, nonalbino adults. Greaves says that's due to less sun exposure today — partly thanks to sunscreens — than earlier hominids had.

Studies have indicated that a gene needed to produce skin-darkening melanin appeared between 1.8 million and 1.2 million years ago in Africa. Genetic changes that lightened skin appeared as humans left the tropics at least 60,000 years ago.

Analyzing ancient DNA could clarify the timing of hominid skin color changes (*SN: 2/22/14, p. 14*). But DNA preserves poorly in tropical climates. ■

MATTER & ENERGY

Trick lights way for death rays

Short laser bursts turn columns of air into energy conduits

BY ANDREW GRANT

Laser pulses lasting tiny fractions of a second have created superhighways in the air that are potentially capable of transporting megawatts of laser power. The advance should help scientists detect pollution in the atmosphere. It could also enable more exotic applications such as redirecting lightning and building practical laser weapons.

Lost in the hype surrounding President Reagan's Strategic Defense Initiative and other laser-based weapon systems was the recognition that it's difficult to deliver large amounts of energy through the atmosphere via laser. Air absorbs laser energy, heats up and expands. That low-density air acts like a defocusing lens, causing the beam to spread apart and weaken.

To traverse meters or kilometers through the atmosphere, laser beams must be short, intense pulses. But at about 50 quadrillionths of a second in duration, such short pulses can't deliver enough energy to remotely power an aircraft or burn a hole through an incoming intercontinental ballistic missile.

Howard Milchberg, a physicist at the University of Maryland in College Park, wondered if he could use rapid, low-energy pulses to clear the way for a longer-duration, higher-energy laser beam. A single pulse wouldn't do the trick, his team found, but multiple adjacent pulses fired simultaneously just might.

In an experiment, Milchberg and his team fired four quick laser pulses in a square configuration. The quartet of pulses cut through the air, heating and disturbing molecules in its wake. The result was a high-density region surrounded by a shell of lower-density air. The pulses effectively carved out a wire for light in the air: a laser-friendly core enclosed by an insulating layer.

The researchers followed up the air-preparation pulses with a laser beam released over the course of seven billionths of a second. The beam's energy barely diminished over 70 centimeters, the researchers report February 26 in *Physical Review X*.

"It's a really intriguing experiment," says Alexander Gaeta, a Cornell University physicist. He's especially intrigued by the finding that the thoroughfare in the air remained stable for a few milliseconds. That's analogous to discovering that a baseball thrown by a major league pitcher leaves an imprint in the air for nearly 500 years. "It's kind of astonishing," Gaeta says.

The gap provides plenty of time for a high-energy laser beam to travel. "In the laser world," Milchberg says, "milliseconds is infinity." He says that his team's technique could eventually allow lasers to deliver megawatts of power over kilometers through the air. For now, he plans to test his apparatus over tens of meters.

The new technique could improve efforts to detect polluting aerosols and other particles in the atmosphere, Gaeta says. Currently scientists use quick-pulse lasers that cause certain airborne molecules to fluoresce. A more complete survey may soon come from probing for longer periods of time. The setup could also protect population centers from lightning, Milchberg says. The airborne thoroughfare could coax lightning to take a desired path from cloud to ground during a thunderstorm.

Then there's the prospect of death rays – or directed-energy weapons, the more formal term for lasers designed to burn or destroy a target. Milchberg isn't shy about saying the study brings such technology closer to reality; Gaeta agrees. And while the Cold War is over, interest in laser weapons is going strong: The U.S. Navy reportedly will deploy a drone-killing laser weapon system on one of its ships.

Milchberg receives funding from the Navy and Air Force, but it is for basic research with no application in mind. ■

MATTER & ENERGY

Laser tweezers manipulate objects just 50 nanometers wide

Technique could allow scientists to move proteins and viruses

BY ANDREW GRANT

A new set of laser tweezers offers scientists unprecedented control over objects just tens of billionths of a meter in size. The device could allow biologists to probe individual viruses and proteins without risk of frying them.

"It's a very clever method," says Phil Jones, an optics physicist at University College London. "You can trap much smaller objects with much less laser power."

Since the 1980s, scientists have studied

LIFE & EVOLUTION

Competition helps flies' brainpower

Males dim mentally after generations without rivals

BY SUSAN MILIUS

The demands of outmaneuvering other guys when courting may help male fruit flies stay mentally sharp.

After more than 100 generations in the lab without competition, male fruit flies didn't do so well in a standard test of learning, reports evolutionary biologist Brian Hollis of the University of Lausanne in Switzerland.

The male *Drosophila melanogaster* still courted with normal enthusiasm and success when alone with a female. But in groups, the sheltered males lagged when competing with another strain of males.

Other tests suggested that the competition-free populations faltered not because of physical weakness but because minuscule objects under the microscope by trapping them with laser light. Lenses focus the light toward the sample, and subtle forces exerted by the light nudge the object toward the center of the beam.

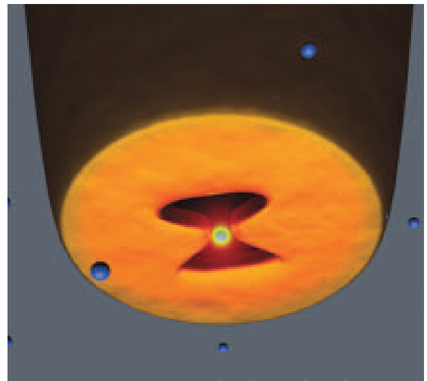
But this technique has trouble trapping objects much smaller than the laser light's wavelength of several hundred nanometers. To probe smaller biological curiosities such as proteins, scientists have to either turn up the laser power (which can overheat samples) or tether the samples to larger objects (which could cause specimens to behave differently than they would on their own).

Romain Quidant, a nano-optics physicist at the Institute of Photonic Sciences in Barcelona, is one of many researchers working on ways to overcome the size limitation. In 2009 he and his group proposed a tweezing technique based on plasmonics, the study of light interacting with components of matter that are smaller than its wavelength (*SN: 11/7/09, p. 26*). The researchers found that electrons swimming around in metals such as gold can act collectively as a nanosized lens to focus light into tiny spaces.

Now Quidant and his team have put that idea into practice with an optical fiber attached to a motor. They tapered the tip of the fiber and attached a thin gold film with a hole between 130 and 180 nanometers wide shaped like a bow tie. Then they shined a laser through the fiber and its custom-made tip into a tank of water littered with plastic beads 50 nanometers in diameter. "The beads cannot be trapped with conventional tweezers," Quidant says.

His team reports March 2 in *Nature Nanotechnology* that the superfocused laser light grabbed hold of individual beads for minutes at a time. When a bead tried to sneak away, the light pushed the bead back in place. The researchers used the motor to move the fiber, and thus a bead, in all directions: left to right, forward and backward, even up and down.

While these laser tweezers could be useful for all kinds of nanotechnology, Jones says they carry the most promise for biology. The laser requires a few milliwatts of power — about as much as a laser pointer does — minimizing the risk of samples absorbing the laser's energy and overheating. Jones envisions biologists grabbing viruses and sticking them onto a cell to watch them attack. "You could put these particles exactly where you want them," he says. ■



A 50-nanometer-wide plastic bead (yellow circle, center) is trapped by light in this illustration. Laser light gets focused by a bow tie–shaped hole etched into a thin gold film at the tip of an optical fiber.

R. QUIDANT

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they had lost some of their smarts for coping with complex mating scenes. Competition and other forms of sexual selection may be unappreciated evolutionary forces for maintaining a species' smarts, Hollis and Tadeusz Kawecki of Lausanne propose in the April 22 *Proceedings of the Royal Society B*.

The results don't mean that "monogamy makes men dumb," Hollis says. Real-world demands of reproducing, for humans as for many other animals, involve much more than being alone in a lab vial with a member of the opposite sex.

> The results don't mean that "monogamy makes men dumb."
> **BRIAN HOLLIS**

Pairing fruit flies with just one partner is how the researchers created their artificial world without male competition, starting in 2007. After 100 generations of such simple pairing, males were still courting lone females as successfully as normal flies.

Fruit flies usually mate in crowds drawn to food. Virgin females may accept male advances after merely 10 or 20 minutes of courtship moves, such as face-to-face stares and intense wing vibrations. A female who has already mated, however, is much harder for a male to persuade. "She'll kick at him, or vibrate her wings in a characteristic way," Hollis says. "There are lots of rejection behaviors. A male can spend hours."

Other research has shown that males learn signs of rejection from their early attempts at courtship. When the researchers mixed an inexperienced male from the noncompetition group with one virgin female and five mated ones likely to reject him, he did seem to learn a bit. After 20 minutes, these males were more likely to focus attention on the receptive females. But a greater proportion of males from the normal population focused their attention.

The researchers also tested learning ability with odor. They gave fly vials a shake during exposure to one odor but not when a different one wafted by. The noncompetition fruit flies didn't score as well as the regular flies in learning to flee the shake-linked smell.

Females of the noncompetition population, however, matched the odor-learning performance of regular females. Though they copulated in private, maybe the challenges of egg-laying in a group had preserved their mental edge, the researchers speculate.

The results from the male flies run counter to research on vertebrates. Among bats and nonhuman primates, scientists have found species investing more resources in brainpower when they faced less intense pressures of courting and competing.

"Primates are highly intelligent and very social; flies are not," says evolutionary anthropologist Michael A. Schillaci of the University of Toronto Scarborough. The flies, he adds, could help scientists understand mammals that don't display a lot of social complexity. ■

ATOM & COSMOS

Black holes may halt stellar factories

Galaxies stop forming stars despite access to raw materials

BY CHRISTOPHER CROCKETT

Supermassive black holes might slowly suffocate galaxies. Researchers have found a cache of galaxies loaded with cold gas that aren't making stars, running counter to astronomers' notion that galaxies stop birthing stars when they run out of cold gas. The team's observations suggest that the galaxies' central black holes stirred up the gas and shut down the stellar assembly lines.

Over the last decade, astronomers have learned that black holes can drive the fates of entire galaxies. "It's a bit like an orange affecting the Earth," says Andrew Fabian, an astronomer at the University of Cambridge. "These black holes are enormously powerful. They're emerging as an important factor in the way galaxies operate."

Stanford astrophysicist Norbert Werner and colleagues looked at eight giant elliptical galaxies, all within about 100 million light-years of Earth. Giant ellipticals are the retirement homes of the universe, devoid of vigorous star birth and filled with older stars. So Werner was surprised to find that six of the eight galaxies are filled with cold gas.

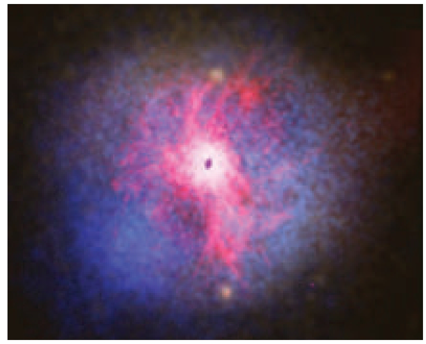
By combining infrared and X-ray images, the team thinks it has solved the mysteries of the origin of the cold gas and the reason it isn't collapsing. Filaments of hot gas — over a million degrees Celsius — thread through the pools of cold gas, Werner's team found. The hot gas appears to cool off as it dumps energy into the cold gas, and the extra energy prevents the cold gas from forming stars.

But the hot gas isn't acting alone. It's just a tool of the supermassive black holes in the galaxies' centers.

As the black holes pull in material, they propel jets of protons and electrons at nearly the speed of light thousands of light-years into intergalactic space. The jets carve out gas bubbles in the galaxies' atmospheres. Like a boiling pot of water, the bubbles churn up the galaxies' gas, Werner's team suggests, dragging around the hot gas filaments and preventing the cold gas from collapsing into new stars.

In the two remaining galaxies, the team saw little or no cold gas. The difference appears to lie with the activity of the black holes. Compared with jets in galaxies with cold gas, the jets in these galaxies are far more powerful. That suggests that the black holes have consumed all the cold gas and are spitting it back out beyond the reach of the rest of the galaxy, the researchers report February 24 in *Monthly Notices of the Royal Astronomical Society*.

The emerging picture, Werner suggests, is that the cold gas is part of an energy cycle operating in galaxies. The black holes suck in cold gas; jets erupt from the galactic centers; the jets stir and heat gas throughout each galaxy; and the hot gas cools to make more cold gas, some of which finds its way back to the black hole.



The giant elliptical galaxy NGC 5044, seen in this composite image, is filled with cold gas, yet it is not making stars. A black hole may be to blame. Threads of warm gas (red) snake through hotter gas (blue) in the galaxy.

DIGITIZED SKY SURVEY, CHANDRA/NASA, SOUTHERN OBSERVATORY FOR ASTROPHYSICAL RESEARCH, VERY LARGE ARRAY

Timothy Heckman, an astrophysicist at Johns Hopkins University, interprets the findings more cautiously. "They have a pretty small sample which is not

EARTH & ENVIRONMENT

Extreme heat still on the rise

Peak high temps on land climb despite stalled global average

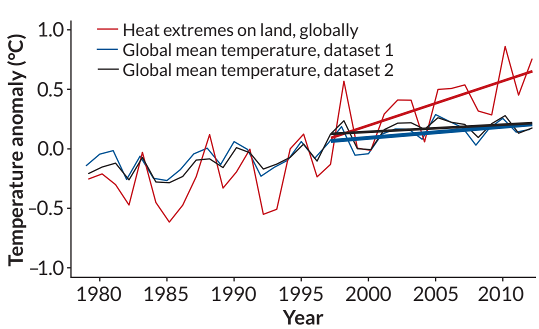
BY BETH MOLE

A surge in heat spikes has struck land over the last 15 years or so, despite an overall plateau of global surface temperature in the same period.

Researchers are still deciphering the reasons for Earth's warming hiatus (*SN: 3/22/14, p. 12*). But the boost in terrestrial high temperatures attests to continuing climate change, scientists argue in the March *Nature Climate Change*.

In an analysis led by climate scientist Sonia Seneviratne of ETH Zurich, researchers combed through global weather records from 1979 to 2010. The team assessed the area of land experiencing peak highs, defined as days above the 90th percentile of a region's typical temperature range in that period.

Despite a plateau in mean global temperature, the authors report a clear rise in the area of land experiencing more than 30 days of harsh heat a year. The pattern was even clearer when the



The heat is on Since 1997, the hottest temperatures on land have gotten hotter (red, with trend line), while multiple datasets of global weather indicate that mean temperature mostly stayed steady (blue and black). Data in blue are from the European Centre for Medium-Range Weather Forecasts and data in black are from the Met Office Hadley Centre. SOURCE: S.I. SENEVIRATNE *ET AL*/*NATURE CLIMATE CHANGE* 2014 directly shedding light on why the gas is cooling in some galaxies but not others," he says. He adds that he is not surprised that the team detected cold gas: Radio telescopes had previously shown hints of cold gas in other giant ellipticals. Nevertheless, the energy transfer between the hot and cold gas intrigues him.

Both Heckman and Werner want to investigate what's happening in the gas next to the black hole. How the gas feeds the black hole, Werner says, appears to affect the energy balance in parts of the galaxy hundreds of thousands of light-years away. New telescopes such as the Atacama Large Millimeter/submillimeter Array, or ALMA, and ASTRO-H, an orbiting telescope being developed by the Japan Aerospace Exploration Agency and scheduled to launch in 2015, can give astronomers a peek at how gas behaves in a black hole's vicinity. Such facilities, Heckman adds, will help astronomers figure out if black holes are truly galactic assassins. ■

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researchers looked at the number of regions experiencing more than 50 days of severe heat.

The results, the authors argue, "show that it would be erroneous to interpret the recent slowdown of the global annual mean temperature increase as a general slowdown of climate change."

Atmospheric scientist Dick Dee of the European Centre for Medium-Range Weather Forecasts in Reading, England, agrees. The mean temperature or any other single variable is "not enough to talk about climate change," he says. "You have to look at many different things."

The finding that terrestrial heat extremes are rising is interesting but not surprising, says climate scientist Michael Mann of Penn State. "This is certainly true in the U.S., where 2012 was the warmest year on record, and where we've suffered devastating heat waves over the past several summers."

Together with other weather and climate observations, Mann adds, the new data are the latest reminder that climate change continues unabated. ■

C.M. BIRD *ET AL*/*PNAS* 2014, ADAPTED BY S. EGTS

BODY & BRAIN

Decision-making brain region tells blue from green

Vision and language areas not crucial for color distinction

BY LAURA SANDERS

The human brain tells green from blue by relying on sophisticated decision-making areas of the brain, not those that first receive visual input. That finding, published March 3 in the *Proceedings of the National Academy of Sciences*, also hints that language isn't necessary for categorizing colors.

Colors can carry important information about an environment — a red berry that's poisonous or a blue baby who is dangerously ill, for instance. Because colors can be linked to survival, our brains go to great lengths to detect and distinguish them from one another, says neuroscientist Bevil Conway of Wellesley College in Massachusetts. "The immediacy of [color] belies the fact that there's lots and lots of computation taking place," says Conway, who was not involved in the study. And those computations, particularly how the brain sorts the rainbow of hues into distinct color bins, are still somewhat mysterious.

"There has been a lot of debate about where color categories come from," says study coauthor Anna Franklin of the University of Sussex in England. Some researchers believe that these color boundaries are hardwired into the brain. Others think that these categories are a product of the environment, or a response to social influences. To find out how the brain actually handles these color distinctions, Franklin and colleagues asked participants to passively view swaths of variously hued blue or green squares in sequence while undergoing functional MRI.

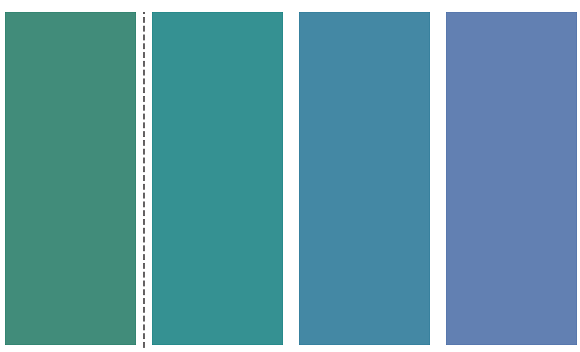
On both sides of the brain, an area toward the top and front in a region called the middle frontal gyrus seems to be involved in telling blue from green, Franklin and colleagues found. This area responded more strongly when people saw a blue square followed by a green one, for instance, compared with blue followed by a different shade of blue. Because the middle frontal gyrus has been implicated in other sorts of categorizations, such as speech and dot patterns, the region may be a more general assessor, Franklin says.

In the case of colors, the middle frontal gyrus is notable for what it's not. The brain isn't relying on the visual cortex — where information from the eye travels first before being analyzed by other brain regions — to tell colors apart. Nor is the brain relying on language centers, which some people believe to be necessary for color categorization. For those reasons, the finding is "a very important and very provocative step," Conway says.

The brain sorts colors into bins without the need for language, the finding suggests. "We're actually able to do that chunking even if we're not explicitly naming the colors at the time," Franklin says.

The results may help scientists ultimately figure out how the brain interacts with its surroundings.

"The world is one big continuum of information, yet our brain somehow has to parse that and make sense of it," Franklin says. "And to do all that, you need to categorize." ■



Most people in a study called the color on the left green and the three colors on the right blue. A brain area called the middle frontal gyrus is involved in making this distinction, the study finds.

HUMANS & SOCIETY

Rare lift for climate science funding

President's 2015 budget request leaves most research flatlined

BY BETH MOLE

Climate science is among the few research winners in President Barack Obama's fiscal year 2015 budget request, which generally kept research funding static. But even the modest increases the administration proposed for climate research are likely to face strong opposition from members of Congress who are resistant to new spending and skeptical of global warming.

The $3.9 trillion budget released on March 4 offered funding agencies like the National Science Foundation and the National Institutes of Health mostly flat budget numbers, while other agencies such as the Environmental Protection Agency would see overall cuts (see Table).

Nevertheless, a few agencies would see a modest rise for climate science, in line with the Climate Action Plan that the White House unveiled in June. "Climate change is no longer a distant threat," the administration declared, outlining a strategy that shifts policy from focusing on tallying the effects of climate change to finding ways to curb them.

The president's 2015 plan allotted $2.2 billion, a $164.8 million increase from 2014, to maintain and expand National Oceanic and Atmospheric Administration satellite systems that monitor weather and environmental conditions. Scientists plug such satellite data into global climate simulations that are used to project regional-scale changes.

The EPA, which overall would lose nearly $310 million compared with the enacted 2014 budget, would still see a $41 million boost for climate and air-quality research, for a total of $1.03 billion. The extra cash would help the EPA find ways to help vehicles meet emissions standards and to develop caps on allowable carbon dioxide pollution from power plants. Two million dollars would go to technical assistance, such as helping water utilities prepare for extreme weather events like storm surges.

For the U.S. Geological Survey, the president's budget packed an extra $18.2 million — a 37 percent increase — for a program devoted to climate science, totaling $67.6 million. "We're happy to see these proposed increases," says Matthew Larsen, associate director of the USGS Climate and Land Use Change division. "We know that we could put them to good use."

USGS' efforts to address climate change have focused on analyzing satellite data, tracking the country's stored carbon and setting up eight regional centers that translate the projections of global climate simulations into regional effects. More than half of the extra $18 million would fund these climate centers. These regional hubs move the nation beyond studying how climate is changing to researching ways to mitigate adverse effects, Larsen says.

Merging climate science into land management is a new and much-needed research area, says ecologist Andrew Hansen of Montana State University in Bozeman. Along with three other labs, Hansen won a $340,000 grant from the USGS North Central Climate Science Center in 2013 to help prepare Yellowstone National Park for climate change.

Picking apart global climate models to see how temperatures will change in the park, Hansen's team is helping managers decide where to plant new trees to dodge the mountain pine beetle. Thanks to a stretch of mild winters, a boom of the bugs has ravaged Yellowstone's forests.

"This is the way we need to move," adds climate researcher Christopher Castro of the University of Arizona in Tucson. With a nearly $173,000 grant from the USGS Southwest Climate Science Center, Castro and colleagues are using climate simulations to assess how the Colorado River basin's waterways — a source of drinking water throughout the Southwest — will change. The region has seen severe drought in the last decade, causing local agencies to rethink how they manage water. New management strategies include letting treated wastewater soak back into the ground to replenish subterranean water stores.

"I think it's great that this is a priority in the president's proposed budget," Castro says of the emphasis on climate change. "But I would suspect that there would be a lot of resistance in Congress." The EPA has already gotten a small taste of this opposition.

The president requested that the EPA receive $10 million to help set limits on carbon emissions from power plants, a key goal of the Climate Action Plan.

"Power plants are the single largest source of carbon pollution in the United States, accounting for roughly one-third of all domestic greenhouse gas emissions," Janet McCabe, acting assistant administrator for the EPA's Office of Air and Radiation, testified at a hearing of the House Committee on Science, Space, and Technology.

The March 12 hearing reviewed the science behind the EPA's September 2013 proposal to cap carbon dioxide emissions from new power plants.

At the hearing, the committee's vice chair, Rep. Dana Rohrabacher, R-Calif., declared that he does not believe climate change is real, and committee member Rep. Randy Weber, R-Texas, referred to global warming as a "religion." ■

Proposed FY15 budgets for science-related federal agencies (billions of dollars)

Agency	2015*	2014**	Change
CDC	6.60	6.84	-3.5%
DOE Office of Science	5.11	5.07	0.8%
EPA	7.89	8.20	-3.8%
FDA	4.75†	4.39†	8.2%
NASA, Science	4.97	5.15	-3.5%
NIH	30.36	30.15	0.7%
NOAA	5.50	5.32	3.4%
NSF	7.26	7.17	1.3%
USGS	1.07	1.03	3.9%

** requested **enacted †includes user fees*
Figures not adjusted for inflation

SOURCE: CDC, AIP, EPA, FDA, NASA, HHS, NOAA, NSF, DOI

Kepler discovers 715 new worlds

New method allows for quick confirmation of exoplanets

BY CHRISTOPHER CROCKETT

The galaxy just got more crowded. Astronomers using data from the Kepler space telescope have confirmed the existence of 715 planets orbiting 305 stars, increasing the total number of known planets to about 1,700. This is the largest number of planet confirmations ever announced at once.

"We've struck the mother lode," said Jack Lissauer, a planetary scientist at NASA's Ames Research Center in Moffett Field, Calif., during a February 26 press conference. "It's an exoplanet bonanza."

The new planets are mostly small — 94 percent are no bigger than Neptune — and circle their stars along with sister planets in compact, circular orbits all in the same plane. The new findings increase the number of confirmed Earth-sized planets by 400 percent.

The planetary arrangements "remind us of home," said Jason Rowe, an astronomer at the SETI Institute in Mountain View, Calif. "We're seeing scaled-down versions of our solar system."

The confirmations more than double the number of planets identified by the now-crippled Kepler since its 2009 launch (*SN: 11/30/13, p. 13*). Kepler searched for planets by looking for tiny dips in starlight that occur when a planet periodically passes in front of, or transits, its star. However, transiting planets aren't the only reason stars appear to flicker. Most commonly, the light dips are caused by a chance alignment with an "eclipsing binary" — a pair of stars that orbit each other, with one occasionally blocking the light from the other.

The team used a new method to rule out these false positives that allowed quick confirmation of the bevy of candidate planets. Mission scientists argued that several detections around a single star are not likely to be false positives. "It's very, very exciting to see this result," says Rory Barnes, an astronomer at the University of Washington in Seattle. The team's reasoning is based on solid mathematics, which they've been perfecting for several years, he adds.

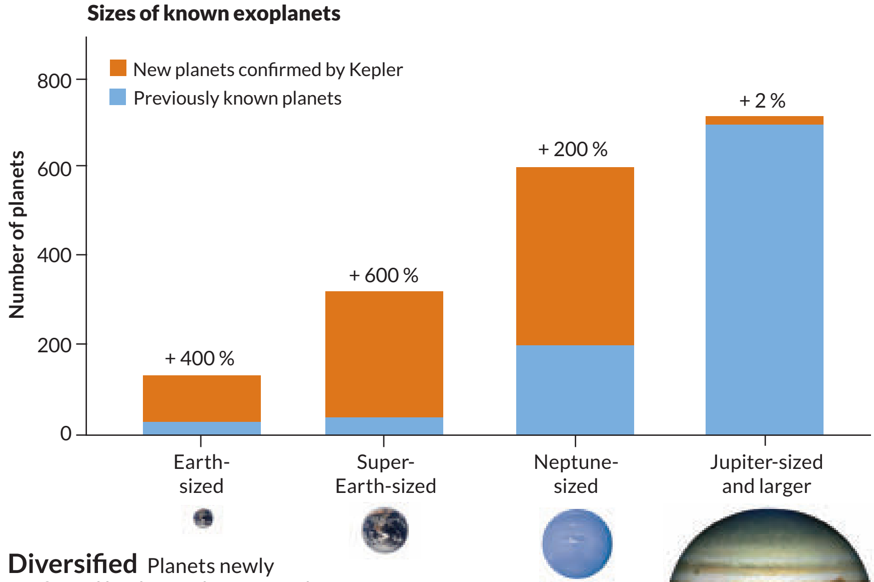
The Kepler scientists calculated that eclipsing binaries would be very unlikely to cause multiple dips in a star's light. While one eclipsing binary getting in the way is possible, two isn't likely. Three or four is nearly impossible. Because astronomers were seeing many more stars that seemed to have multiple planets than expected from random alignments with binaries, nearly all must be actual solar systems, the researchers reasoned. The scientists describe their confirmation techniques and findings in two papers in the March 20 *Astrophysical Journal*.

Before, a team would need many months with a ground-based telescope for each planet confirmation. "Do the math," says Sarah Ballard, an astronomer also at the University of Washington. With the more than 3,600 candidates that Kepler has identified, that's a staggering amount of work. Now, astronomers can confirm exoplanet systems in bulk. "It's like the Costco of planet validation," she says.

The next step for the Kepler team is to pore over the rest of its data. The 715 planets emerged from candidates identified in only the first two years of observations. But Kepler observed for an additional two years before the second of its four reaction wheels, which are needed to accurately point the telescope, failed in May 2013 (*SN: 6/15/13, p. 10*). Mission scientists are confident that this technique will turn up hundreds more exoplanets.

Meanwhile, astronomers now have an additional 300 solar systems to mull over. The compactness of these systems, along with the prevalence of small planets, is surprising. Theorists will stay busy figuring out why planets stop growing after reaching the size of Earth or Neptune and how all these worlds end up huddling close to their suns. Kepler is more sensitive to planets with compact orbits, so it's too early to say whether this type of arrangement is the norm.

Previously discovered exoplanets tended to be larger than the new finds, making it clear that the galaxy is littered with an enormous diversity of planetary systems. ■



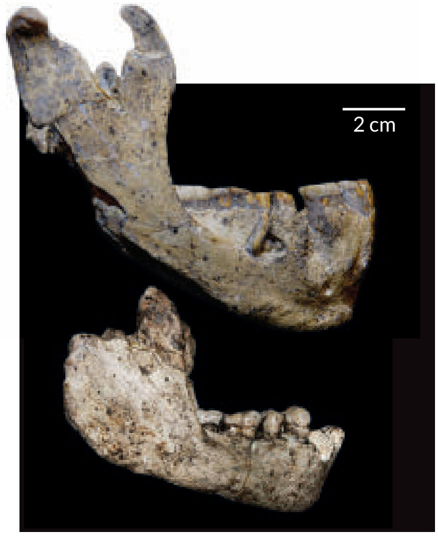
Diversified Planets newly confirmed by the Kepler space telescope (orange) substantially increase the total number of planets known outside our solar system. Most of these new worlds are smaller than Neptune, whereas most previously known planets (blue) are the size of Jupiter or larger.

GRAPH: W. STENZEL/NASA AMES, ADAPTED BY M. ATAROD; PLANETS: LUNAR AND PLANETARY INSTITUTE

HUMANS & SOCIETY

Human ancestors at West Asian site deemed two species

A controversial analysis concludes that a key West Asian site hosted not one but two *Homo* species, one living around 1.8 million years ago and another several hundred thousand years later. A team that excavated partial skeletons at Dmanisi, in the nation of Georgia, recently categorized the finds as one species, *Homo erectus*, that lived in Africa and West Asia 1.8 million years ago (*SN: 11/16/13, p. 6*). But differences in several features that emerge during childhood that are unrelated to size or sex distinguish a large lower jaw (top, right) from two smaller ones (one shown, bottom, right), signaling the presence of separate species, says a team led by José María Bermúdez de Castro of the National Research Center on Human Evolution in Burgos, Spain. The smaller, older jaws come from a population that was closely related to some species of early African *Homo*, the scientists conclude February 20 in *PLOS ONE*. The team suggests the larger, younger jaw belonged to *Homo georgicus*, a poorly known species. Excavation director David Lordkipanidze of the Georgian National Museum disagrees. He says shape similarities among Dmanisi skulls that fit the lower jaws indicate that only one *Homo* species occupied the site. *— Bruce Bower*



DMANISI TEAM/GEORGIAN NATIONAL MUSEUM

MATH & TECHNOLOGY

Shining a light on radio waves

A new device, no bigger than a salt grain, captures feeble radio waves and transforms them into laser pulses. The compact gadget works at room temperature. That makes it considerably more attractive than the expensive, cryogenically cooled amplifiers used today in radio astronomy, medical imaging and navigation. In the contraption, a laser bounces off one side of a square membrane of silicon nitride, just 500 micrometers on a side, coated in aluminum. Radio waves impinging on the opposite side cause the membrane to vibrate like a drum. The vibrations change the brightness of the reflected laser beam, which a detector captures, Eugene Polzik of the University of Copenhagen and colleagues describe in the March 6 *Nature*. Faint signals currently get boosted by costly amplifiers cooled to a couple hundred degrees Celsius below zero, then travel along leaky metal wires to computers. Membrane-coupled lasers can bypass the amplifiers and replace antiquated wiring with fiber optics, dramatically reducing signal losses. *— Christopher Crockett*

BODY & BRAIN

Acetaminophen use in pregnancy linked to child's risk of ADHD

Pregnant women who take acetaminophen are more likely to have a child with attention-deficit/hyperactivity disorder than are those who don't, finds an analysis of nearly 41,000 pairs of mothers and children in a Danish birth registry. More than half of the women, who gave birth between 1996 and 2002, used the pain reliever during pregnancy. Follow-up questionnaires when the children were 7 years old revealed that kids whose moms used any acetaminophen during pregnancy were 37 percent more apt to be diagnosed with ADHD or a related disorder than kids whose moms didn't use the drug. If the women used it in all three trimesters, the apparent risk was 61 percent higher than for kids whose moms didn't use the drug. Of nearly 41,000 children, fewer than 1,000 were diagnosed with ADHD and related disorders. The data, reported February 24 in *JAMA Pediatrics*, establish an association, not cause and effect. But the researchers note that acetaminophen, also sold as Tylenol, can cross the placental barrier. *— Nathan Seppa*

Music doesn't move some people

Music doesn't speak to everyone. Some otherwise healthy people just don't derive pleasure from music, scientists report in the March 17 *Current Biology*. Ernest Mas-Herrero of the Bellvitge Biomedical Research Institute in Barcelona and colleagues studied 10 people who say they don't enjoy music. These people's bodies backed their claims: Music, both chosen by the participants and rated by others as pleasurable, didn't have a big effect on heart rates or skin conductance, a measure of sweat. For others who said they liked music, song excerpts moved these bodily measures. The result isn't because the people without a taste for music had trouble processing it. Participants knew whether music they heard expressed happiness, sadness, scariness or peace. Understanding why some people don't enjoy music might help researchers figure out what goes wrong in disorders such as depression that leave people unable to experience pleasure, the authors write. *— Laura Sanders*

LIFE & EVOLUTION

Chimps catch people's yawns

Chimpanzees possess a flexible, human-like sensitivity to the mental states of others, even strangers from another species, researchers suggest March 11 in the *Proceedings of the Royal Society B*. Matthew Campbell and Frans de Waal, both of Emory University in Atlanta, treated chimps' tendency to yawn when viewing videos of others yawning as a sign of spontaneous empathy. Nineteen chimps living in a research facility yawned when they saw the same action from chimps that they lived with, researchers and staff they had seen before and people who were new to them. Unfamiliar chimps and baboons failed to elicit yawning. Unfamiliar chimps were probably viewed as threats, and chimps in the study hadn't seen baboons before. Having socially connected with facility workers, chimps reacted empathically to human strangers who yawned, the researchers propose. Imitating others' facial expressions represents a rapid way to forge empathic ties, Campbell says. *— Bruce Bower*

Watch a video of yawning chimpanzees at **bit.ly/SNchimpyawns**

FEATURE

COSMIC QUESTION MARK

The Planck mission's data put a kink in precision cosmology

By Tom Siegfried

For as long as humans have wondered about it, the universe has concealed its vital statistics — its age, its weight, its size, its composition. By the opening of the 21st century, though, experts began trumpeting a new era of precision cosmology. No longer do cosmologists argue about whether the universe is 10 billion or 20 billion years old — it was born 13.8 billion years ago. Pie charts now depict a precise recipe for the different relative amounts of matter and energy in the cosmos. And astronomers recently reached agreement over just how fast the universe is growing, settling a controversy born back in 1929 when Edwin Hubble discovered that expansion.

Except now the smooth path to a precisely described cosmos has hit a bit of a snag. A new measurement of the speed of the universe's expansion from the European Space Agency's Planck satellite doesn't match the best data from previous methods (*SN: 4/20/13, p. 5*). Just when all the pieces of the cosmic puzzle had appeared to fall into place, one piece suddenly doesn't fit so perfectly anymore.

"Something doesn't look quite right," says astrophysicist David Spergel of Princeton University. "We can no longer so confidently go around making statements like all our datasets seem consistent."

73.8 +/-2.4
km/s/megaparsec
Hubble constant based on supernovas and stars

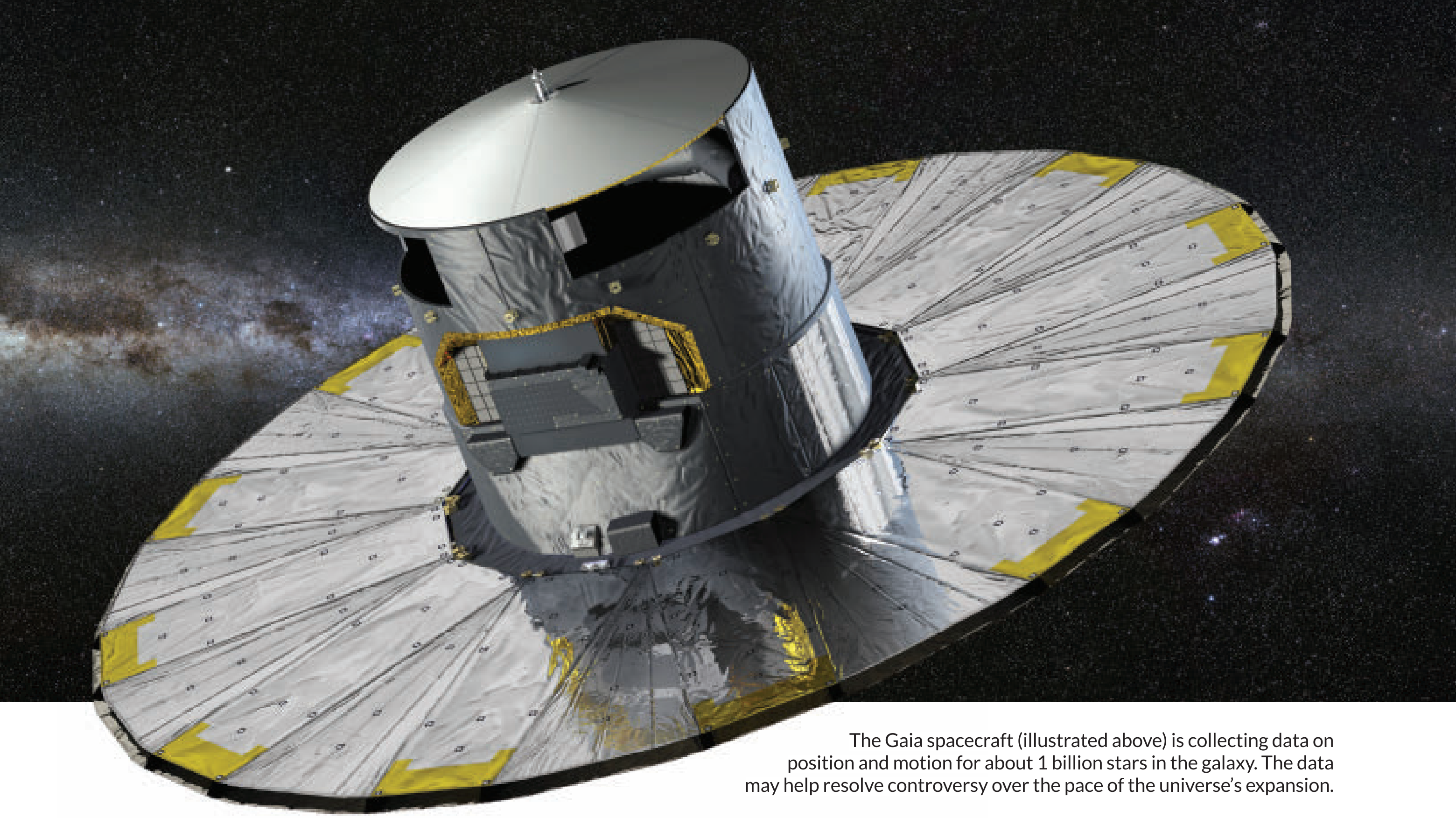
67.3 +/-1.2
km/s/megaparsec
Planck mission's Hubble constant estimate

In other words, different ways of measuring the universe's expansion rate — a number called the Hubble constant — no longer converge on one value. That calls into question the whole set of numbers describing the properties of the cosmos, known as the standard cosmological model. Accepting the new Hubble constant value means revising the recipe of ingredients that make up the universe, such as the dark matter hiding in space and the dark energy that accelerates the cosmic expansion.

Over the years, the Hubble constant's value has been as elusive as it is important. Hubble himself badly overestimated the expansion speed, which depends on distance — the farther away two objects are, the faster space's expansion pushes them apart. Hubble calculated that objects separated by a million parsecs (roughly 3 million light-years) would fly apart at 500 kilometers per second. At that rate, the universe would be, paradoxically, younger than the Earth.

Refined measurements gradually reduced the estimate to a more realistic realm. By the 1970s, experts argued over whether the Hubble constant is closer to 100 or to 50. By the late 1990s, Hubble Space Telescope observations of supernovas and other data placed the expansion rate value in the 70s, eventually settling in at around 73 km/s/megaparsec.

Confidence in that value was enhanced by



The Gaia spacecraft (illustrated above) is collecting data on position and motion for about 1 billion stars in the galaxy. The data may help resolve controversy over the pace of the universe's expansion.

MILKY WAY: SERGE BRUNIER/ESO; GAIA: D. DUCROS/ESA

measurements of the radiation glow left over from the Big Bang, primarily by a satellite probe known as WMAP. Its value for the Hubble constant was about 70, close enough to 73 that the margins of error for the two values overlapped (*SN: 3/15/08, p. 163*).

But last year, the Planck satellite reported even more precise measurements of that glow — known as the cosmic microwave background radiation — implying a Hubble constant around 67. That was about 10 percent lower than the Hubble telescope value, a difference that most physicists found too big to ignore.

"We seem to be having some disagreement," says Wendy Freedman of the Carnegie Observatories in Pasadena, Calif., and leader of the team that measured the expansion rate using the Hubble telescope.

An inconvenient discrepancy

Freedman, Spergel and other experts expect that further refinements of the measurements will eventually resolve the conflict with no major repercussions. Nevertheless, the discrepancy was a constant topic of discussion in December at the Texas Symposium on Relativistic Astrophysics, held in Dallas. Krzysztof Górski of the Planck team acknowledged the disagreement during his talk at the symposium, but he noted that much of the Planck data has not yet been analyzed. "I think we should just stay calm and carry on," he said.

It may just be that unknown problems in calibrating instruments afflict one or the other of the two methods. On the other hand, the chance remains that something might be wrong with science's basic model of the universe.

"The latter possibility would be the most exciting," says Spergel, "because it would point potentially to something about dark energy or some new physics that we could study."

Already several speculative proposals have appeared offering novel ways to reduce or eliminate the disparity. Perhaps gravity itself has mass, leading the supernova method to overestimate the Hubble constant, one group proposes. Or maybe dark energy and dark matter, supposedly independent ingredients in the cosmic recipe, interact in a way that favors a Hubble constant higher than the Planck results suggest. And possibly an uneven distribution of matter in the universe means that the Hubble constant based on supernovas and other objects in the nearby (and therefore recent) universe won't match the value derived from the cosmic microwave background, which dates to nearly the beginning of time.

Most experts are betting that more data will relieve the tension without the need for major cosmological surgery. And plenty more data are on the way. Planck's report, for instance, was based on about 15 months of observations, corresponding to two sweeps of the sky. Eventually the Planck team will analyze 50 months' worth of data, which should further reduce the margin of error when the analysis is released later this year.

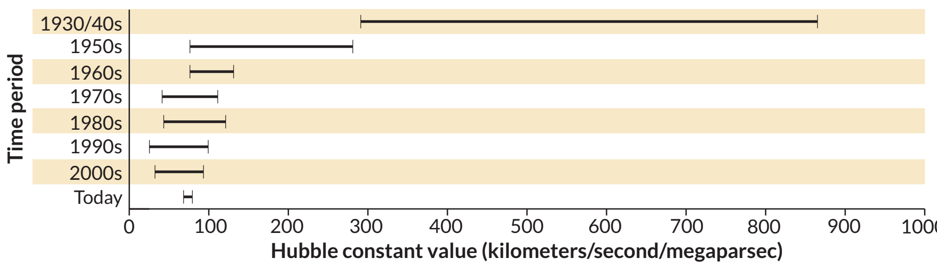
Meanwhile, Freedman and colleagues with the Carnegie Hubble project have continued to refine the Hubble constant estimate. That endeavor combines data from the Hubble telescope, the Spitzer Space Telescope and ground-based telescopes to establish the cosmic distance scale.

Since the universe's expansion rate depends on how far apart two objects are, measuring it depends on accurate knowledge of cosmic distances. Nearby, distances are calculated directly from parallax. Simple geometry can tell how far away a star is by viewing it from opposite sides of the Earth's solar orbit. Farther out, distance measurements rely on "standard

Closing the gap Historically, uncertainty over the universe's growth rate has been much bigger than it is today. But techniques developed in recent decades have allowed researchers to narrow in on the value of the expansion rate, known as the Hubble constant. That number describes how fast the expansion of space causes objects to recede from each other.

SOURCE: JOHN HUCHRA/HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

Changing estimates of cosmic expansion rate



candles" — objects of known brightness whose distance can be inferred by how bright they appear.

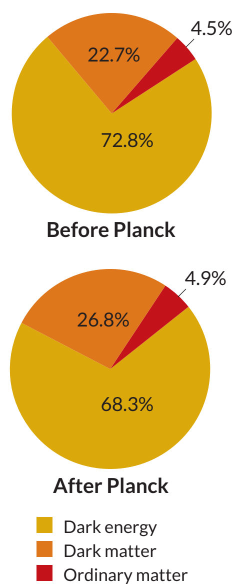
Traditionally, astronomers have exploited the standard candle potential of a particular class of stars known as Cepheid variables. Cepheids periodically brighten and dim on a regular schedule, with the timing depending on their intrinsic average brightness. Parallax establishes the brightness-distance relation for nearby Cepheids; that relation can then be used to estimate distances for those much farther away.

For measuring the Hubble constant, though, even more distant standard candles are needed, and that's a job for supernovas. Supernovas of one category, known as type 1a, are not exactly all equally bright, but their intrinsic brightness can be calculated based on how fast their light dims over time. Currently Freedman and colleagues are combining data on type 1a supernovas in galaxies that also contain Cepheids, allowing a calibration of the distance scale. Along with how fast objects are receding — inferred from the colors of light they emit — those distances determine the expansion rate. Combining supernova and Cepheid data "at present offer the best opportunity to measure the Hubble constant and minimize the systematic errors," Freedman says.

She points out that this method offers a direct measure of the expansion rate, while the cosmic microwave background readings give merely indirect estimates. Planck measured temperature differences in space, relics of variations in the matter density in the baby universe. Combined with other data and assumptions, those measurements can be used to deduce other properties of the cosmos. Planck's value for the Hubble constant is the best fit for a whole model of the universe, including a model for the nature of the dark energy.

"So maybe the disagreement is a clue that the dark energy is not quite as simple as you think," says Harvard University cosmologist Robert Kirshner. "But it's too soon to conclude that."

If the Hubble constant is truly on the high side, as supernova data indicate, then the expansion of the cosmos is now a little faster than it has been, on average. That could imply that the dark energy's strength changes over time. "It's an interesting possibility," says Kirshner. Dark energy that changes in strength has implications for the fate of the cosmos. Rather than expanding forever, the universe could someday get torn to shreds in a "Big Rip."



New recipe
Planck's data imply new estimates for the relative amounts of dark matter and dark energy in the universe.
SOURCE: ESA

If the Planck value for the expansion rate is correct, though, then the standard model of the universe's ingredients needs to be adjusted to make all the numbers fit. Those ingredients include a little ordinary matter, a lot more dark matter and considerably more dark energy. Taken together, these components produce a consistent model of the universe in which the geometry of space is just about perfectly flat (meaning that ordinary Euclidean plane geometry describes it accurately).

Before Planck, the universe's mass-energy recipe consisted of 4.5 percent ordinary matter, nearly 23 percent dark matter and almost 73 percent dark energy. Planck's estimates shift the dark energy down to about 68 percent, with dark matter nearly 27 percent and ordinary matter at close to 5 percent.

Speculative solutions

Since the Planck results came out in March 2013, physicists have searched for ways that tinkering with the standard model could explain the Hubble constant inconsistency. One proposal calls for modifying Einstein's general relativity, the theory of gravity that provides the foundation for all cosmological science. In this approach gravity itself would be massive: Gravitons, the supposedly massless particles that transmit gravitational force, would possess a small mass, adding a new field to space. That field could influence the acceleration of the universe's expansion attributed to dark energy, Douglas Spolyar of the Institute of Astrophysics in Paris proposed in a paper published December 11 in *Physical Review Letters* with Martin Sahlén and Joe Silk of the University of Oxford.

If graviton mass diminishes the effect of dark energy, they point out, then dark energy would be stronger in regions with less gravity, such as nearby voids in space. More vigorous, expansion-producing dark energy in local voids could explain why data from nearby supernovas would yield a higher value of the Hubble constant than measures of the more distant universe probed by Planck.

In another departure from standard cosmology, André Costa of the University of São Paulo and colleagues propose a conspiracy between dark matter and dark energy, the two most mysterious ingredients in the cosmic recipe. In the standard view, the dark sides of the universe are independent components. One adds to gravitational attraction (playing an important role in forming galaxies); the other exerts gravitational repulsion, causing the cosmic expansion rate to accelerate. But if they renounce independence and interact in some way — like two medications that cure separately but kill in combination — Hubble constant measurements could be contaminated.

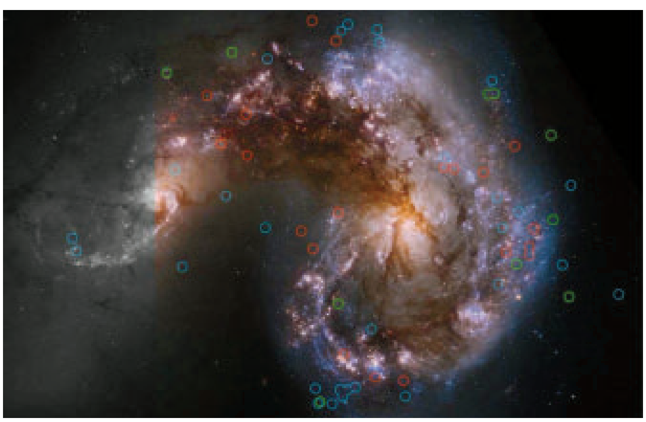
If, for instance, energy can flow from dark matter to dark energy, then the Planck data would underestimate the true Hubble constant, which would be closer to the value measured by supernova studies, Costa and colleagues pointed out in a paper posted last November at arXiv.org.

It's possible, other researchers suggest, that resolution will come without such drastic challenges to current orthodoxy. It may just be that the two measurements differ because they probe different parts of the universe. And not only do the two methods measure the expansion at different eras of time, they also probe physics on different scales. Supernovas are big by human standards, but on the cosmic scale they're like points in space. Measurements of the cosmic microwave background probe vastly bigger patches of sky, as a team of French cosmologists pointed out in a paper last year in *Physical Review Letters*.

Waiting for more data

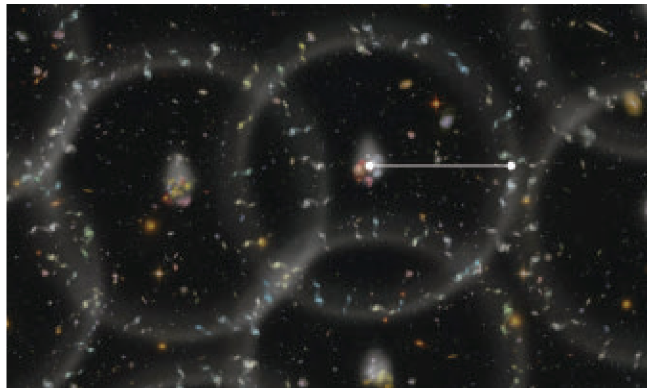
Ultimately all the speculations will be filtered by more data — from Planck, supernova studies and other methods. In December, for instance, the European Space Agency's Gaia probe was launched; it will produce more precise Cepheid parallaxes to feed into measurements of the Hubble constant using the supernova method. Already the BOSS project, part of the Sloan Digital Sky Survey, has contributed new fodder for the Hubble debate using clues called baryon acoustic oscillations.

Interaction of matter and light in the very young universe produced concentric pressure waves, or acoustic oscillations, much like the ripple in a pond produced when a rock falls in



Astronomers measure distance to faraway galaxies — a key to the Hubble constant — by recording the brightness of supernovas and Cepheid variable stars. In this Hubble telescope image of galaxies NGC 4038/4039, Cepheids are circled in red, blue or green depending on their period.

FROM TOP: ZOSIA ROSTOMIAN/LBNL, SDSS-III, BOSS; A.G. RIESS ET AL/ARXIV.ORG 2011



Pressure waves in the early universe deposited matter at a preferred separation distance of 150 megaparsecs (white line in illustration). That figure can help establish the cosmic distance scale.

the water. The ridges of these sound-wave ripples would have deposited matter — small seeds that would grow into galaxies — at specific separation distances. Thus the signature of those ripples ought to be reflected in the distribution of galaxies in space today. BOSS observations show that the preferred distance between two galaxies is about 150 megaparsecs (roughly 450 million light-years). Combined with a redshift measurement, which reveals how fast a galaxy is moving away from Earth, BOSS data provide a new check on the cosmic distance scale. Adding in data from cosmic microwave background probes allows another computation of the Hubble constant.

In January, at the American Astronomical Society meeting near Washington, D.C., BOSS scientists presented their latest results, which yield a Hubble constant of 68 to 69. That result remains lower than the value from supernova measurements, said BOSS team member Daniel Eisenstein of the Harvard-Smithsonian Center for Astrophysics.

"It's not in sharp disagreement, but it is interesting, so there are a lot of groups trying to track this problem and trying to understand what the resolution might be," he said. "Today we still have this mild tension. We'll see where we're at in six to 12 months."

In any case, as Freedman points out, the current Hubble constant debate is about a drastically narrower range than in the days when competing camps championed values as high as 100 or lower than 50.

"Fortunately the range of values for the Hubble constant that are now being measured, and the uncertainties in those measurements, have come down quite considerably," she said at the Texas symposium. "And there's also a huge amount of progress planned for the future that will set this controversy to rest. There remains the exciting opportunity that there is new physics. Or not." ■

Explore more

- Planck 2013 Results Papers: bit.ly/SNPlanckpapers

Tom Siegfried is the former editor in chief of Science News.

SUDDEN DEATH

Proposed EKG screening for student athletes spurs medical debate

By Laura Beil

With the score tied and 30 seconds left in overtime, Wes Leonard, a 16-year-old point guard for the Fennville Blackhawks, sank the winning layup that carried his team to a 57-55 victory on March 3, 2011. It was a Hollywood triumph for the final game of an undefeated season. Leonard's teammates from his Michigan high school hoisted their star player skyward. Seconds later, to the horror of the packed stadium, the boy collapsed. Doctors at a nearby hospital soon pronounced Leonard dead of cardiac arrest.

By one often-used estimate, about 1 out of every 200,000 U.S. high school athletes dies suddenly each year, quite often in full view of shocked teammates and fans, sometimes on live television. Almost every one would have seen a doctor who used a medical history and physical to look for silent heart problems.

Under the specter of tragedies like Wes Leonard's, however, some advocates want more rigorous tests. Their solution: Add an electrocardiogram (referred to as an EKG), which measures the electrical signature of the heart.

"Your gut instinct is to do everything you can to save a kid's life," says N.A. Mark Estes, director of the New England Cardiac Arrhythmia Center at Tufts Medical Center in Boston. It seems to make sense: Identify players at risk of dying and bench them for their own safety. Already in Israel and Italy, competitive athletes ages 12 to 35 must have an EKG before they can step onto a court or playing field.

The problem is, for every life saved, the test

Fennville High School basketball team members stand for a moment of silence days after teammate Wes Leonard died of cardiac arrest.

BILL PUGLIANO/STRINGER/GETTY IMAGES

could mistakenly flag many more who aren't in danger. Estes tells the story of a talented young athlete who came to his office after being recruited to one of New England's legendary pro teams (to protect the patient's privacy, Estes won't publicly reveal which one). The young man's electrocardiogram appeared to indicate massive cardiomyopathy, a dangerous enlargement of heart muscle that can trigger sudden death. Three previous doctors —"three very good doctors," Estes is quick to say — had made the same diagnosis. Without ever seeing a minute of game time, a gifted prospect was in danger of being cut. Estes ordered more tests.

"His MRI was stone-cold normal," Estes says. The young man's heart was nearly perfect. His risk of dropping dead was very slim, but by the time this became clear, the team had already let him go.

30 percent
Rate at which cardiologists misread EKGs in one study

Heart of an athlete

The main problem is that, on the etchings of an EKG, the heart of a conditioned athlete might look too much like a heart with hypertrophic cardiomyopathy, the most common cause of sudden death in young athletes. With this inherited condition, the muscle cells that make up the heart are not stacked into tidy rows as they should be, and the heart walls grow thick and rigid. As a result, the waves of electricity that sweep across the heart to orchestrate rhythmic contractions can become disorderly. Under physical exertion, the heart can be seized by cardiac arrest and stop pumping blood — which is fatal within minutes unless the heart is restarted with a defibrillator.

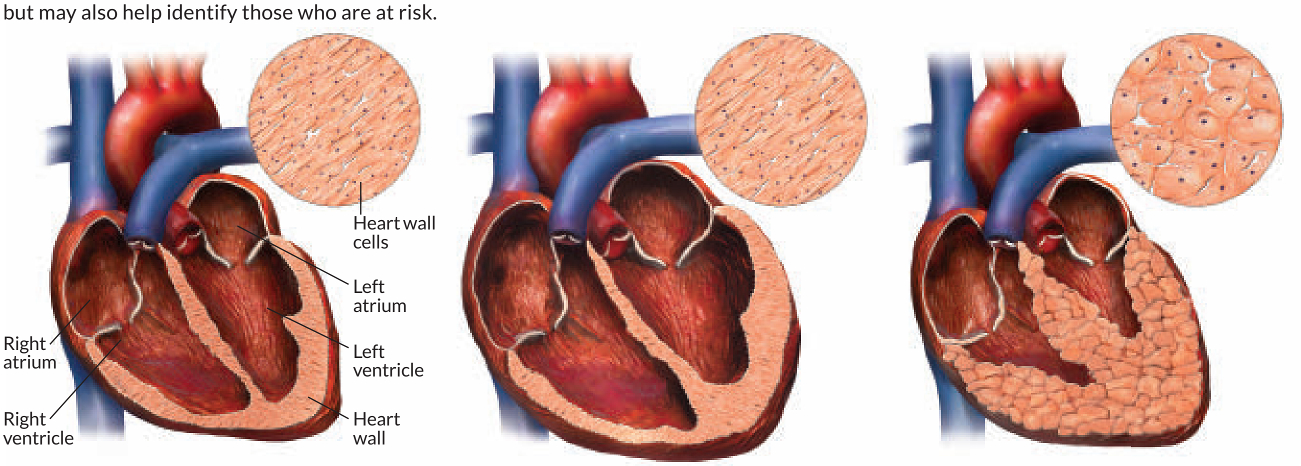
An EKG can pick up signs of hypertrophic cardiomyopathy by detecting an abnormally high voltage when the heart's ventricles contract. Yet often even to skilled eyes, the interpretation is not straightforward. The same telltale elevated voltage can occur in the muscled heart of an athlete as a result of conditioning, not disease, Estes says.

To add to the complexity, reading an EKG is not like measuring blood pressure, with distinct demarcations that anyone with medical training can understand. In a study published in the *Journal of Pediatrics* in 2011, 53 pediatric cardiologists read 18 EKGs from both healthy and ill hearts. They misread the results about 30 percent of the time. In addition, they ordered 380 follow-up tests that were deemed unnecessary and failed to order 340 further tests that were considered necessary for correct diagnosis. In 26 percent of the cases where the doctors would have recommended restriction from sports, the hearts actually were fine.

Opponents of universal EKG screening say that the risk of disqualifying healthy athletes — and of falsely clearing those truly in danger — far outweighs the test's benefits. A misdiagnosis can be more than an inconvenience. It can saddle a young life with a diagnosis that may be hard to take back. One ambiguous or misread EKG could write the next Michael Jordan or Wayne Gretzky out of sports history.

Estes recalls another patient who walked into his office on the brink of surgery to receive an

Silent risk Years of training can reconstruct the heart of an athlete (middle) in response to a greater demand for fuel. An electrocardiogram can sometimes misdiagnose a healthy athlete as someone with a heart problem (right), but may also help identify those who are at risk.



Normal Cells in the heart wall are stacked like bricks, allowing an electrical signal to smoothly sweep across the muscle and regulate beats.

Athlete normal Heart chambers may enlarge and the heart wall thicken, but cells retain normal structure. EKGs may flag as abnormal.

Hypertrophic cardiomyopathy The heart wall is enlarged and its cells chaotically arranged, putting a person at risk for sudden death.

NICOLLE RAGER FULLER

Incidence of sudden cardiac death among NCAA athletes, by sport, 2004–2008

Sport	Number of deaths	Overall incidence	Incidence in males	Incidence in females	Incidence in African-Americans	Incidence in Caucasians
Basketball	14	1:11,394	1:6,993	1:37,799	1:5,743	1:21,824
Swimming	4	1:21,293	1:34,552	1:16,457	No deaths	1:20,981
Lacrosse	3	1:23,357	1:19,770	1:30,531	No deaths	1:23,357
Football	8	1:38,497	1:38,497	No deaths	1:59,814	1:14,401
Cross-country	3	1:41,695	1:59,484	1:32,801	1:12,043	1:51,033

Risk by sport The incidence of sudden death in athletes is often said to be 1 in 200,000 per year. But scientists at the University of Washington recently took a detailed look and found a more frequent risk that varied greatly by sport, with basketball having the highest risk, for reasons unknown. SOURCE: K.G. HARMON *ET AL*/*CIRCULATION* 2011

implantable defibrillator. Estes determined that the teenager was, in fact, healthy. "There will be many people with the sword of Damocles over their head who believe they have the condition, when they don't," Estes says. "They could live their whole life with this diagnosis."

He and others want to keep using the standard history and physical for student athletes.

"The problem is that the history and physical doesn't work," says Jonathan Drezner, a sports medicine specialist at the University of Washington in Seattle. He says 80 percent of young athletes who die do not have symptoms that a doctor can detect through routine methods. That means when he starts an exam, "I'm going to walk into the evaluation knowing I'm going to miss four out of five." And despite the uproar over false-positive rates of EKGs, he believes false-positive rates for history and physical can be even higher, with diagnoses that are made but often left unconfirmed.

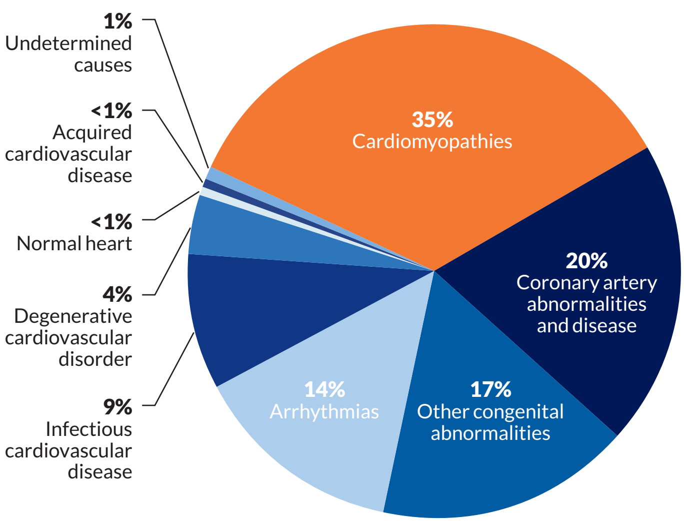
The latest opinion of the issue is expected to come out this spring, when the American Heart Association releases an updated scientific statement on the screening of young athletes for heart disease. Up to now, the country's premier voice on medical matters of the heart has not supported routine EKG screening for asymptomatic athletes. Whatever the new statement says, few in the field believe the matter will be settled.

Counting headlines

Though heartbreaking when they happen, deaths from cardiac arrest are extremely uncommon among young athletes. In the United States, about 8 million high school and college students play sports, yet only about 100 die from cardiac arrest each year. That's good news for athletes, but a burden for scientific study. Cases arise so infrequently that large randomized trials (considered the gold standard in medical research) are lacking. To capture the few athletes who might die or show symptoms of heart problems, studies would need to be so large as to make them logistically and financially challenging. That means scientists must cobble together research that relies on indirect measures to weigh the value of EKGs.

Central to the controversy is the true number of athletes at risk. "If you really think the incidence is 1 in 200,000 [per year], it's hard to justify EKG screening," Drezner says. "At one point, that was the best data we had." That figure appears in a 1998 analysis of Minnesota high school athletes published in the *Journal of the American College of Cardiology*.

He contends the number is much higher. Estimates tend to rely on counting media reports, he says, since most, like the case of Wes Leonard, generate news stories. They don't all, however, and he says even death certifications can be unreliable. In 2011 in *Circulation*, Drezner and his colleagues published a study that scoured not only the media, but insurance databases and records at



Heart problems Sudden cardiac death in athletes is most frequently caused by the heart condition known as cardiomyopathy. But it is not the only cause. Most of these causes can be detected with an electrocardiogram. SOURCE: M. PAPADAKIS *ET AL*/*BMJ* 2008 the National Collegiate Athletic Association from 2004 to 2008. He found 45 deaths from cardiovascular disease among athletes during that time, which, given the number of college athletes, would put the death rate from sudden cardiac death far above previous estimates, at about 1 in 44,000 per year among NCAA athletes. For reasons not understood, male basketball appeared to have the highest death rate, at 1 in 7,000 players — far from the often-cited 1 in 200,000 number.

The incidence of cardiomyopathy in nonathletes is even harder to measure than in athletes, since the student who doesn't die in a sports arena is unlikely to generate widespread media coverage. Among the young, more nonathletes die of cardiac arrest simply because they outnumber their athlete peers, says cardiologist Barry Maron, director of the Hypertrophic Cardiomyopathy Center at the Minneapolis Heart Institute Foundation. Maron is chairman of the heart association committee that is writing the new athlete screening statement. If it turns out that athletes are not at higher risk, policy makers have an ethical dilemma: Is it right to require screening only for sports participation if a member of the chess team has the same odds of sudden death?

Drezner is trying to calculate comparisons with nonathletes. Last year at the annual meeting of the American Medical Society for Sports Medicine, he presented data on the risk of sudden cardiac death in the general high school population. After studying the occurrence of cardiac arrest at more than 2,000 U.S. high schools, he determined that student athletes have a risk of cardiac arrest nearly four times higher than their peers.

The Italian model

The closest thing to a comprehensive look at the benefits of EKGs — the research often cited as a cornerstone in arguments for widespread screening — comes from a study headed by Domenico Corrado, a cardiologist at the University of Padua Medical School in Italy, whose study appeared in the *Journal of the American Medical Association* in 2006. He and his colleagues tracked more than 42,000 athletes between 1979 and 2004. Beginning in 1982, Italy launched a nationwide EKG screening program for athletes. Compared with the years before the screening program began, sudden death, mostly from cardiomyopathy, dropped by 44 percent in the first 10 years, and 79 percent between 1993 and 2004.

Overall, 55 deaths occurred in EKG-screened athletes, and 265 in nonscreened. Nearly 4,000 athletes had initial positive findings during the years of the study, but after further tests, only 879 were ultimately disqualified from playing. "All these findings suggest that screening athletes for

RON HEFLIN/ASSOCIATED PRESS

Having a defibrillator, or AED, readily available and in working order wherever athletes practice and play can save lives.

Shock to the heart

The benefit of routine EKGs may be in question, but one proven means of saving young athletes in cardiac arrest is available today and underused. Requiring automated defibrillator devices, or AEDs, at all schools and sports venues and making coaches and players keenly aware of the signs of sudden cardiac arrest can dramatically cut the mortality rate of players who go into cardiac arrest during practice or competition.

In case studies collected by Jonathan Drezner of the University of Washington, 16 of 18 athletes who suffered cardiac arrest during practice or games survived when their campuses were equipped with AEDs. "The defibrillator piece is so important," says Drezner, who published the research in 2013 in the *British Journal of Sports Medicine.*

Inspired by Drezner's work and similar studies, the Wes Leonard Heart Foundation's goal is to ensure that all schools have working defibrillators in easy-to-find locations around campus and people trained to use them. When Leonard collapsed, the crowd around him initially thought he was dehydrated or overheated; the recognition that he was in cardiac arrest came too late. When rescuers finally did locate an AED at Leonard's school — they had to dig it out of a storage room — the battery was dead. While it's not known whether an EKG could have protected his heart from stopping, a working defibrillator might have gotten it pumping again. *— Laura Beil*

Healthy or not?
These lines on an EKG represent one heart's electrical activity. Interpreting this readout is not straightforward, even for skilled eyes.

N. ESTES/TUFTS MEDICAL CENTER

cardiomyopathies is a lifesaving strategy," the authors wrote in the journal.

The Italian research profoundly affected the debate, says Maron, creating "a cottage industry of EKG screening." But he remains unconvinced. If anything, he says, the study affirmed the rarity of sudden death in athletes, with just 315 occurring during the 25 years. And it did not demonstrate that screening caused the drop in deaths, only that the two occurred simultaneously.

There is also the problem of equating the screening experience in the United States with that in Italy, says Estes. Italy has a sophisticated system for screening, he says, with referral centers that specialize in the interpretation of athlete EKGs. Drezner, who is also a team physician for the Seattle Seahawks, says that the false-positive risk "is the critical point of discussion in this EKG debate. If it is 20 percent, it's not worth it." Yet if it is high from a lack of skill "maybe what we want to focus on is training physicians to read an EKG in an athlete." In other words, if the root of the problem is that the U.S. medical system doesn't have enough expertise in athlete EKGs, the solution is to better train cardiologists, not abandon the idea altogether.

10
times
Likelihood that black athletes, as compared with white athletes, have an enlarged right ventricle plus EKG abnormalities that can mimic disease

America's diverse population makes importing the Italian model even more challenging. For reasons that are unexplained, studies have found that the hearts of black athletes are more likely to undergo changes that could be mistaken for cardiomyopathy. Take one study, published last spring from researchers at St. George's University of London in the journal *Circulation*. Using EKGs and other methods, the researchers examined the hearts of 675 high-level athletes, including 300 black athletes. In addition to the enlargement of the left ventricle that is known to occur in highly trained athletes, black athletes were 10 times more likely than white athletes to have enlargement of the right ventricle combined with EKG abnormalities that could lead to a disqualification from sports because it mimics disease.

Considering the greater proportion of black players in the United States, the lack of infrastructure and the dearth of experience in reading EKGs of athletes, Maron believes, "in the United States, the percentage of false positives is going to be much greater." So are false negatives, he says, "which hurts the very population you're trying to help."

But Sanjay Sharma of St. George's, one of the researchers in the *Circulation* study of black athletes and a proponent of wider screening, says a takeaway like that misses the point. If the problem is that EKGs are likely to be misread, the solution is to make sure that they are performed by skilled cardiologists who can either take into account the normal remodeling of an athlete's heart, or order follow-up tests that will confirm a diagnosis. "In our clinical practice, our false-positive rate is only 2 percent," he says.

Any full assessment of the issue must consider not just the cost of needlessly derailing student aspirations, but also the financial burden of widespread EKG screening and the follow-up tests to verify a diagnosis. Those cost estimates are remarkably inconsistent. One study from researchers in Israel, published in the *Journal of the American College of Cardiology* in 2012, put the price of one life saved at more than $10 million. "The idea that you could have a national mandatory screening program that cost $10 million because it might save one life is not something most scientists could relate to," says Maron. In total, U.S. costs could reach into the billions.

That said, another study presented at the European Society of Cardiology in 2012, this one of Swiss athletes, came up with a screening cost of $157 per athlete. And in March 2010, researchers from Stanford University published a study in the *Annals of Internal Medicine* also suggesting that screening, when compared with the years of life saved, could be cost effective.

As the debate continues, the stakes get higher. Participation in high school sports is growing, and with skyrocketing college costs, many student athletes push hard to win scholarships to fund their educational goals. On the sidelines, scientists and policy makers are left to figure out whether EKGs will be lifesaving diagnostic tools or wasteful impediments to promising athletic careers. ■

Explore more

- Navin Chandra *et al*. "Sudden cardiac death in young athletes: Practical challenges and diagnostic dilemmas." *Journal of the American College of Cardiology*. March 2013.

Intel STS 2014 winners (left to right) William Kuszmaul, Kevin Lee and Eric Chen.

Flu drug research takes Intel STS top honors

WASHINGTON — A teenager's computer analyses that identified six potential new flu-fighting compounds claimed first place March 11 at the awards gala for the 2014 Intel Science Talent Search.

Eric Chen, 17, of San Diego won the $100,000 by using supercomputers to analyze molecules that might block activity of an enzyme that all flu viruses use to reproduce. From a database of more than 450,000 compounds, he narrowed the list to 237. Lab studies identified six potent antiflu agents. The research may lead to medicines that could work during a flu outbreak while new vaccines are developed.

"I didn't expect this at all," Chen said. "All the other students are so amazing."

Chen's winning effort beat the research presented by 39 other Intel STS finalists (*SN: 2/8/14, p. 26*), who had been winnowed from 1,794 entrants representing 45 states, the District of Columbia and seven overseas schools.

"Society for Science & the Public proudly joins Intel in congratulating Eric Chen for his impressive research toward potential new drugs for influenza," said Rick Bates, interim CEO and chief advancement officer of SSP. "By linking technology and science to the problems of the world they see around them, Eric and all the Intel STS finalists are tomorrow's problem solvers."

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

Second place and $75,000 went to Kevin Lee, 17, of Irvine, Calif. He developed a computer simulation of the heart's contractions and the electrical signals that they produce. The simulation may provide insights about the causes of and potential treatments for irregular heartbeats.

William Kuszmaul, 17, of Lexington, Mass., won third place and $50,000 for research in an area of mathematics called modular enumeration. His work could help encrypt and verify data being transferred over a computer network.

"We at Intel celebrate the work of these brilliant young scientists as a way to inspire the next generation to follow them with even greater energy and excitement into a life of invention and discovery," said Wendy Hawkins, executive director of the Intel Foundation. "Imagine the new technologies, solutions and devices they will bring to bear on the challenges we face. The Intel Science Talent Search finalists should inspire all of us with hope for the future." — *Sid Perkins*

BOTH: CHRIS AYERS PHOTOGRAPHY/SSP

Top 10 Winners

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

1ST PLACE Eric Chen (pictured below), 17, of San Diego. $100,000 for identifying potential flu treatments.

2ND PLACE Kevin Lee, 17, of Irvine, Calif. $75,000 for a computer simulation of beating human hearts.

3RD PLACE William Kuszmaul, 17, of Lexington, Mass. $50,000 for mathematical research that could help with data encryption.

4TH PLACE Joshua Meier, 18, of Teaneck, N.J. $40,000 for identifying a gene that makes certain stem cells age rapidly, which limits their potential use in medical treatments.

5TH PLACE Natalie Ng, 18, of Cupertino, Calif. $30,000 for developing a statistical model to assess the spread of breast cancer.

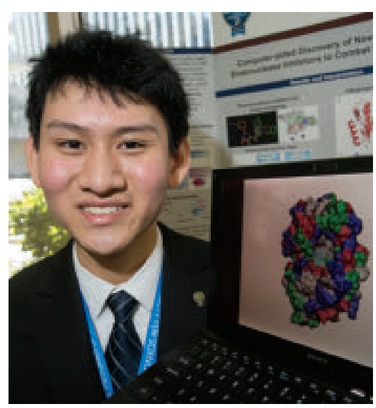
6TH PLACE Aron Coraor, 17, of Huntington, N.Y. $25,000 for laboratory research shedding light on how certain minerals formed on the moon.

7TH PLACE Zarin Rahman, 17, of Brookings, S.D. $25,000 for studying how adolescents' use of smartphones and other devices affects sleep, stress and academic performance.

8TH PLACE Anand Srinivasan, 17, of Roswell, Ga. $20,000 for a computer model that identifies gene boundaries in organisms whose cells have nuclei.

9TH PLACE John Clarke, 17, of Syosset, N.Y. $20,000 for computer simulations of charged particles in Jupiter's magnetic field.

10TH PLACE Shaun Datta, 18, of North Potomac, Md. $20,000 for computer simulations of the interactions between subatomic particles in neutron stars.

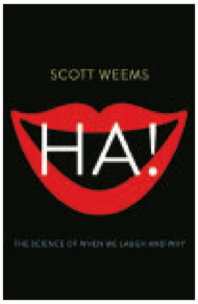


BOOKSHELF

Ha!

The Science of When We Laugh and Why

Scott Weems



It's certainly possible to overanalyze a joke. But can the same be said for humor as a whole? Considering the abundant research on the topic, maybe not.

Weems, a neuroscientist, takes readers on a wide-ranging tour that explains what humor is and why readers should care. Turns out, humor influences health and social well-being in many ways. Humor improves interpersonal relationships, and studies show that simply watching a funny movie can lower stress, improve immune system response and even help viewers better solve problems.

The complexity of the human brain makes humor possible, Weems argues, and it also helps explain how some people can find a joke hilarious while others deem it grossly offensive.

Humor takes many forms — as many as 44 by one researcher's count — but shares certain traits and themes. From puns and riddles to slapstick, humor is inherently subversive, Weems says, often treating serious subjects with frivolity or even rudeness. Prisoners of war and others in dire situations, for instance, often turn to dark humor.

Ha! isn't a self-help guide to being funny, though a careful reader can find useful nuggets throughout. The funniest jokes carry a little edginess, but not too much. Surprise helps, too, whether it's the incongruity of an elephant hiding in a cherry tree or the absolute improbability of Raquel Welch and the pope ending up in the same lifeboat.

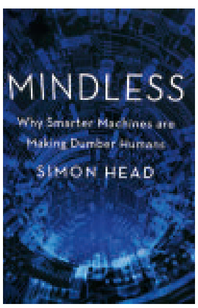
The final chapter divulges Weems' semisuccessful attempt at stand-up comedy. He got a few laughs, he says, but not where he expected them. Maybe practice does make perfect: The joke that got Weems the most laughs, and judged by one website's readers as the best in the world, is a story that he had practiced many dozens, maybe hundreds, of times. — *Sid Perkins*
Basic Books, $26.99

BOOKSHELF

Mindless

Why Smarter Machines are Making Dumber Humans

Simon Head



As scientists ponder whether the Internet is turning our brains to mush, technology and labor scholar Simon Head worries about the role of computer business systems operating largely without notice from the public. These computer and software systems, often called enterprise systems, drive the decision-making apparatuses of large companies — and not necessarily with the workers' best interests as a priority.

Made by IBM, Oracle and a few other giants, the systems guide day-to-day operations and provide data for strategic decisions. They can provide efficient guidelines for manufacturing and sparkling logistics for shipping goods.

But in the service sector, Head says, overreliance on business systems comes with a cost. He recalls phoning Microsoft with a computer problem. The call center employee clearly had flexibility in talking him through it, and the chat advanced rapidly toward a solution. But when a hardware issue emerged, Toshiba was brought into the call. Progress collapsed as the Toshiba agent, required to follow a business system's script, had no agility to get to the heart of the problem.

Head argues that computer business systems leave middle managers and workers with little creative latitude. They acquire fewer skills and their wages stagnate, hurting their job quality and buying power.

A century ago Henry Ford paid his workers a living wage in part because he needed them to buy the cars they built, Head points out. But poor wages are slowing the current economic recovery, while the income gap grows. He argues that applied science has become a tool of this income inequality by putting short-term productivity ahead of worker flexibility and advancement. His conclusions may irk some readers, but his documentation is thorough. — *Nathan Seppa*
Basic Books, $26.99

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TO DO

Say Hello to the Nation's *T. rex*
APRIL 15, 2014
A nearly complete *T. rex* skeleton arrives in D.C. and kicks off a redesign of the Smithsonian's dinosaur hall beginning April 28. A cast of the skull (above) will remain on display during construction.
NATIONAL MUSEUM OF NATURAL HISTORY, WASHINGTON, D.C.

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Explore interactive exhibits, fossils and more to learn about these flying reptiles.
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Life Beyond Measure: A Short History of Longevity
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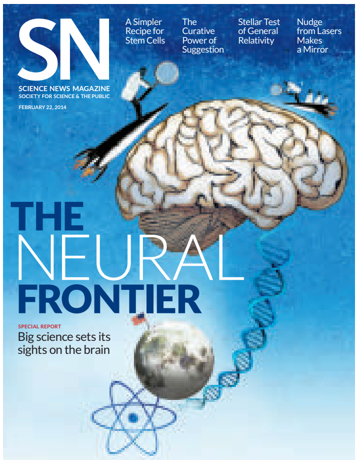

FEBRUARY 22, 2014

"Your February 22 issue was by far the most visually attractive that I can remember. The graphics were crisp and sharp, and the text and tables were an easy, logical read."

THOMAS N. HELGET

Big neuroscience maps the brain

With the BRAIN Initiative, researchers have set their sights on revealing the intricate parts and processes of the human brain. Science News *explored some of the challenges facing this venture in a Special Report in the February 22 issue.*

"I am unequivocally happy that this project exists," tweeted **Ben** (@bxburton). "So am I," responded **@LisaGoogles**. "Neuroscience is an exciting frontier."

Some readers had thoughts on how to decode the brain's connections. "I wouldn't consider trying to understand a computer by tracing the wiring — it is much too complex, although not nearly as complex as a human brain. Since nature has neglected to provide us with a user's manual, I would turn to the next best thing: the schematics or (perhaps more aptly for a biological computer) the recipe — namely, the DNA," wrote **David Gross**, a retired computer professional, in an e-mail. "It should be far simpler to decode the recipe than to pick apart the end product."

Steven Ostrom wrote, "I thoroughly enjoyed reading your recent issue on the brain. The articles were extremely interesting and written so they could be well understood by readers like me without a degree in neuroscience. But I do need to take you to task for making a sensational statement with no data or explanation to back it up. On Page 17 you state, 'A pea-sized lump of brain tissue contains more information than the Library of Congress.' I can't deny that claim, but what unit of measurement is being used to quantify 'information,' and how is the comparison being made? It would be nice for the benefit of readers if you would explain any such sensational statements."

Author **Laura Sanders** says, "By some estimates, the library's print collection amounts to about 10 terabytes. It takes 100 terabytes to store a reconstruction of the connections in a salt-grain-sized speck of mouse cortex. And that doesn't account for other ways that the brain stores and processes information."

Moon dust mystery

The "50 Years Ago" update in Notebook mentioned that Earth's moon is accruing dust at a rate of about a millimeter every thousand years, about 10 times faster than scientists had previously thought (SN: 2/22/14, p. 4).

Reader **Bob Wake** was amazed by this number. "This would predict 3 kilometers of dust in the three-plus billion years that most of the lunar surface has been unchanged!" he wrote in an e-mail. "I can think of three possibilities: a) Some process consolidates the dust into much firmer regolith, b) some process removes the dust in time spans well less than 1 million years or c) the rate of dust accumulation has increased by many orders of magnitude in the geologically recent past. None of these seem plausible. Your guess?"

That figure does seem high if the dust is simply accumulating on the lunar surface, responds **Meghan Rosen**, who reported on the new estimate in "Moon dust gathers surprisingly fast" (*SN: 1/11/14, p. 6*). "In fact, some scientists I spoke with were skeptical that so much dust could build up on the moon. But if it does, you're right that it seems like there would be some mechanism to compact it." Scientists still aren't quite sure what happens to lunar dust, and whether it moves around or mostly stays still, says **Rosen**. "I'm hoping we learn more about the moon's dust with results from NASA's Lunar Atmosphere and Dust Environment Explorer, which launched in September 2013."

Correction

In "Second bird flu wave ups pandemic worries" (*SN: 3/22/14, p. 32*), the chart of illnesses and deaths erroneously shows four more cases of flu, two each in weeks 46 and 47, than were confirmed. This error led to two others: Two extra cases were added to both the 50–59 and the 60–69 age categories in the "Illnesses by age" bar chart, and the "Illnesses by sex" pie chart should show 68 percent for males and 32 percent for females.

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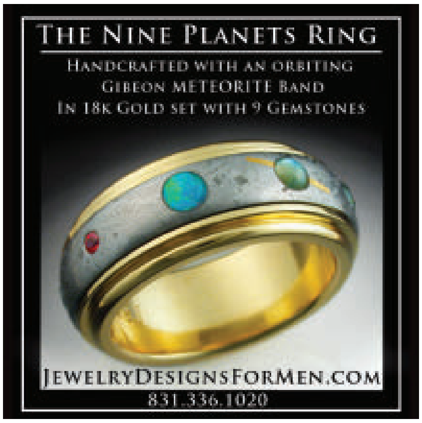
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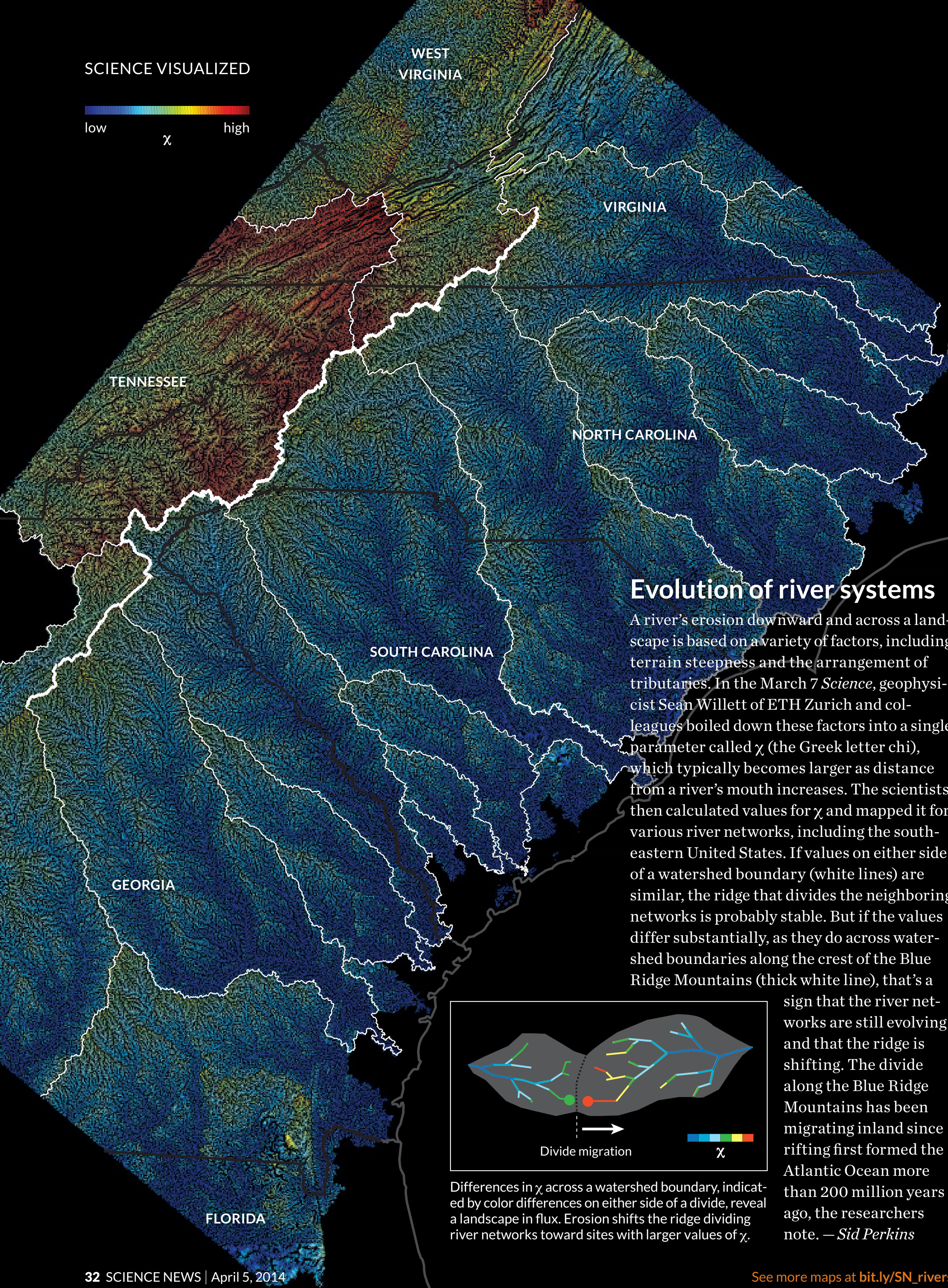

Evolution of river systems

A river's erosion downward and across a landscape is based on a variety of factors, including terrain steepness and the arrangement of tributaries. In the March 7 *Science*, geophysicist Sean Willett of ETH Zurich and colleagues boiled down these factors into a single parameter called χ (the Greek letter chi), which typically becomes larger as distance from a river's mouth increases. The scientists then calculated values for χ and mapped it for various river networks, including the southeastern United States. If values on either side of a watershed boundary (white lines) are similar, the ridge that divides the neighboring networks is probably stable. But if the values differ substantially, as they do across watershed boundaries along the crest of the Blue Ridge Mountains (thick white line), that's a sign that the river networks are still evolving and that the ridge is shifting. The divide along the Blue Ridge Mountains has been migrating inland since rifting first formed the Atlantic Ocean more than 200 million years ago, the researchers note. *— Sid Perkins*

Differences in χ across a watershed boundary, indicated by color differences on either side of a divide, reveal a landscape in flux. Erosion shifts the ridge dividing river networks toward sites with larger values of χ.

BOTH: S.D. WILLETT ET AL/*SCIENCE* 2014, COURTESY OF *SCIENCE*/AAAS

See more maps at **bit.ly/SN_rivers**