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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 24, 2013

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Living Night-Lights

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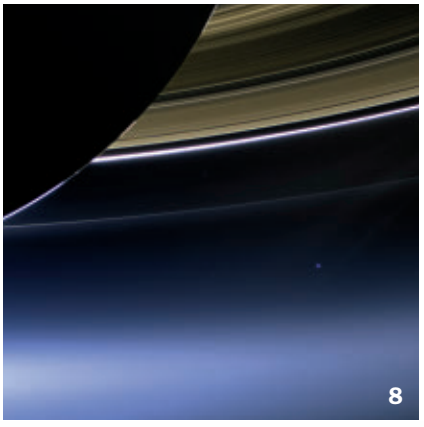

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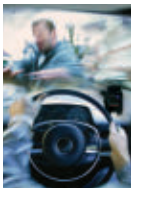

COVER Even hands-free cell phones limit a person's ability to drive safely. Yet laws fail to reflect what's known of the perils of talking while driving. *Ocean Photography/Veer, georgeclerk/iStockphoto*

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FROM THE EDITOR

Like a mind, science is a terrible thing to waste

At its grandest, science addresses deep questions about the nature of the universe. But sometimes science just tries to make our lives better. And when it fails, as it does more often than we would like, the fault doesn't always lie with the research process. The feature stories in this issue both illustrate science gone to waste, in one case because society has been too shortsighted to provide consistent funding for research and in the other because people don't like the findings it produced.

Research suggests that using a cell phone, even a hands-free device, while driving is hazardous, biomedical writer Nathan Seppa reports on Page 20. Yet translating those results into legislation has been slow: A majority of states ban texting while driving, and some ban talking on hand-held phones, but not one broadly prohibits talking on a hands-free cell phone. As Seppa reveals in his story, however, hands may not be the issue. Brainpower given to a conversation — especially with an absent interlocutor — is brainpower taken away from the road. Such missing attention can make an accident more likely. That laws have yet to change seems less a failing of science than one of a society too willing to sacrifice lives for convenience.

The search for alternative rubber sources, a story told by science writing intern Cristy Gelling on Page 26, has had its share of setbacks. Some were scientific: A number of research efforts spent years studying characteristics of a rubber-poor dandelion species that grows alongside, and looks very similar to, a rubber-rich species. But more often, the rise and fall of rubber research has been a result of policy and economics. When supplies were endangered or prices spiked, rubber research boomed. Researchers figured out how to first make and then mass manufacture synthetic rubber in fits of activity after the First World War and again during World War II. They studied rubber-producing plants such as the Russian dandelion in the '30s and '40s. But when the crisis passed, plants were destroyed and the fledgling research all but forgotten. As historian Mark Finlay puts it: "We have a culture in which it's possible for knowledge to be dismissed and tossed aside. There was no foresight that the next crisis might be around the corner."

New sources of rubber are now being sought and developed again. Imagine if the WWII-era effort had been sustained, even at a low level, all these years. And imagine the many things our society could achieve if science designed to improve lives had a greater chance to do so. — *Eva Emerson, Editor in Chief*

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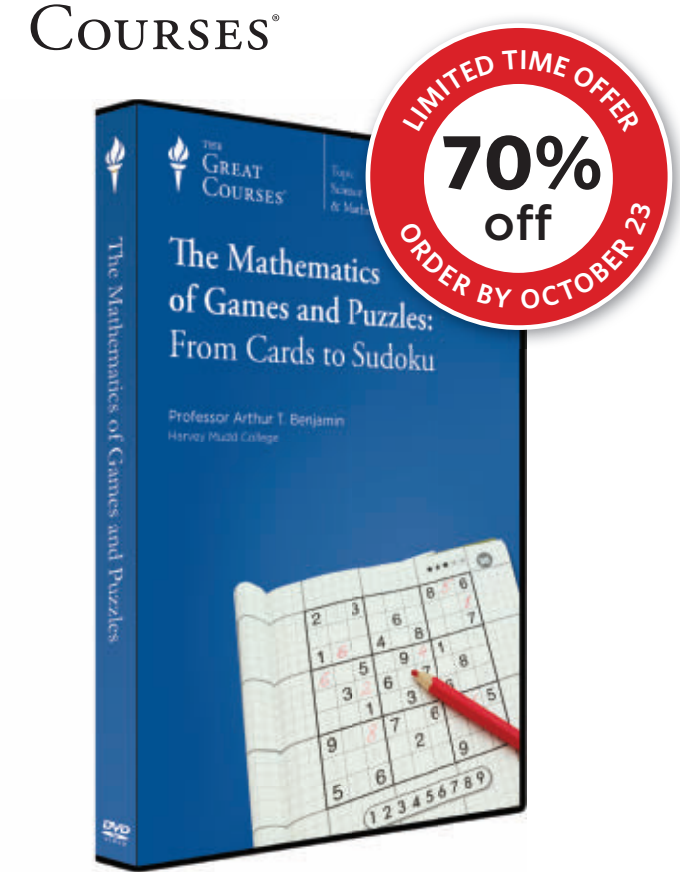

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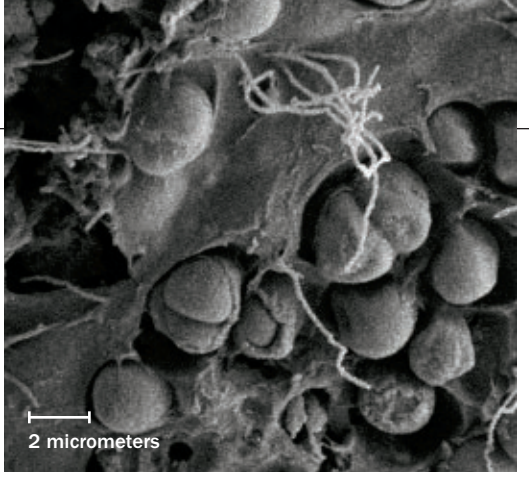
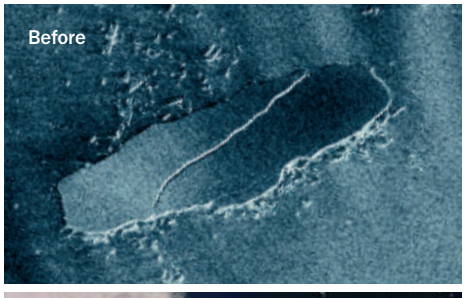


PLASTISPHERE *PLAS-tih-sfeer*\ *n.*
The microbial community living on pieces of plastic floating in the open ocean. Plastic has become the most common kind of human-made marine debris, quickly moving from shore to sea and accumulating in the center of the oceans' vast gyres. Erik Zettler of the Sea Education Association in Woods Hole, Mass., and his colleagues analyzed bits of plastic netted during two research cruises in the North Atlantic and found a diverse collection of microbes living on the material, including potentially pathogenic *Vibrio* bacteria. Some bacteria appear to be nestled in cell-shaped pits on the plastic's surface (above), possibly indicating that plastisphere microbes actively break down debris, the researchers report in the July 2 *Environmental Science & Technology*. —*Sarah Zielinski*



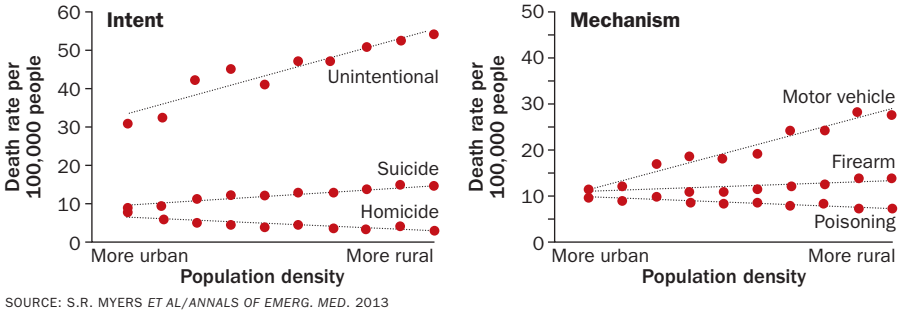
How Bizarre | NOISY ICE

Icebergs do not go gently into the night. When underwater microphones recorded the breakup of a floating chunk of ice drifting away from Antarctica, scientists got an earful. The 2008 collapse released as much sound energy as would have been generated by more than 200 supertankers over the same period, Robert Dziak of Oregon State University and colleagues report June 18 in *Oceanography*. Because sound can travel thousands of kilometers underwater, the team says such noise might disturb marine animals — and could become harmful as more Antarctic ice melts. —*Erin Wayman*

Science Stats | SAFETY IN NUMBERS

So much for the peaceful countryside. Researchers examining nearly 1.3 million injury-related U.S. deaths report that an individual's overall risk of death from injury is 1.22 times higher in the most rural counties than in the most urban ones.

Means of death in urban and rural areas



SOURCE: S.R. MYERS *ET AL/ANNALS OF EMERG. MED.* 2013

50 Years Ago

Excerpt from the August 17, 1963, issue of *Science News Letter*

KEY TO OTHER WORLDS

Neutrinos, nature's most elusive atomic particles, could serve as a key to detecting other "suns" in the universe made of anti-matter, the opposite of the kind of matter found on earth, and in our sun. This possibility was suggested by Dr. Bruno Pontecorvo, [who] fled from England to Russia in 1950 and is now a Soviet citizen, considered one of Russia's top physicists.... Anti-matter worlds cannot be detected by their light, since the photons carrying light's energy are neutral and therefore the same, whether emitted by normal matter or by anti-matter. However, neutrinos and anti-neutrinos can be told apart since they have a different direction of spin, or helicity. A star made of anti-matter, which would be converting antihydrogen into antihelium, would emit anti-neutrinos and could therefore be told from a star burning normal matter. Neutrinos can also be used to detect the nuclear reactions occurring in the center of our sun, Dr. Pontecorvo suggests.

UPDATE: There is no evidence of stars or other large bodies made of antimatter. But many of Bruno Pontecorvo's ideas about neutrinos have been validated. He proposed that neutrinos oscillate, shifting between neutrinos and antineutrinos or among different "flavors" of neutrino. On July 19, physicists from Japan's T2K experiment reported conclusive evidence of this switching (*SN Online: 7/23/13*). Next, physicists plan to compare the flavor shifting of neutrinos with that of anti-neutrinos in hopes of revealing why matter, not antimatter, dominates the universe.

FROM TOP: E.R. ZETTLER *ET AL/ENVIRON. SCI. TECHNOL.* 2013; ESA (BOTH)

“Some material swung by the back side of the black hole and is now flying toward us.” —STEFAN GILLESSEN, PAGE 9

In the News

COURTESY OF D. LUKAS

STORY ONE

Roots of monogamy feed scientific spat

Researchers clash on how fidelity evolved in mammalian species

By Cristy Gelling

Meerkats are unusual among mammals in forming monogamous pairs. Scientists disagree on what factors drove the evolution of mammalian monogamy.

Why some mammalian species choose to spend their lives with the same mates has long baffled scientists — and will probably continue to do so as two new massive studies present contradictory results.

One group of researchers says monogamy evolved in primates to counter the threat of males killing babies to boost their siring success. The other team concludes that mammals, including primates, become monogamous when females live far away from one another.

The differences in the conclusions have raised eyebrows. “They do seem to be saying the opposite thing,” says Anthony Di Fiore, an evolutionary anthropologist at the University of Texas at Austin. “It’s interesting because they use very, very similar methods,” Di Fiore says.

The two groups also disagree on whether the research has implications for why humans evolved fidelity to mates (see Back Story, Page 6).

Both teams investigated the evolution of social monogamy, which researchers define as males and females living in breeding pairs. It does not necessarily mean that each animal is always faithful and never mates outside the pair.

Social monogamy is normal for birds but rare in mammals. That’s because birds of both sexes can participate in parenting duties such as incubating eggs and feeding chicks, but male mammals can’t help gestate or breastfeed a baby. During the long period when a mother mammal is occupied with parenting, an opportunistic father can take off to sire more offspring with other females.

Less than 10 percent of mammal species, such as wolves and beavers, live in pairs in which the male sticks by his mate. This living arrangement is more common among primate species, about a quarter of which live in pairs.

To determine what factors drove the evolution of mammalian monogamy, Dieter Lukas and Tim Clutton-Brock from the University of Cambridge in England collected information about more than 2,500 species — nearly half of all mammals. The researchers used published reports to classify each species as monogamous or not, and then noted whether that species practices infanticide and whether the females live in discrete territories. Using this

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Some gray bamboo lemurs (*Hapalemur griseus*) live in monogamous pairs. Others of the same species live in groups with one male and two females.

dataset, the researchers reconstructed the likely evolutionary history of mammalian monogamy.

The team concludes in the Aug. 2 *Science* that monogamy evolved independently 61 times, almost always when females lived far from one another.

In those situations, Lukas says, males have difficulty mating with multiple females. By sticking with one female and guarding her against amorous advances from other males, he might produce more offspring than if he attempted to spread himself around.

The other group, led by Kit Opie of University College London, performed a similar evolutionary reconstruction but focused on 230 primate species. These researchers conclude July 29 in the *Proceedings of the National Academy of Sciences* that the trigger for the evolution of monogamy was high rates of infanticide by males.

In nonmonogamous species such as gorillas, males may benefit from killing other males' babies because losing a baby forces the mother to enter her fertile period sooner. But males that hang around their mates and offspring can defend them from roving killers. Monogamy could have evolved as a counterstrategy, Opie and colleagues suggest. Today, monogamous primates such as titi monkeys native to South America have very low rates of infanticide.

Opie is confident that infanticide drove many primates to live in pairs. "It solves the puzzle. It finishes the debate," Opie says. "Or we certainly hoped, before we heard about the other paper, that it would finish the debate."

The debate is, of course, far from over. "We don't find any support that infanticide has been important for the evolution of monogamy across mammals," Lukas says. In his team's dataset, monogamy is as likely to have evolved from an ancestor that did not practice infanticide as from one that did. This was also true when they examined only primates.

But Opie says that widely spaced female territories can't be the cause of the switch to monogamy in primates, because in his team's analysis, females shifted into discrete territories after the evolution of monogamy.

The dispute might stem from the way the groups classify the key behaviors: monogamy, infanticide and female territories, says Charles Nunn, an evolutionary anthropologist at Duke University.

Opie's methods were slightly better at handling the blurry lines between types of mating systems, Nunn says, whereas Lukas' team "really wants to pin each species into one cubbyhole." For example, Opie's team classified the gray bamboo lemur, which has some variation in its mating habits, as both monogamous and polygynous, while Lukas' team classified this species as not monogamous. "The devil is going to be in the details," Nunn says.

Both teams emphasize that they do not yet know why their conclusions on primates differed, but they have exchanged data and agree that they need to work together to iron out the details.

Ultimately, the factors that led to monogamy might differ among species. "Many times we forget that this is not math," says evolutionary anthropologist Eduardo Fernandez-Duque of the University of Pennsylvania. "It's unlikely that one size will fit all." ■

Back Story

HOW ABOUT HUMANS?

The two groups studying monogamy disagree about their work's implications for human evolution. Kit Opie of University College London says that humans evolved to live in monogamous pairs to minimize the threat of infanticide. Humans were part of his team's analysis. "We treated them just the same as all the other primates, because that's what they are," he says. But Dieter Lukas of the University of Cambridge and his colleague say their own results have little bearing on humans. Humans evolved from an ancestor that lived in social groups, so the theory that monogamy evolves when females live far apart doesn't apply. Besides, he says, humans may not actually have evolved monogamy at all. In many traditional societies, one man may take several wives. — *Cristy Gelling*

A man from Utah with three wives may not be out of the ordinary. Some scientists think that, like most other mammals, humans are not strictly monogamous.

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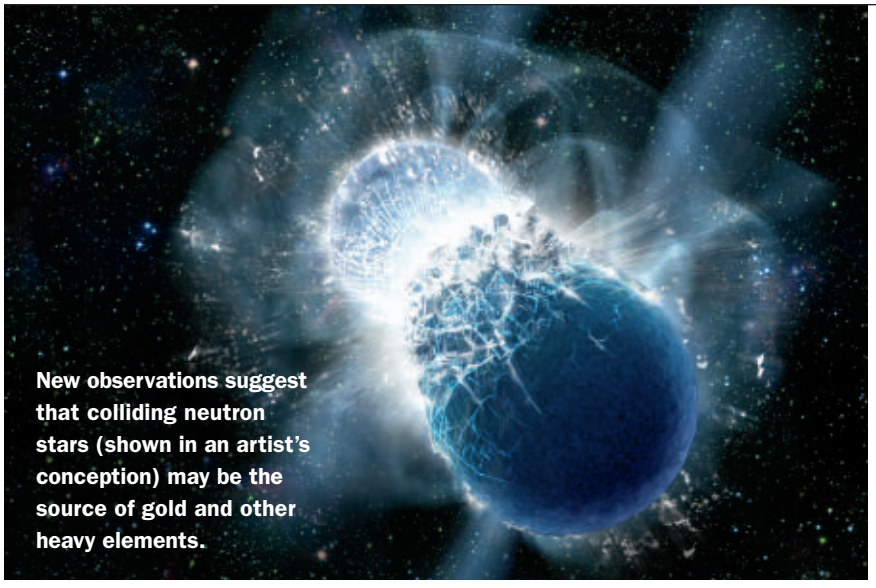


New observations suggest that colliding neutron stars (shown in an artist's conception) may be the source of gold and other heavy elements.

Gold seen in neutron star debris

Observation suggests collisions as source of heavy elements

By Erin Wayman

Dead stars make good alchemists.

Images snapped by the Hubble Space Telescope suggest that gold may have been generated by a violent neutron star collision that also yielded lead, platinum, uranium and other heavy elements.

The stellar smashup was detected on June 3, when NASA's Swift satellite observed a gamma-ray burst 3.9 billion light-years away. Astrophysicists believe that a crash between two neutron stars, the dense, neutron-rich cores left over after massive stars explode, released the 0.2-second flash of energy.

Images captured by Hubble nine days later saw evidence for a bounty of heavy elements amounting to about 1 percent of the sun's mass and including several moon masses of gold, says Edo Berger of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Given the amount of gold and the fact that these collisions probably happen once every 10,000 or 100,000 years in any given galaxy, such crashes could account for all of the gold in the universe, he says.

Berger's team posted its findings June 17 on arXiv.org.

The idea that neutron star collisions create heavy elements was suggested in the 1970s by James Lattimer, now at Stony Brook University in New York, and colleagues. Back then, Lattimer says, there were few observations of neutron stars and computers were slow. So, Lattimer says, "the calculations were fairly crude, and I'm not sure people believed the model that much."

Instead, most astrophysicists thought elements heavier than iron — those that don't form via fusion within a star — results from massive stars collapsing in supernovas. But computer simulations have had a tough time showing that this is possible, Lattimer says.

Although Lattimer says it's "comforting" that the findings fit with the neutron star theory, he notes the results are "still fairly speculative." The Hubble images show a glow of infrared light that Berger's team says is characteristic of radiation emitted by the radioactive decay of heavy elements. Yet the team can't rule out that the light was produced by the gamma-ray burst itself, Lattimer says.

You are here: Earth seen from afar

It's more of a bright blue blotch than a pale blue dot, but Earth still looks awfully insignificant in this July 19 photograph. It was taken by NASA's Cassini probe, which is more than 1.4 billion kilometers away in orbit around Saturn. Earth is just right of center in the photo, while the moon is barely visible as a protrusion off Earth's right side. Saturn dominates the upper left of the image and the planet's rings are brightly illuminated. Twenty-three years ago, unbeknownst to all but a handful of Earthlings, the NASA probe Voyager 1 took the famous Pale Blue Dot portrait of Earth, showing it as a tiny speck in the vastness of space. This time, there was advance warning. Carolyn Porco, who was on the Voyager team and now leads Cassini's imaging efforts, announced the new photo shoot in June. The Cassini probe has been exploring Saturn and its moons since 2004. The new image is one tile of a 33-tile mosaic that will include Saturn and its entire ring system. —*Andrew Grant*

FROM TOP: DANA BERRY/SKYWORKS DIGITAL, INC.; JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE

3,000 kilometers per second | Top speed that gas cloud G2 is moving through Milky Way

29.8 kilometers per second | Average speed of the Earth in orbit around the sun

Central black hole reels in gas cloud

Telescopes watch galaxy's maw tear up approaching object

By Andrew Grant

An ill-fated gas cloud has begun a close encounter with the monstrous black hole at the center of the Milky Way, a fresh set of observations reveals. Astronomers don't expect the cloud to emerge intact, resulting in an unprecedented view of our galaxy's largest black hole feasting on its prey.

In December 2011, astronomers identified the gas cloud, called G2, and found that its orbit would bring it perilously close to the Milky Way's central black hole by mid-2013. Twenty months ago, the immense gravity of the black hole, which weighs in at about 4.3 million times the mass of the sun, was already squeezing and stretching the gas cloud as if it were pasta dough.

Now images captured in April with the Very Large Telescope in Chile show that the leading edge of G2 has whipped around the black hole's far side. "The line of sight is such that the gas cloud is falling away from us toward the black hole," says Stefan Gillessen of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany. "Some material swung by the back side of the black hole and is now flying toward us."

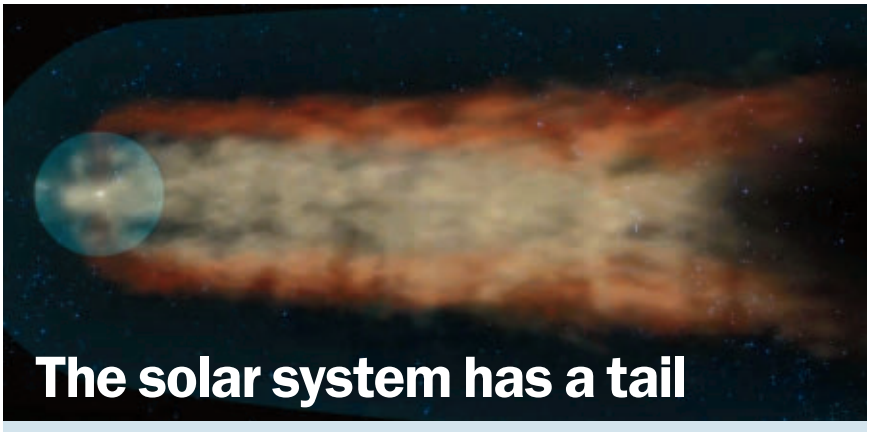
"If you think of the cloud as a roller coaster train, the first carriage has already swung by the black hole," Gillessen says. "The main part of the train is still in approach."

The gas cloud is whizzing through space at up to 3,000 kilometers per second, 100 times the speed at which Earth orbits the sun and a whopping 1 percent of the speed of light. In just a few months, the black hole has not only accelerated the cloud to those speeds, but reversed the motion of the front side a full 180 degrees. The findings will appear in an upcoming *Astrophysical Journal*.

Gillessen and his team also found that the black hole has stretched G2 to twice its length last year. As a result, the researchers predict that the bulk of the cloud won't make its closest approach to the black hole until early next year. When that happens, telescopes around the world will point at the galactic center to capture the drama.

Dimitrios Giannios, an astrophysicist at Purdue University in West Lafayette, Ind., does not expect G2 to survive its encounter with the galaxy's central black hole. The cloud will probably fade from view in coming months as it continues to stretch out, he says. But its remnants might gradually get funneled into the black hole within a few decades, culminating in a rare bright display as they approach the point of no return. "It would be a last echo of the death of this cloud," he says. ■

GSFC/NASA



The solar system has a tail

The solar system drags along a lengthy, twisted tail of charged particles as it moves through the galaxy, researchers announced July 10 in a press conference and in the *Astrophysical Journal*.

Scientists had always presumed that a tail existed, said Eric Christian, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Md. "But this is the first time we have data that tells us about the tail."

The discovery comes from data gathered by the Interstellar Boundary Explorer, or IBEX, a satellite launched in 2008. It charts the trajectories of speedy atoms that originate in the outskirts of the solar system before getting an inward kick from collisions with charged particles from the sun. The distribution of those atoms helps scientists map the boundaries of the heliosphere, the bubble that contains the planets and other material in the solar system and is inflated by particles continually jetting out from the sun (illustrated above).

A cross section of the tail resembles a four-leaf clover, with two clumps of slow-moving solar particles and two of high-speed particles. The data also reveal that the clover shape is flattened and twisted by galactic magnetic fields acting on the sun as it whizzes through the Milky Way at around 84,000 kilometers per hour—the same magnetic fields that cause a giant ribbon of charged particles to wrap around the edge of the heliosphere (*SN: 11/21/09, p. 15*).

The IBEX team could not determine the exact length of the tail, said principal investigator David McComas of the Southwest Research Institute in San Antonio, but estimated it at 150 billion kilometers, or 1,000 times the distance between Earth and the sun. The team plans to see whether the tail's shape changes as the sun's activity wanes. —*Andrew Grant*

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Sound waves let objects levitate

Technique transports cells, water droplets and coffee

By Meghan Rosen

Objects bathed in sound waves can spin, glide and collide in air — no magnets or magic required.

Using nothing but sound, engineers maneuvered toothpicks, coffee granules and water droplets through the air, a team from ETH Zurich reports July 15 in the *Proceedings of the National Academy of Sciences*. The technique could be useful for gently handling delicate or hazardous lab chemicals or to avoid contaminating cells in biological experiments.

"It's a beautiful piece of work," says Penn State bioengineer Tony Jun Huang, who has used sound to manipulate particles in liquid.

Scientists have known for years how to use sound waves to hoist particles in the air, a process known as acoustic levitation. But moving the lifted bits around has been more challenging. The sound waves tend to trap a levitated object in a fixed pocket of space.

The new technique moves the pockets around by deforming a field of sound waves, letting researchers transport trapped objects several centimeters, says study coauthor Dimos Poulikakos, a mechanical engineer at ETH Zurich.

"Before, it was like you had a beautiful car, but you could only park it," Poulikakos says. "Now you can drive the car."

To achieve levitation, Poulikakos and colleagues vibrate aluminum blocks about the size of postage stamps up and down, like tiny jackhammers. The rapid buzz kicks up sound waves that sail upward until they hit a Plexiglas reflector and then bounce back down to the blocks.

When these falling waves run into the climbing ones, they cancel out, creating a low-pressure pocket that can support an object's weight. By adjusting vibration rates to control the position of the pocket, the researchers could float particles across a chessboard of aluminum blocks. The team used the technique to mix droplets of cells with DNA. They also glided a bubble of water into a globule of sodium metal to demonstrate how to safely work with hazardous materials from a distance. When the water struck the metal, the combo exploded, spewing flammable hydrogen gas.

Doppler effect goes for a spin

Light's angular momentum can reveal rotational speed

By Andrew Grant

A twist on the physics that cops use to clock speeding drivers can determine how fast an object is spinning. The approach could be used to protect wind turbines from damaging winds, learn about distant astronomical objects or detect tornadoes.

The Doppler effect is familiar to anyone who has heard the pitch of a siren rise and fall as an ambulance whizzes past. It describes how the frequency of light waves (or the pitch of sound waves) emitted by a moving object becomes higher as the object approaches an observer and lower as it moves away. Today people exploit the Doppler effect to track the motion of raindrops, cars and galaxies.

But Doppler's kryptonite has always been rotating objects that are neither moving toward nor away from the observer, like the second hand on a clock.

Physicist Martin Lavery at the University of Glasgow in Scotland and colleagues thought that they could measure rotational speed by determining how a spinning object changes light waves' orbital angular momentum. In focused beams such as lasers, successive waves of light move like ocean waves on a beach: straight on, with periodic crests and troughs. But most light is messier: The waves wind around like a corkscrew.

Lavery's team plated a plastic disk with aluminum foil and hooked it up to a spinning motor. Then the researchers bounced off the disk a light beam that had a special property: Its waves twisted either clockwise or counterclockwise.

When the researchers measured the light after it bounced off the disk, they found that the frequency of waves twisting in the same direction as the disk was spinning had become higher, while the light twisting in the opposite direction had a lower frequency. The change allowed the scientists to calculate the disk's speed of rotation, they report in the Aug. 2 *Science*. "This is the first experimental evidence that this is possible," says Bo Thidé, a physicist at the Swedish Institute of Space Physics in Uppsala.

Lavery's team then did a similar experiment with ordinary light to prove that, even with waves twisting in all directions, they could take advantage of the Doppler change in angular momentum to measure the speed of the disk's rotation.

Engineers could exploit the technique to protect wind turbines, which can get damaged by violent, swirling air currents. Lavery envisions a sensor on the nose of a turbine that would detect dangerous vortices and switch the turbine off.

Thidé says that weather radar could exploit the rotational Doppler effect to detect tornadoes before they reach the ground. Two years ago, he proposed a similar method to detect the rotation rate of supermassive black holes like the one lurking at the center of our galaxy (*SN: 3/12/11, p. 14*). "This experiment tells the rest of the world that there's a lot to be gained by using this technique," he says. "It will push people to go ahead and start to build applications." ■

Earth

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Day length changes every six years

Cycles in rotation speed suggest Earth's core plays a role

By Cristy Gelling

The world turns slightly faster and slower on a regular 5.9-year cycle, a new study suggests. The research also found small speed changes that happen at the same time as sudden alterations in Earth's magnetic field.

The world's rotation speed can change slightly, by up to milliseconds per day, because of shifts in winds or the movement of fluid in Earth's interior. Scientists can measure how fast the Earth spins by observing distant objects in space and timing how long they take to come back into view — that is one day length.

The new study, published in the July 11 *Nature*, found trends in day length after subtracting the influence of weather, allowing researchers to home in on the effect of Earth's fluid core.

Scientists have previously found hints of six-year oscillations in day length, which occur at the same time as larger, slower changes. But the new analysis revealed that the cycle is remarkably regular, with the maximum change in day length occurring once every 5.9 years.

Using decades' worth of data, the researchers found that the oscillations maintained this precise timing and strength for half a century. "That's got to be saying something important," says geophysicist Bruce Buffett of the University of California, Berkeley, who was not involved in the study. It's too early to say exactly what causes the oscillations, he adds.

This regularity undercuts one hypothesis for the cause of the cycles: fluctuations in the sun's energy, which are more variable, says study author Richard Holme of the University of Liverpool in England. Instead, the cycle must be caused by something inside the Earth.

Holme's team also detected sudden, tiny increases and decreases in the Earth's rotation speed that coincided with abrupt changes in the behavior of Earth's magnetic field, known as geomagnetic "jerks." The new day-length data could help scientists understand what causes the mysterious jerks, Buffett says.

Along with hinting at what's going on in the Earth's core, the research may help improve geomagnetic forecasts, which are crucial in mining exploration and drilling. ■

Life

For more Life stories, visit **www.sciencenews.org**

Peahens make a tough audience

Eye tracker shows females often look away from male plumage

By Susan Milius

When a peacock fans out the iridescent splendor of his train, more than half the time the peahen he's displaying for isn't even looking at him. That's the finding of the first eye-tracking study of birds.

In more than 200 short clips recorded by eye-tracking cameras, four peahens spent less than one-third of the time actually looking directly at a displaying peacock, says evolutionary biologist Jessica Yorzinski of Purdue University in West Lafayette, Ind.

When peahens did bother to watch the shimmering male, they mostly looked at the lower zone of his train feathers. The feathers' upper zone of ornaments may intrigue human observers, but big eyespots there garnered less than 5 percent of the female's time, Yorzinski and her colleagues report July 24 in the *Journal of Experimental Biology*.

These data come from a system that coauthor Jason Babcock of Positive Science, an eye-tracking company in New York City, engineered to fit peahens. Small plastic helmets hold two cameras that send information to a backpack of equipment, which wirelessly transmits information to a computer. One infrared head camera focuses on an eye, tracking pupil movements. A second camera points ahead, giving the broad bird's-eye view.

The headgear weighs about 25 grams and takes some getting used to. If a peahen with no experience of helmets gets the full rig, Yorzinski says, "she just droops her head to the ground." Adding bits of technology gradually let Yorzinski accustom peahens to walking around, and even mating, while cameraed up.

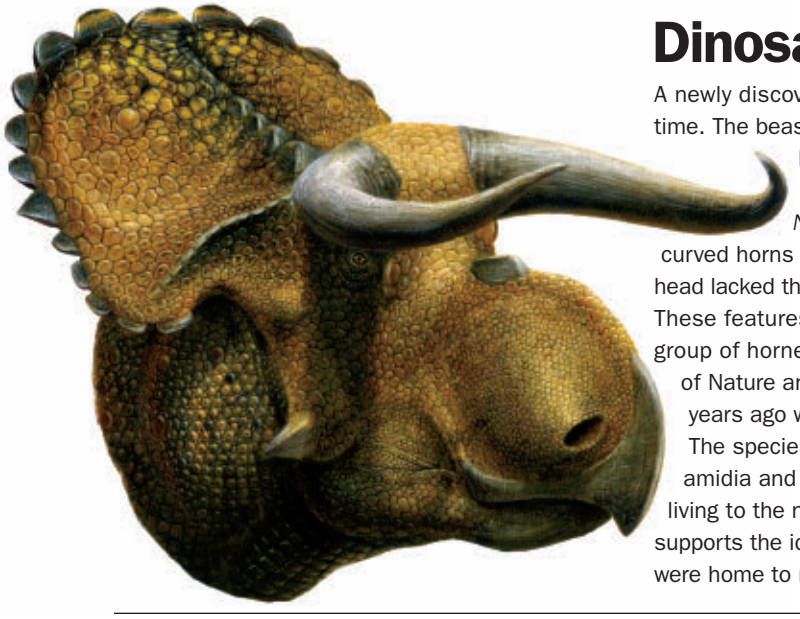
"What they've done is difficult and marvelous," says evolutionary biologist Bob Montgomerie of Queen's University in Kingston, Canada. "But it's just a first step."

Now comes a rich world of questions about how to interpret the time peahens spend looking at something. Brief glances don't necessarily mean a sight is unimportant, cautions Montgomerie, who with Roslyn Dakin at Queen's has done research on peacock displays. People can pick out information with barely a glance, such as which of two people is wearing glasses or which end of a store rack has the blue shirts instead of the orange ones. Birds may have similar abilities.

The camera setups measure where the eye aims its most sensitive area. But Montgomerie wonders whether peahen peripheral vision might be important, too.

For now, the setup requires that avian subjects can bear some weight. Yet other research technologies, such as satellite tracking devices, started big and eventually miniaturized. "It's early days," Montgomerie says. ■

Fitting peahens with eye-tracking devices demonstrates that they often glance away from the magnificent displays of their suitors.



Dinosaur had impressive schnoz

A newly discovered dinosaur species was the Cyrano de Bergerac of its time. The beast, a horned dinosaur similar to *Triceratops*, had an especially large snout, scientists report in the Sept. 7 *Proceedings of the Royal Society B*. Unearthed in 2006 in Utah, the big-nosed *Nasutoceratops titusi* (illustrated at left) also had unusually long, curved horns that grew about a meter long. A simple bony frill behind its head lacked the fancy hooks or spikes found in some other horned species. These features indicate that *N. titusi* belonged to a previously unknown group of horned dinosaurs, say Scott Sampson of the Denver Museum of Nature and Science and colleagues. *N. titusi* lived roughly 76 million years ago when Utah was part of an isolated landmass called Laramidia. The species is the first horned dino of its age found in southern Laramidia and was part of a lineage separate from the horned dinosaurs living to the north in Alaska and Canada, the researchers say. The new find supports the idea that during that time northern and southern Laramidia were home to non-overlapping sets of dinosaur species. — *Erin Wayman*

FROM TOP: COURTESY OF J. YORZINSKI; © LUKAS PANZARIN

Humans

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The inhabitants of a newly excavated village in western Iran where emmer wheat was domesticated by 9,800 years ago left behind artifacts such as this clay animal figurine.

Agriculture's roots spread east

Iranian sites suggest gradual shift to farming

By Bruce Bower

Agriculture originated across a broader swath of southwestern Asia's Fertile Crescent, and over a longer time period, than many scientists have thought, excavations in western Iran suggest.

Between 11,700 and 9,800 years ago, residents of Chogha Golan, a settlement in the foothills of Iran's Zagros Mountains, went from cultivating wild ancestors of modern crops to growing a form of domesticated wheat called emmer, say archaeobotanist Simone Riehl of the University of Tübingen, Germany, and her colleagues. Until now, most evidence of farming's origins came from sites 700 to 1,500 kilometers west of Chogha Golan, the scientists report in the July 5 *Science*.

Unlike early farming villages that archaeologists previously unearthed in what are now Turkey, the West Bank, Syria and Iraq, Chogha Golan preserves a sequence of human occupations that provide a look at how agriculture developed over many centuries.

"The whole process, from cultivating wild precursor species to cultivating domesticated plants, took 1,000 to 2,000 years at Chogha Golan," Riehl says.

Wild cereal cultivation began around the same time at sites extending east from the West Bank, Turkey, Syria and the Mediterranean island of Cyprus to Iraq and Iran, writes archaeobotanist George Willcox of Lumière University Lyon 2, France, in the same issue of *Science*.

But domestication of emmer occurred several hundred years later at Chogha Golan than at sites to its west, Willcox says.

Discoveries by Riehl's team align with other recent evidence that various crops were gradually domesticated at sites across the Fertile Crescent, with the process proceeding more slowly in some areas than in others, Dorian Fuller of University College London says. Researchers traditionally thought that a rapid shift to farming occurred in the western Fertile Crescent.

In 2009 and 2010, Riehl's team — which includes Iranian archaeologists — unearthed remains of 11 human occupations at Chogha Golan. The site's first residents arrived around 12,000 years ago, the scientists say. Within a few hundred years, village inhabitants began cultivating wild plants including barley, wheat and lentil.

A spike in the proportion of distinctively shaped domesticated emmer wheat remnants appeared almost two millennia after wild wheat cultivation had started.

Increasing numbers of clay figurines, bone implements, stone grinding tools and stone vessels turned up at the Iranian site after 11,000 years ago, signaling an expanding population.

Agricultural knowledge may have spread from one or a few western farming centers eastward as far as Iran, either due to migration of crop-growing groups or to long-distance trading, Willcox says.

Riehl suspects, however, that people in at least a few areas — probably including western Iran — launched agriculture on their own. "There was no single core area where everything started, but rather regions where domestication of plant species began more or less independently." ■

Incan teen drank, did drugs

In the month before her death as a sacrifice to Incan gods, a teenage girl drank heavily and chewed coca leaves, according to a new analysis of her mummified remains (shown). The girl may have been heavily sedated or perhaps already dead when she was entombed around 500 years ago in a shrine atop the Llullaillaco volcano on the border between Argentina and Chile. Her death was probably part of the sacrifice ritual called *capacocha*. CT scans of the girl's body exposed a mass of coca leaves tucked into her cheek (inset), an international team reports July 29 in the *Proceedings of the National Academy of Sciences.* Chemical analyses of her hair reveal that her coca use peaked about 6 months before her death, while her drinking spiked in her final weeks. The cause of her death remains unknown. —*Rachel Ehrenberg*

FROM TOP: TISARP/UNIV. OF TÜBINGEN; JOHAN REINHARD; INSET: J. REINHARD AND M.C. CERUTI, 2010

Health & Illness

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After bypass, gut burns more sugar

Changes could explain bariatric surgery's diabetes benefits

By Meghan Rosen

A beefed-up chunk of intestines might account for the rapid diabetes-improving effects of gastric bypass surgery.

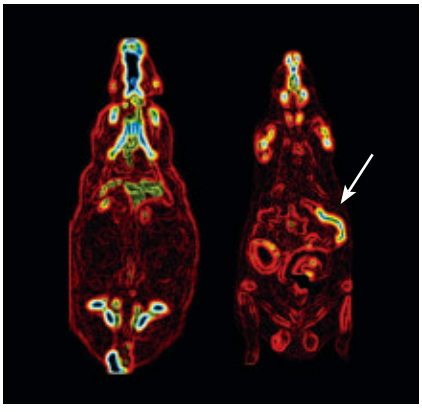
After having an operation to remodel the gut, obese rats build new intestinal tissue by drawing sugar from the blood, researchers report in the July 26 *Science*. This energy drain could explain how the most popular type of gastric bypass lowers diabetic patients' sugar levels surprisingly swiftly, says coauthor Nicholas Stylopoulos, an obesity researcher at Harvard Medical School.

It's the first time researchers have linked the effects of gastric bypass surgery to the gut's sugar use, says Blandine Laferrère, a clinical diabetes researcher at Columbia University. "It's a fascinating new piece of the puzzle," she says.

Currently, gastric bypass surgery is one of the best treatment options for morbid obesity and obesity-related diabetes, says Randy Seeley, an obesity and diabetes researcher at the University of Cincinnati. Patients typically lose weight and no longer need insulin shots to lower blood sugar. But it isn't practical to use the procedure on millions of people. Beyond the risks and complications of major surgery, Seeley says, "There aren't enough surgeons or surgery tables to treat everyone."

So researchers would like to engineer drugs or other scalpel-free treatments that mimic the effects of gastric bypass. But first, scientists have to figure out how the surgery alleviates diabetes symptoms.

In the most common type of bypass surgery, called Roux-en-Y, surgeons rearrange the gut's plumbing by hooking the middle part of the small intestine to a golf ball–sized pouch that they cut away from the patient's stomach. (Normal stomachs are roughly the size of a football, Stylopoulos says.) Food travels through the small pouch to the intestine section, which is nicknamed the Roux limb, bypassing most of the stomach and upper intestine.



After gastric bypass surgery, the intestines of an obese rat (Roux limb at right, arrow) burn more sugar (bright red and yellow) than before (left).

COURTESY OF STYLOPOULOS LABORATORY

For years, researchers assumed patients lost weight and reduced blood sugar after the surgery because they had to restrict food intake due to the smaller stomach pouch. Or perhaps the surgery reduced calorie absorption because of the intestinal bypass. "It seems so obvious," says gastroenterologist Lee Kaplan, of Massachusetts General Hospital's Weight Center. "But it's not true."

Several puzzling observations cued scientists to look for explanations. After surgery, patients' blood sugar levels tend to return to normal in just a few days — before they've lost any weight, Stylopoulos says.

And after scientists perform the surgery in rats, the animals' food preferences seem to change. Instead of eating fatty meals, the rats switch to foods with fewer calories. "That's exactly the opposite of what you would expect," Seeley says. If the drastically smaller stomach were the main driver of the weight loss, he says, animals would chow down on fatty foods to pack in calories before their pouches got too full.

Researchers have previously picked out key differences between the guts of gastric bypass patients and people who haven't had the surgery. Gastric bypass flips several hormonal switches that within weeks seem to alter patients' appetites and insulin levels (*SN: 9/10/11, p. 26*). Surgery might also nurture growth of gut microbes that help burn fat (*SN: 5/4/13, p. 10*).

But scientists still can't explain why blood sugar levels improve so quickly after surgery — often before patients have left the hospital.

To find out which organ uses up the sugar, Stylopoulos and his team injected a radioactive form of glucose into rats that had undergone bypass surgery. Compared with rats that underwent a sham surgery, rats with gastric bypasses shuttled nearly twice as much sugar to the intestine, especially to the Roux limb.

After dissecting the animals, the researchers noticed that the Roux limb looked big. It had grown at least 40 percent thicker than the intestine of normal rats, Stylopoulos says.

The burly new gut section cranks up metabolism and starts making a protein that grabs glucose from the blood, the researchers found. Then the gut burns through the sugar to build the new intestinal tissue.

Stylopoulos and his colleagues are trying to figure out why surgery makes the Roux limb get so big. The researchers suspect that undigested food dumped into the intestines from the stomach pouch might somehow trigger the growth.

The research helps quash the idea that gastric bypass surgery's effects stem simply from limiting caloric intake. "It's one more nail in the coffin," Seeley says.

Kaplan agrees: "That body is dead and buried." ■

"If you publish lunar stuff, you are going to be put in the 'lunatic' corner and not be considered a serious sleep researcher anymore." —CHRISTIAN CAJOCHEN

Full moon may mean less sleep

Slumber waxes and wanes with lunar cycles, study finds

By Cristy Gelling

A full moon deprives people of sleep even when they are shielded from moonlight in a windowless lab, a new study suggests.

People snoozed less deeply within four nights of a full moon than during other parts of the lunar cycle, researchers report July 25 in *Current Biology*. The authors suggest that humans may have internal clocks that track the lunar cycle, much like circadian clocks that sync up with the rise and fall of the sun.

Christian Cajochen of the University of Basel in Switzerland and his colleagues reanalyzed sleep data they had collected over several years from 33 people who had each spent several days half-reclining in bed under constant dim light. Looking at only the second night of each participant's stay, the researchers found that around the full moon, participants took about five extra minutes to nod off, slept for about 20 minutes less each night and slept less deeply.

The team was surprised to uncover the lunar rhythm, and Cajochen was initially reluctant to share the findings. "If you publish lunar stuff, you are going to be put in the 'lunatic' corner and not be considered a serious sleep researcher anymore," he says.

But other scientists praise the work. "This was done under really controlled laboratory conditions," says Kenneth Wright, a sleep researcher at the University of Colorado Boulder. It's the first laboratory study to detect an influence of the moon on human sleep, he says.

The result needs explanation. The shifting gravitational effects of the moon are too weak to influence human bodies, Cajochen says. His hypothesis is that humans have an internal body clock synchronized to the phases of the moon.

An alternative is that participants' light exposure before the study may have affected their circadian clocks enough to disturb their sleep in the lab. People's circadian clocks are particularly sensitive to light at night, so extra moonlight before the study might be the simplest explanation for differences during it, says David Dinges, a sleep researcher at the University of Pennsylvania.

Scientists also aren't sure why humans might have evolved lunar rhythms, though some marine organisms have lunar clocks to keep track of tides, Dinges says. "Stay tuned," he says. "There's going to be a lot more research to nail this down." ■

Genes & Cells

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Tiny livers made from stem cells

Critics of new study say work is preliminary and unconvincing

By Meghan Rosen

A minicluster of lab-grown human cells that sprouts into liver tissue could one day nix the need for organ donors. But the promise has drawn both praise and criticism, with some scientists arguing that the results are unconvincing.

Using a new technique to craft the tiny organs, stem cell biologist Takanori Takebe of Yokohama City University in Japan and his colleagues report having created human livers in a dish. After transplantation into mice, the liver cells hooked up to blood vessels and behaved like functional livers, Takebe's team reports July 3 in *Nature*.

"It's a tantalizing study," says Ira Fox, a clinician and transplant scientist at Children's Hospital of Pittsburgh. "But the real issue is that almost nothing they've done is complete."

In the last few years, scientists have figured out how to conjure up different cell types from induced pluripotent stem cells, or iPS cells. These mature cells have been reprogrammed back to an embryonic-like state. Dosing them with a chemical concoction can transform them into just about any cell type, including liver cells.

But shepherding iPS cells into adulthood isn't easy. So Takebe and his colleagues worked on a new method that encourages the liver cells to grow up into organs.

After mixing lab-made liver cells with cells collected from umbilical cords, the team noticed that the commingled cells began to clump together, as if reeled in by invisible wires. "The cells self-assembled and organized into a liver bud," says Ken Zaret, a developmental biologist at the University of Pennsylvania in Philadelphia. "It's a remarkable discovery."

The buds, three-dimensional lumps of cells that resemble a rudimentary liver, pumped out proteins and broke down drugs. But stem cell biologist Stephen Duncan says he is skeptical that Takebe's liver buds are much better than cells made by other methods. Liver cells harvested from humans also have basic function, as do other liver cells that scientists have made from iPS cells. "It's pretty much what I would expect to happen," says Duncan, of the Medical College of Wisconsin in Milwaukee.

And an experiment meant to showcase the new buds' value is not convincing, Duncan says. In that experiment, Takebe tried to prove that the buds can save mice with damaged livers. The researchers grafted buds about the size of a pencil eraser into the abdomens of living mice. Then Takebe's team damaged the mouse livers, leaving the human-derived buds intact. After one month, about 90 percent of the mice with buds stayed alive, compared with just 20 percent of the mice without bud transplants.

But the researchers watched the animals for too short a time, says vascular biologist Shahin Rafii of Cornell University. Since the experiment ended after a month, the researchers can't say whether the mice with buds would have lived much longer.

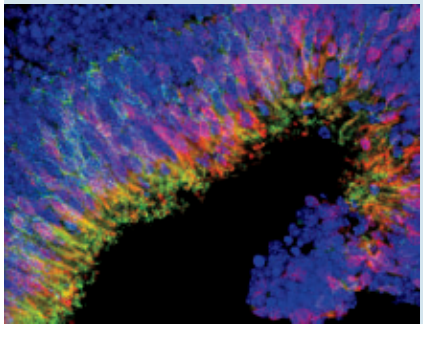
What's more, Rafii says, iPS cells are known for forming tumors. Only a longer experiment would show whether the buds cause cancer.

"It's not the perfect liver," Takebe acknowledges. He says he would like to improve the buds and make a more sophisticated organ that includes a bile-duct system.

Still, Fox says that Takebe's buds seem to be a little better at making protein than cells other researchers have made. "It's a cute study and I think it's going to advance the field," he says. "But is it life changing? No. It's an incremental improvement." ■

Mouse retinas grown in lab

Retina cells can be grown from mouse stem cells in the laboratory and become working parts of a mouse's eye, a new study indicates. Last year, Robin Ali of University College London and colleagues demonstrated that immature retina cells from newborn mice could form rod cells — a type of light-gathering cell — that wire into the retinas of night-blind adult mice (*SN: 5/19/12, p. 13*). But for the technology to restore sight in people, such as those with macular degeneration, the researchers needed to come up with a ready source of immature retinal cells. Ali and colleagues report July 21 in *Nature Biotechnology* that they have devised a way to coax mouse embryonic stem cells to form primitive retinas in a laboratory dish (one shown, with proteins that collect and transmit light signals in green and red). The trick, Ali's team found, was to embed the stem cells in a gel, which provided cues to mimic normal developmental signals. The stem cells formed primitive retinas from which the researchers harvested cells to inject into the eyes of adult mice. A small number of those lab-grown cells matured into rods that formed connections with the mice's optical nerves. — *Tina Hesman Saey*



ANAI GONZALEZ-CORDERO

"With the H5N1 controversy, some people claimed we were not sufficiently transparent." —RON FOUCHIER

Flagellum failure lets bacteria steer

Buckling of appendage drives tiny two-point turn

By Cristy Gelling

When headed the wrong way, some bacteria turn by letting their propellers flop.

The newly discovered turning mechanism explains how a marine bacterium can control its direction using only a single flagellum, a stiff, rotating appendage that propels the cell forward. A successful turn depends on a mechanical characteristic that engineers might consider a failure if the flagellum were human-made: the tendency of flexible materials to buckle under pressure.

A multiflagellated bacterium like *Escherichia coli* turns by releasing one flagellum from a spinning bundle, which unwinds and sends the cell tumbling in a new direction. But 90 percent of mobile marine bacteria have only one flagellum. In the past, scientists thought that these one-prop microbes could swim only in a straight line, says coauthor Roman Stocker of MIT. Then in 2011, a team led by Xiao-Lun Wu of the University of Pittsburgh showed that the single-flagellum bacterium *Vibrio alginolyticus* can make sharp turns. To change course, the cell backs up a little and swings its flagellum to one side, like a boat rudder.

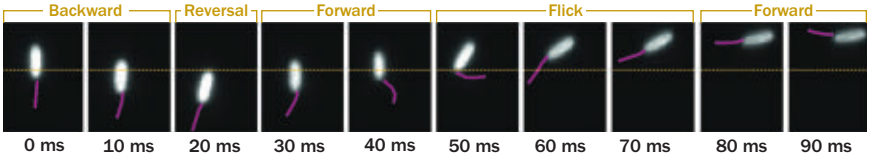
But Wu's team could not say how the bacterium controlled the flagellum flick. In research published July 7 in *Nature Physics*, Stocker's team answered this question by filming *V. alginolyticus* with a high-speed video camera. His team found a crucial clue in the timing of the flick: It always happens about 10 milliseconds after the bacterium starts moving forward again.

The team guessed that the forward movement compresses the flagellar "hook," the small flexible region that connects the flagellum to the cell. In reverse motion, the flagellum pulls on the cell; when the cell then moves forward, the flagellum goes from pulling to pushing. The team showed that above a certain speed the hook buckles, causing the flagellum to swing to one side.

But the researchers also found that the bacterium's normal swimming speed was just as high as the speed that caused the flagellum to flop. "It should fail all the time," Stocker says. "Whenever it tries to swim forward, it should just buckle." Instead, they found that during steady forward swimming, the hook becomes much firmer. Stocker thinks the rotation of the flagellum may stiffen it.

The microbe's minimalist approach to turning could work for tiny robots, says Bradley Nelson of the Institute of Robotics and Intelligent Systems at ETH Zurich. "It certainly provides inspiration to us to consider designing artificial flagella that also exhibit buckling." ■

Tiny rudder Over the course of 90 milliseconds, a bacterial cell (*Vibrio alginolyticus*) makes a hard right turn. It does so by backing up and then moving forward, causing the base of its flagellum to buckle and flick to the side.



K. SON ET AL./NATURE PHYSICS 2013

Flu labs to repeat thorny research

Scientists announce intent to make transmissible H7N9

By Tina Hesman Saey

After stirring up controversy by creating airborne-transmissible versions of one deadly bird flu virus, scientists intend to do it again with another. This time, the experiments will involve H7N9, a new strain of influenza that infected 134 people in China this year, killing 43.

The experiments involve mutating the virus or mixing it with other flu viruses to create ones that can do things the existing virus can't currently do, such as spread through the air from person to person. Information gained from the experiments could help scientists understand how bird flu adapts to live in people, the potential of the virus to cause a pandemic and how best to design vaccines and antiviral therapies, say Ron Fouchier of Erasmus Medical Center in Rotterdam, the Netherlands, Yoshihiro Kawaoka of the University of Wisconsin–Madison and 20 coauthors. Similar research on the H5N1 virus by Fouchier and Kawaoka went unpublished for half a year due to concerns that terrorists could use the information to make a biological weapon.

The new announcement, published August 7 in both *Nature* and *Science*, is an attempt to be upfront about the research, Fouchier says. "With the H5N1 controversy, some people claimed we were not sufficiently transparent about what research we did, why we did it and what risk mitigation measures were in place," he says. "We would like to prevent such allegations this time."

But the letter of intent has other virologists mystified about its purpose. The experiments the researchers propose are important and should be done, says Vincent Racaniello, a virologist at Columbia University. "I think they should just do them, and not talk about it," he says.

Mind & Brain

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Light pulse puts false memories in mouse brains

Tweaking just a few neurons makes imagined connections

By Jessica Shugart

Just a tiny fraction of the brain's neurons firing at the wrong time may be able to make a figment of the imagination seem real. Scientists have come to that conclusion after implanting false memories into the brains of mice.

"It's fairly astounding," says neurobiologist Mark Mayford of the Scripps Research Institute in La Jolla, Calif., who was not involved in the research. "Stimulating a small amount of cells can put a thought into an animal's head."

Neurobiologists have known for years that the hippocampus, a seahorse-shaped region deep in the brain, plays a role in learning and memory. And countless studies have shown that when it comes to recalling events, humans tend to make mistakes. (Of the first 250 U.S. prisoners exonerated based on DNA evidence, about three-quarters were originally convicted at least in part because of faulty eyewitness testimony.)

But exactly how neurons in the hippocampus harbor and retrieve memories — and where they go wrong — has been difficult to understand without observing an example in animals, says Susumu Tonegawa, a neuroscientist at MIT.

To understand how neurons create memories, Tonegawa and his colleagues used optogenetics. In the relatively new technique, researchers implant tiny optical fibers in the brains of living animals. The fibers deliver pulses of light directly to neurons that have been genetically engineered to react to the flashes.

In previous work, the researchers engineered mice with neurons that are sensitive to blue light — but only when a gene that turns on during new experiences is active. The team then showed that flashing the neurons with light alone forced a previously created memory of a new experience to pop into a mouse's head (*SN: 4/21/12, p. 10*). Neurons in a small region of the hippocampus called the dentate gyrus were particularly adept at triggering memories this way.

For the new study, Tonegawa's team tested if neurons in the dentate gyrus could create a memory of an event that never happened. The researchers allowed the mice to explore a new cage, switching on their memory-forming neurons.

The mice then entered a second cage where they received a series of mild electric shocks on their feet, making them fear the new place. At the same time, the researchers delivered pulses of blue light to the animals' brains to conjure up memories of the first cage. When back in the safe environment of the first cage, the animals froze in fear even though nothing upsetting had ever occurred there.

The false memories could be produced by stimulating just 3 percent of the cells in the dentate gyrus — about 30,000 cells, the team reports in the July 26 *Science*. "It is really surprising that these things can be done by stimulating this relatively small amount of cells," Tonegawa says. The researchers don't know the smallest number of cells capable of making a memory.

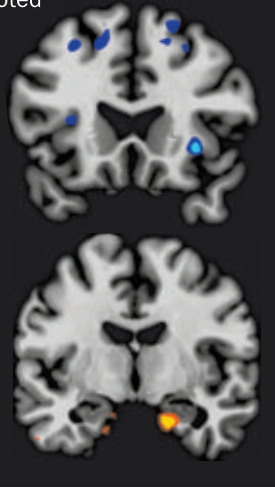
Tonegawa says pleasurable experiences probably alter memories just as much as fearful ones do. The team is testing that hypothesis by looking at how memories change when male mice spend time with females.

The study could help scientists understand false memories in humans, Tonegawa says, but the jumble of memories stored in the human brain is more complex than that of a caged mouse. Along with the evolution of higher thought and imagination, Tonegawa says, came the ability of the human mind to create elaborate memories, some of which are false.

"This tendency to form false memories would probably increase as animals evolved from rodent to monkey to human," Tonegawa says. "Without this very rich mind activity which allows us to be a creative species, we wouldn't have art or culture. But we're paying a tax for it." ■

Sleeplessness weakens resolve

All-nighters tweak the brain, weakening willpower and making people more likely to succumb to double bacon cheeseburgers, a new study suggests. The results help explain the link researchers have noted between sleep loss and obesity. After staying awake through the night in a sleep lab, 23 people looked at pictures of food while undergoing brain scans. When calorie-laden foods such as doughnuts and potato chips appeared, brain activity changed in two ways: People showed a diminished response in their frontal and insular cortices (top) — regions involved in making decisions about what to eat — and a greater response in the amygdala (bottom), thought to promote eating. What's more, sleep deprivation boosted the people's desire for junk food, Stephanie Greer of the University of California, Berkeley and colleagues report August 6 in *Nature Communications*. — *Laura Sanders*



MATTHEW WALKER *ET AL*

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IMPACTFUL DISTRACTION

Talking while driving poses dangers that people seem unable to see

By Nathan Seppa

"Keep your eyes on the road, your hands upon the wheel."

The late rock and roll singer Jim Morrison was not a poster boy for public safety — and was no authority on safe driving. After all, later in "Roadhouse Blues," he has beer for breakfast. But the opening line of that Doors' song still resonates as sound guidance.

If only such good advice could stand the test of time. "Roadhouse Blues" hit the airwaves in 1970, long before the unlikely marriage of driving and talking on a cell phone. Millions of people now routinely conduct remote conversations while driving, despite research showing that it's dangerous — even with two eyes on the road and both hands upon the wheel.

It turns out that hands don't matter. It's the conversation that can be lethal. Cell phone conversations impede what a driver sees and processes, a number of studies have shown. That, in turn, slows reactions and other faculties.

This distracted state should be familiar to everyone. "That's why you can drive home and not remember having driven home," says Daniel Simons, a psychologist at the University of Illinois at Urbana-Champaign. "Just because you look at something doesn't mean you see it."

Simons has shown that people assigned to observe certain activities in a lab setting can totally miss other events occurring in the very same space. The on-road versions of such blind spots show up when drivers engaged in a cell phone conversation fail to look at side streets or watch for pedestrians. This distraction may seem subtle and even fleeting, but it takes a toll: The risk of an accident quadruples when the driver is on the phone, studies have suggested.

Research into driving behavior has produced a three-way disconnect between scientists who study it, legislators who regulate it and drivers who talk on the phone. Majorities of all groups acknowledge that texting while driving is risky (see sidebar, Page 30). Fewer accept that chatting on a hand-held cell phone while behind the wheel is dangerous. And most drivers and state legislators don't worry at all about hands-free calls.

As a result, the science of distracted driving has run well ahead of policy. Not a single U.S. state bans hands-free cell phone talking for most adult drivers. Some states limit hand-held cell phone use, but many others apply bans to only bus drivers or novices. Three states have no restrictions whatsoever on calling or even texting while driving.

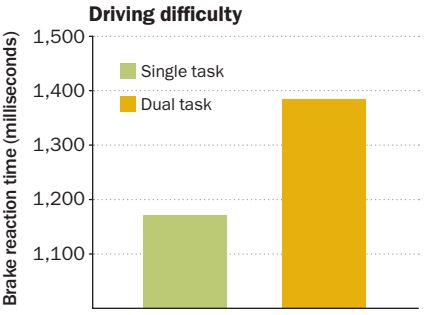
Public views are also out of sync with the scientific findings, in part because it's easy and usually harmless to drive while distracted. And many people assume that they can successfully perform multiple

tasks simultaneously. But researchers are challenging that assumption. David Strayer, a cognitive neuroscientist at the University of Utah in Salt Lake City, has found that such supertaskers do exist, but comprise only 2.5 percent of people tested. As for the other 97.5 percent, he says, "I suspect they are kind of kidding themselves."

Split attention

Data began showing up in the 1990s suggesting that cell phones and driving are a poor mix. In 1997, researchers at Sunnybrook Health Sciences Centre in Toronto combed through nearly 27,000 cell phone calls during a 14-month period made by hundreds of drivers who had been in crashes. The average risk of getting into a collision was four times as great when people were on the phone than when they weren't. Phones with a hands-free option offered no advantage, the researchers reported in the *New England Journal of Medicine*.

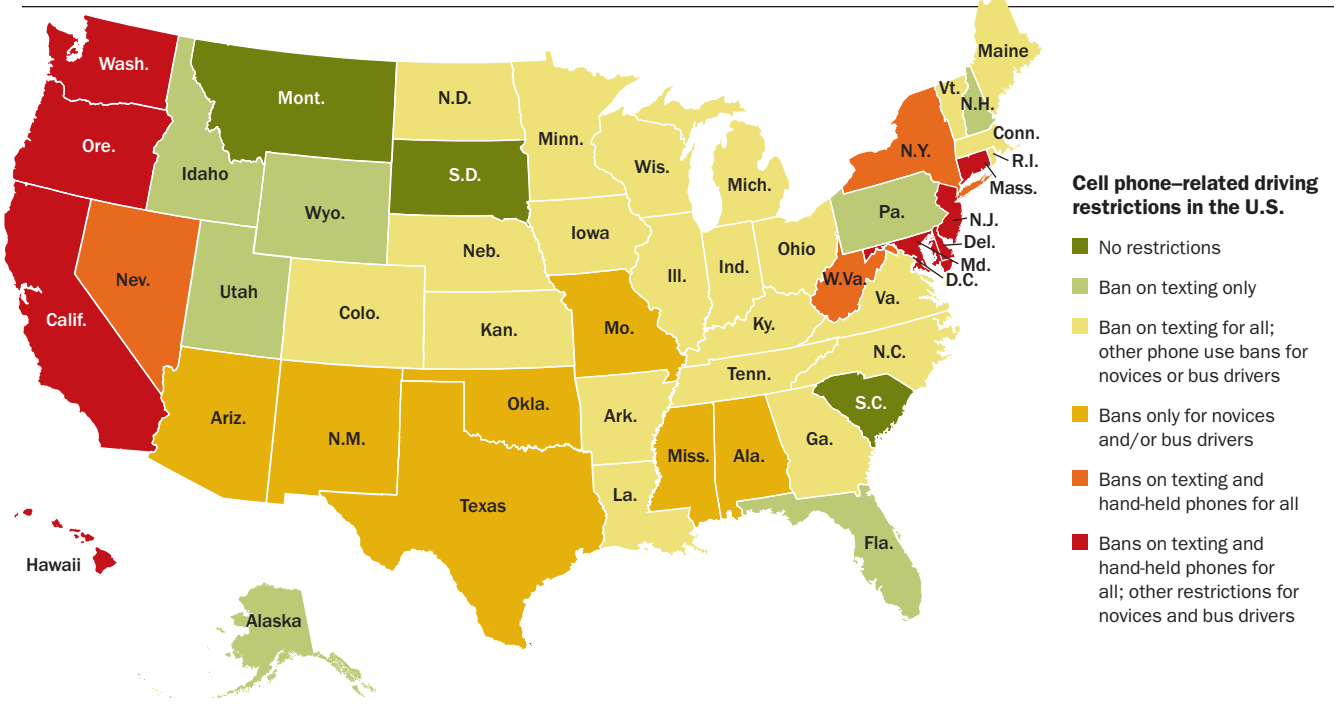
The problem isn't confined to North America. Scientists in Perth, Australia, checked on people who owned cell phones and who wound up in emergency rooms after car crashes. The researchers compared the likelihood of being on the cell phone before the crash with cell phone use during an uneventful drive at the same time of day one week earlier. The patients were four times as likely to have been on the phone during the smashup, the researchers reported in 2005 in *BMJ*.



Braking badly Undergraduate students in a driving simulator are slower to brake when given auditory tasks via a hands-free cell phone while driving (dual task) compared with just driving (single task). SOURCE: J.M. WATSON AND D.L. STRAYER/*PSYCHONOMIC BULLETIN & REVIEW* 2010

Such observational studies don't establish cause and effect. So scientists at Complutense University of Madrid actually got into cars with volunteer drivers and distracted them. The researchers had drivers make phone calls using hands-free phones that needed only the push of a button to work. Special vision-tracking devices showed that conversations requiring extra thought or concentration diminished drivers' extent of visual scanning, speed control, detection of warning flashers and decision-making ability. That study, which appeared in *Transportation Research Part F* in 2002, still stands as one of the clearest examples of what it means not to give full attention to the road.

Since then, Strayer and his colleagues have fine-tuned understanding of just how incapacitated drivers are when on the phone. In June, Strayer's team described monitoring 32 drivers in city traffic and asking them to listen to a radio, have a conversation with a passenger, use a hand-held phone, use a hands-free phone or operate voice-to-text



Inconsistent restrictions A pastiche of state laws addresses driving while texting or making cell phone calls, hand-held or hands-free. Eleven states and the District of Columbia have banned all drivers from using hand-held cell phones, and 41 states plus D.C. have banned drivers from texting. None has banned drivers' general use of hands-free phones, but 32 states and D.C. restrict novice drivers from using hands-free phones and 19 states and D.C. ban bus drivers from using them. Oklahoma, Kentucky, Louisiana and Mississippi prohibit localities from enacting their own distracted driving bans. SOURCE: U.S. DEPARTMENT OF TRANSPORTATION

VECTORAPZ, ADAPTED BY S. EGTS

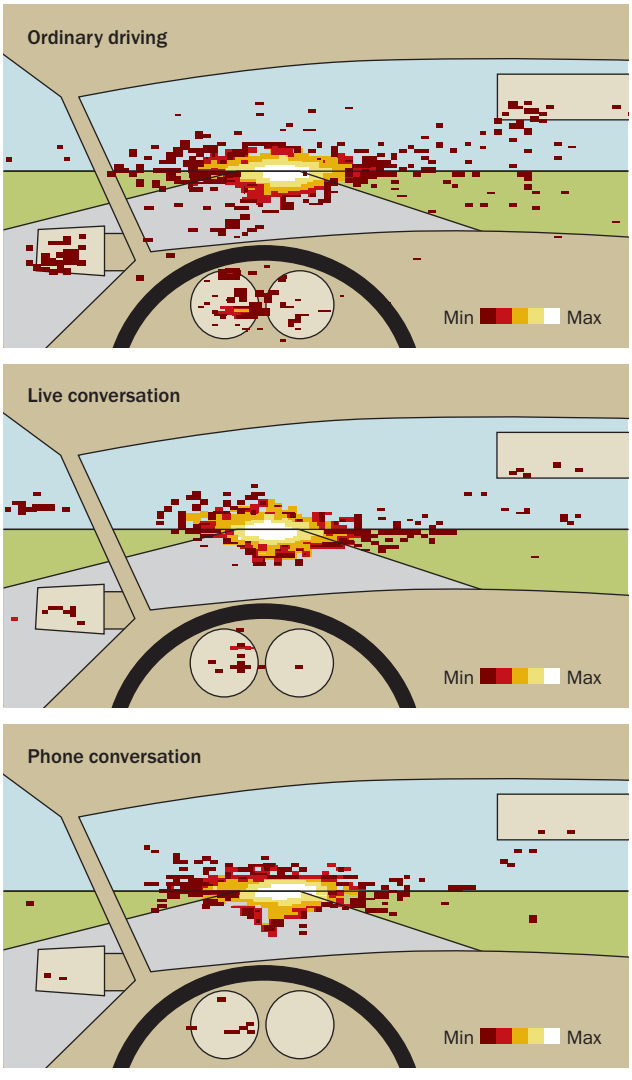
technology. Compared with driving free of any distractions, radio was the least problematic, while voice-to-text was the most. The three conversations were about equally distracting and led to substantially degraded driving, marked by less scanning for potential hazards, monitoring mirrors less regularly and showing poor surveillance at pedestrian crosswalks and four-way stops. This effect occurred even though the tasks didn't require the drivers to take their eyes off the road.

"A cell phone draws attention away from the routines that would provide a good representation of the driving environment," Strayer says.

Simons calls it inattentional blindness: looking at something and not seeing it. In the most famous demonstration of this phenomenon, six people — three dressed in black and three in white — spend several minutes moving about a room and tossing a ball to each other. Test subjects observe this activity in four 75-second videotapes and are tasked with counting how many times one team passes the ball.

During each video, a brief event occurs that is out of context but plain to see. Either a woman walks across the room holding an umbrella or a person in a gorilla costume passes through. These events each take about five seconds. But when asked afterward if they noticed "anything unusual," roughly half of the observers don't recall seeing the gorilla or the umbrella-toting woman. When Simons and a colleague repeated the test with other observers — this time with the gorilla stopping to face the camera and thump its chest — only six of 12 people noticed it.

The study, published in 1999 in *Perception*, established that people viewing a particular space and concentrating on a task can miss shockingly obvious things (*SN: 5/21/11, p. 16*). "It reveals how limited our awareness of our environment is, and driving is one context where it matters a lot," Simons says. Drivers need to be ready for the unexpected. The more distracted a person is, he says, "the less likely you are to see the unexpected."



Tunnel vision Eye-tracking equipment reveals the broad coverage of drivers' gazes without distraction (top). Doing an auditory task requiring a live conversation with an experimenter in the car (middle) or over a cell phone (bottom) limits the extent of drivers' attentiveness.
SOURCE: L. NUNES AND M.A. RECARTE/*TRANSPORTATION RESEARCH PART F* 2002

Cognitive demand

It's all part of what scientists call cognitive load. "When we communicate with a person we can't see, we create a mental image of them," says sociologist Clifford Nass of Stanford University. The task occupies more available brain power than passively listening to a radio, which requires no interaction.

The more remote the conversation, the more taxing it is. Nass says he realized this after his team told drivers in a test simulation that a voice piped into the simulator was coming from nearby in some cases and from faraway Chicago in others. Although the voice was identical, "people drove significantly worse when they thought it was from Chicago," he says. The drivers had to fill in more context.

Paul Atchley, a cognitive psychologist at the University of Kansas in Lawrence, says having a remote conversation and driving a car means performing two tasks at once, what some people consider multitasking. But the vast majority of people don't really multitask, he says — they toggle back and forth between tasks. In so doing, something has to give. When a conversation becomes more dense and complicated, cognitive demand devoted to it increases and that means less brainpower is available for driving.

These decrements change how people drive, and it doesn't matter where their hands are. A team from Canada found in 2007 that drivers asked to do math problems via cell phone with both hands on the wheel spent more time looking straight ahead and less time scanning the periphery of their vision field — even while cruising through intersections — than people not talking on a phone did. The drivers also slammed on the brakes harder when traffic got sticky, the researchers reported in *Accident Analysis & Prevention*.

Because driving is often boring and uneventful, drivers get away with these lapses most of the time. That makes the

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concept of cognitive burden difficult to convey, Atchley says. "It's hard to explain why talking is dangerous."

Strayer says people should know better. They experience blank spots in their driving all the time, sometimes at 60 miles per hour. But they fail to perceive the risk of these episodes because these are the very moments when people lack "metacognitive awareness." That is, they temporarily lose the ability to step outside themselves and monitor how they are doing. They can't take stock of their own behavior. Metacognitive awareness is important to safe driving because it provides the ability to snap to attention, scan intersections, assess cars far ahead, check the dashboard and assess how well one is driving.

When metacognitive awareness loses out to a cell phone call, Strayer says, "people are not noticing that they are driving badly." Nor do they recall it later. That's why even drivers who accept in principle the risks of distracted driving often don't apply the lesson to themselves. In the January-March issue of *Journal of Trauma Nursing*, researchers reported that 63 percent of survey respondents still believe they could drive safely while distracted.

It's the same reason people can acknowledge statistics that prove that airplane travel is safer than driving, Strayer says, but decide to drive because they assume things will be OK if they themselves are behind the wheel.

Risky driving

Jeffrey Coben, an emergency room physician at West Virginia University in Morgantown, has seen the results of plenty of car accidents. He says injuries seldom occur because of chance events, such as equipment failure or lightning strikes. "Vehicle injuries are not accidents. They are predictable and preventable," he says. "Every crash is an interaction between an individual operating the vehicle and the environment it's in." The more distractions involved, he says, the greater the risk.

British scientist James Reason, a specialist in risk analysis, developed what he dubbed the "Swiss cheese" model of risk. He applied it to industrial environments such as nuclear power plants and aircraft carriers. Strayer argues that it fits with distracted driving, too.

The model suggests that a person operating a piece of equipment seldom has an accident, thanks to layers of protection reducing the odds of that happening. Reason portrayed each layer as a slice of indestructible cheese standing between the individual and disaster. "In an ideal world," he wrote in *BMJ* in 2000, "each defensive layer would be intact. In reality, however, they are more like slices of Swiss cheese." When holes in different slices align, a situation becomes hazardous.

In driving, keen attention is often the protective slice that enables the driver to swerve out of harm's way. But that's the very slice that is degraded by distractions. Other intact layers might allow a driver to escape harm, such as scant traffic on the road. "An impaired driver may get home without crashing," Strayer says. Most usually do.

But the safety of a distracted trip hinges on factors out of the driver's control. The roads might be wet. Traffic could be heavy. There's drowsiness, road construction, darkness, a novice driver in the oncoming lane. Sometimes there are lots of holes in the cheese. "You need to be able to react," Strayer says, "because you never know when the other holes will line up."

Safety versus freedom

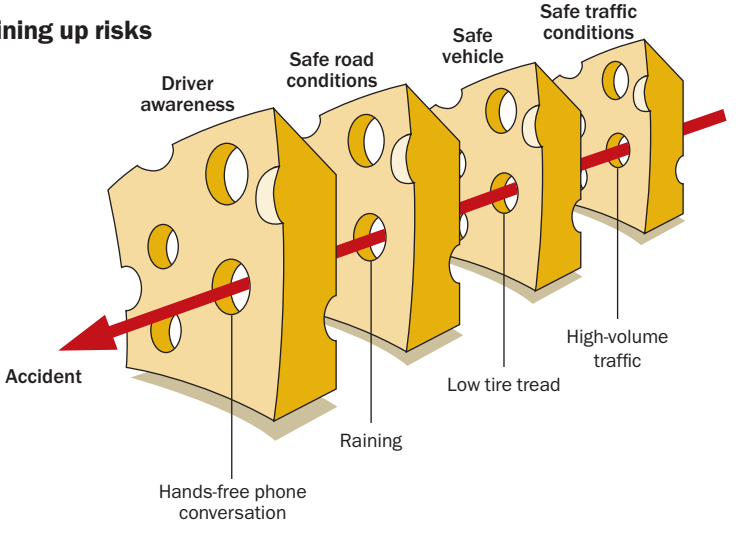
Sometime in the future, driving and cell phones may get a divorce. "We might actually look back and say, 'Well *that* was really stupid,' " Strayer says. "But I don't know if that's going to happen."

Coben favors a strict ban on phone calls while driving but anticipates resistance. "We've had similar discussions in other areas. People argued viciously against seat belts, air bags, too," he says. "Public safety trumps personal freedom in this case."

But people often don't readily accept science that angers or inconveniences them, Nass says. And there are built-in obstacles to cell phone regulation. A generation of young adults raised on elec-tronic devices has a high affinity for the gadgets and engages in less face-to-face contact than was once the norm, he says. "Paying attention is less important and is taken less seriously than it used to be, and that's very consequential for driving. The windshield is just another screen for some young people."

Holes in the safety net Even with multiple safeguards, terrible accidents happen, a reality captured in the "Swiss cheese" model of risk, developed by British scientist James Reason. While a hole in one protective "slice" doesn't normally lead to a bad outcome, an alignment of holes can be catastrophic. Distracted driving adds a hole to the awareness slice, a slice that also includes holes due to drowsiness or alcohol use. SOURCE: J. REASON/*BMJ* 2000

Lining up risks



Texting means trouble

While all distractions impair a driver to some degree, texting while driving draws eyes away from the road for longer than fiddling with the radio or even dialing on a cell phone. Since texting adds to risks already caused by inattention, it takes the prize for distracting drivers the most.

A 2006 study in Australia found that texting quadrupled the time that young drivers took their eyes off the road, leading to swerving and other poor driving. Texting while operating a driving simulator delayed reaction time, and texting while driving increased crash risk by 23-fold in a study of truck drivers at Virginia Tech.

James Hedlund, a consultant in Ithaca, N.Y., for the Governors Highway Safety Association, says regulation of electronic devices involves balancing how much risk society will accept in exchange for the convenience or benefit they provide—and texting is losing out.

Texting has become the whipping boy of distracted-driving regulators, who have now banned it in 41 states and the District of Columbia. AT&T, in recent cell phone billing mailers, cites the National Safety Council in announcing: "100,000+ crashes a year involve drivers who are texting—no text is worth the risk." Public service announcements on television describe real-life tragedies of accidents caused by texting.

But the texting war is far from over. Recent analyses show that more than 40 percent of high school drivers surveyed had texted while driving in the previous month. "There's a very strong generational issue here," Hedlund says. Texting has become routine for people under age 25 or 30, he says. "It's so ingrained into daily life that it might be really tough to separate that from driving."

While researchers applaud bans on texting while driving, some have concerns that state legislators are pouncing on texting while leaving other distractions unregulated. "People just choose the easiest target," says lawyer Lawrence Gostin of the Georgetown University law school. The wide variation among state laws nonetheless reveals a clear trend—a clampdown on texting with no uniform bans on hands-free calling.

"It sends a very bad message," Gostin says, "that we don't take this very seriously." —*Nathan Seppa*

There have been some changes in attitudes—many people have turned against texting while driving and consider it a problem. But other distractions still get mild scofflaw treatment. Atchley's team asked volunteers to read hypothetical car-crash scenarios, rate the responsibility of the drivers and mete out justice. The participants reviled drivers who were drunk or texting but handed down harsher "sentences" to the drunk drivers. Drivers responsible for crashes while talking on cell phones got lower fines and milder jail time that was similar to that given to drivers responsible for crashes while not distracted at all.

Katie Womack, a traffic safety researcher at Texas A&M University in College Station, sees parallels between the regulatory histories of distracted and drunk driving. Despite the terrible consequences of drunk driving, she says, at one time "it was still socially acceptable and it took an entire social movement to effect a change."

There seems to be no social movement against distracted driving afoot in the United States yet. Womack and her colleagues surveyed people visiting Texas motor vehicle departments and asked them to rank how dangerous other drivers' behaviors were. Using a cell phone while driving came in second-to-last out of nine items, with driving well under the speed limit rated as only slightly less dangerous, she says.

With a lack of social pressure, many states have felt little push to clamp down on the use of cell phones while driving. But states certainly have the power to do so, says Lawrence Gostin, a lawyer at Georgetown University in Washington, D.C. In the eyes of the law, he says, driving is a privilege, not a right.

Gostin has concerns about the future. It may get worse before it gets better. "Cars are already being engineered and redesigned in dramatic ways to increase connectivity," he says. "This translates into increased distraction. I fear you have the worst combination of industry making big profits on it and consumers really wanting it." ■

Ratings of responsibility and proposed penalties

		Drinking	Talking	Texting
No laws	Responsibility	5.86	5.86	6.20
	Fines	~$3,200	~$2,400	~$2,500
	Jail time	2–3 days	<8 hrs	1 day
With laws	Responsibility	5.86	5.50	6.33
	Fines	~$2,100	~$750	~$850
	Jail time	4–5 days	<8 hrs	1–2 days

SOURCE: P. ATCHLEY *ET AL/ACCIDENT ANALYSIS & PREVENTION* 2012

Crime and punishment

Norms have shifted regarding the acceptability of drunk driving, but changing how people perceive distracted driving may be harder. When asked to rate on a scale of 1 to 7 how responsible a driver is for a crash, college students recognize the risk of distraction and rate the driver as responsible. But students are more lenient in meting out fines and jail time—even when the scenario includes laws against the behavior—perhaps because so many college-age kids and their peers talk and text while driving (averages shown).

Explore more

■ P. Jacobson and L. Gostin. Reducing distracted driving: Regulation and education to avert traffic injuries and fatalities. *JAMA*. April 14, 2010.

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Scientists revive search for new rubber sources

By Cristy Gelling

In the summer of 2008, Jan Kirschner led an expedition to the highlands of southeastern Kazakhstan in search of a dandelion. Not just any dandelion: He was hunting kok-saghyz, a flower much like the common roadside weed that flourishes all over the world. But kok-saghyz (pronounced "coke-suh-GEEZ") grows only in remote valleys of the Tien Shan Mountains.

Kirschner, a Czech taxonomist, was not the only dandelion hunter to visit Central Asia around that time. An expedition from the U.S. Department of Agriculture scoured the same valleys just a few weeks behind him. Two years earlier, an Israeli-Kazakh team had visited the area and concluded that kok-saghyz was worryingly rare.

Scientists from around the world aren't traveling to remote corners of Central Asia out of concern for the region's dandelion biodiversity. Their motivation is a curious substance in the flowers' roots: rubber.

Bendable, stretchable and waterproof, rubber is one of the essential materials of the modern world. Each year, manufacturers transform more than 25 million tons of rubber into things like tires, shoes, adhesives, paint, hoses, gaskets, gloves, condoms, machine belts, phone protectors and yoga mats. Without rubber, trucks would never drive and planes could never land.

But for all its importance, there are only two economically important sources of rubber. The first is *Hevea brasiliensis*, a tree that is grown at commercial scale in only a few countries. The second source is fossil fuels, which have their own well-known supply issues.

Over the last century, the precarious nature of the global rubber supply has spawned repeated efforts to find a substitute source of the material. These campaigns have almost always started — and ended — with supply crises like the Arab oil embargo or World War II, when the Japanese occupation of Asian plantations cut off supplies of natural rubber to the Allies and synthetic rubber saved the day.

Now, with various economic and environmental forces threatening to squeeze rubber supplies again, researchers like Kirschner are attempting to revive defunct research programs while other scientists try to harness biotechnology to find alternative sources of rubber.

Natural rubber comes from latex, a sticky, milky goop made by some plants as a defense against herbivores. When an insect (or rubber harvester) pierces the plant tissue, latex oozes out, delivering natural pesticides, trapping bugs and sealing the wound.

Only once latex dries does it become rubbery. Long, flexible chains of polyisoprene, which is made up of many individual units of the hydrocarbon isoprene, form an interlocked tangle that allows rubber to compress, stretch and bend without breaking.

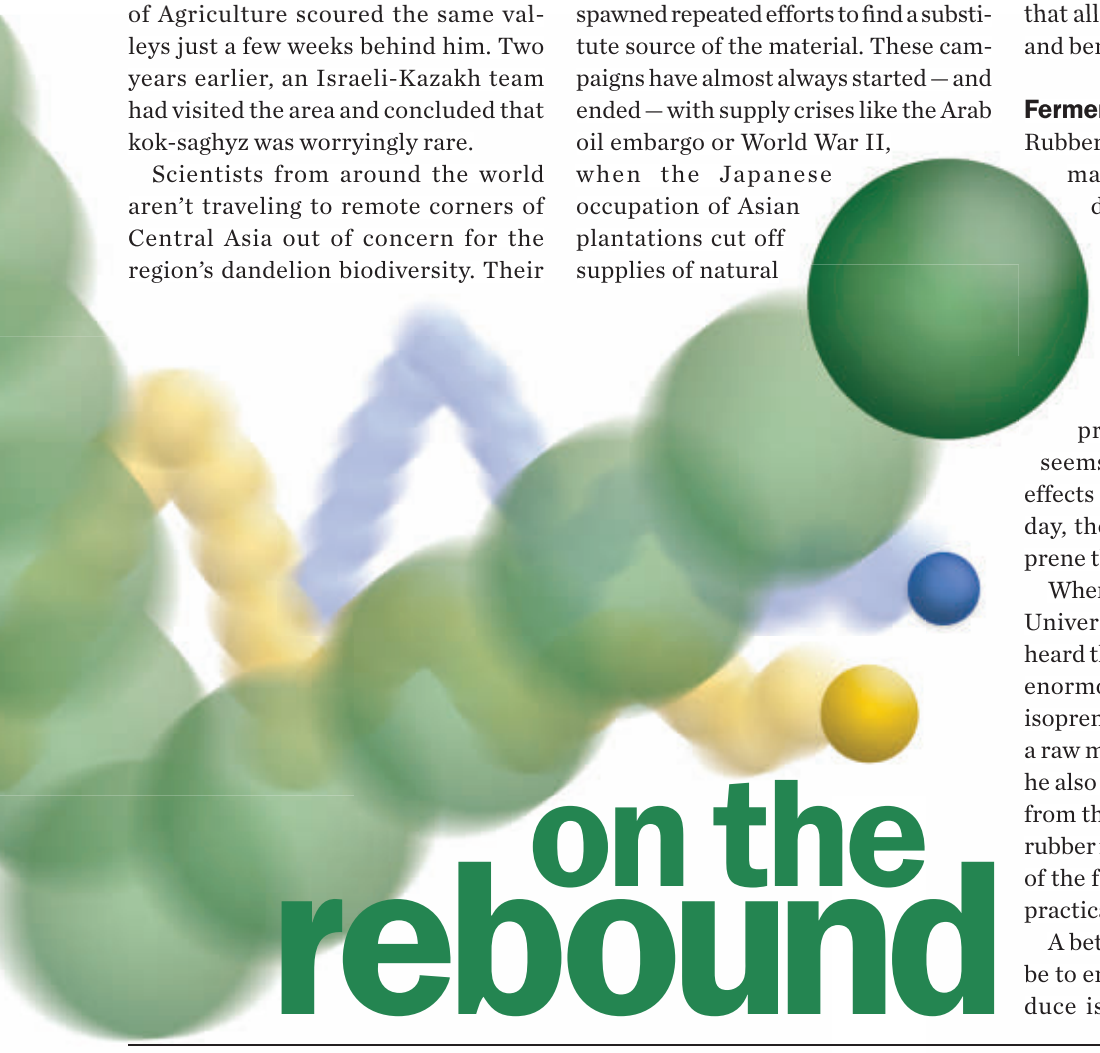
Fermenting rubber

Rubber trees aren't the only plants that make isoprene. On hot, windless days in the Blue Ridge Mountains stretching from Georgia to Pennsylvania, a bluish haze of isoprene gas often settles over the forest canopy.

Although scientists don't know exactly why some plants produce isoprene, the chemical seems to protect from the damaging effects of high temperatures. In a single day, the world's plants emit more isoprene than manufacturers use in a year.

When biologist Anastasios Melis of the University of California, Berkeley first heard these figures, he was struck by the enormous potential of plant-produced isoprene as both a hydrocarbon fuel and a raw material for rubber synthesis. But he also realized that collecting isoprene from the air is not as simple as draining rubber from a tree. "Covering the canopy of the forest is not going to be the most practical thing," Melis says.

A better approach, he thought, would be to engineer a microorganism to produce isoprene. Introducing the gene



E. OTWELL

for the plant enzyme isoprene synthase into an easy-to-work-with microorganism could produce the raw material for rubber in a convenient form. "It's a very straightforward approach," Melis says.

He is not the only one who thinks so. Several research groups are currently working on microbial production of isoprene. One of the processes closest to commercial viability comes from a biotech company that is now part of DuPont Industrial Biosciences. The idea was developed in response to a 2007 request from the Goodyear Tire & Rubber Co. — the consumer of 13 percent of the world's isoprene supply — which was under pressure due to spiking oil prices.

In 2010 in *Industrial Biotechnology*, the DuPont group described how to use engineered *Escherichia coli* bacteria to ferment isoprene from sugar. The isoprene bubbles out of the fermenting *E. coli* soup as a gas, making it simple to collect in the very pure form needed for rubber production. From this microbial isoprene, Goodyear made "green" rubber that was indistinguishable from standard synthetic rubber.

One drawback of DuPont's approach is that it relies on a fuel — sugar — that is also a food. The same oil price spike that prompted Goodyear to look for new sources of isoprene also sparked a global food price crisis that in some cases culminated in riots. Some people blamed part of the crisis on the diversion of food resources into biofuel production. To avoid any such competition with food, many companies, including DuPont, are now trying to come up with ways to ferment fuel and chemicals from inedible woody plant waste.

But Melis argues that rather than try to convert the energy in plants to isoprene via bacteria, it would be even greener to cut out the middleman. Engineered photosynthetic microorganisms, such as cyanobacteria and microalgae, could directly convert the energy of the sun into isoprene. This would eliminate the need to grow, harvest, dry and process plant material to feed the microbes. Last year in *Biotechnology and Bioengineering*, Melis and UC Berkeley researcher Fiona Bentley described a system for producing isoprene using the cyanobacterium *Synechocystis* engineered with an isoprene synthase gene from the kudzu vine. Though yields are too low for commercial production, Melis hopes his team can re-engineer the microbes' metabolism to force more of its resources into synthesizing isoprene.

57.6 percent

Synthetic rubber as a fraction of worldwide consumption, 2012

SOURCE: IRSG

Several companies are also working on ways to coax microbes into making large quantities of 2,3-butanediol, which can be chemically converted to butadiene, the basis of another kind of synthetic rubber. For the most part, these companies feed their fermentations with plant material. But the company LanzaTech is trying to feed its microbes pollution emitted by steel mills.

Steel smelting produces a mixture of waste gases — including carbon monoxide, carbon dioxide and hydrogen — that are often burned off in huge flares. LanzaTech takes these waste gases and converts them into 2,3-butanediol with the help of a species of bacteria isolated from rabbit feces.

That bacterium, *Clostridium autoethanogenum,* taps gases animals emit as waste — carbon monoxide, carbon dioxide and hydrogen — for energy. In the process, it makes acetic acid and ethanol. LanzaTech researchers are trying to harness *C. autoethanogenum* and its relatives to create biofuels from the steel mill waste.

But like many other startups working on biofuels, LanzaTech is also investigating whether its process can be adapted to produce more profitable chemical products like rubber. In 2011, LanzaTech researchers reported in *Applied and Environmental Microbiology* that *C. autoethanogenum* produces respectable amounts of 2,3-butanediol when grown on carbon monoxide–containing waste gas.

Dandelion rubber

Biotechnologists are confident that renewable chemicals will one day feed into the growing stream of synthetic rubber products. But even after a century of research, synthetic mimics can't completely replace the sticky stuff produced by wounded trees.

Part of the reason is that tree latex also contains traces of other plant biochemicals that make it more resilient than synthetic rubber and better at dispersing heat. That's why high-performance tires, like those used for trucks and planes, must contain a very high percentage of natural rubber.

Though native to the Amazon, the rubber tree can't be grown for commercial operation there because a fungal disease called South American leaf blight quickly infests any closely spaced plantations. Over 90 percent of natural rubber comes from the leaf blight–free plantations of Southeast Asia.

Natural sources Rubber trees are not the only plants that produce rubber. Researchers have been working on and off since before World War II to extract commercially viable amounts of rubber from both the Russian dandelion and guayule, a desert plant native to northern Mexico.

SOURCE: J.B. VAN BEILEN AND Y. POIRIER/*CRITICAL REVIEWS IN BIOTECHNOLOGY* 2007

RUBBER TREE
Hevea brasiliensis
Yield: 500–3,000 kg/hectare/year

RUSSIAN DANDELION
Taraxacum koksaghyz
Yield: 150–500 kg/hectare/year

GUAYULE
Parthenium argentatum
Yield: 300–1,000 kg/hectare/year

FROM LEFT: MISSISYA/ISTOCKPHOTO; J. KIRSCHNER/INST. OF BOTANY OF THE ACADEMY OF SCIENCES OF THE CZECH REPUBLIC; HOWARD F. SCHWARTZ/COLORADO STATE UNIV.; BUGWOOD.ORG

Thanks to strict import regulations, leaf blight has never made it to Asia. But if the fungus ever snuck through quarantine and spread there, a shortage of tires for trucks, planes and construction equipment would hit the global economy hard.

Fortunately, almost 2,000 plants besides rubber trees produce rubber. It may not be as easy as drilling a hole in a tree trunk, but with enough cultivation the sticky stuff could be harvested from some of them.

During World War II, the United States created an enormous research program to develop emergency rubber supplies from two plants: guayule (pronounced "gway-OO-lay"), a desert shrub native to northern Mexico, and *Taraxacum koksaghyz*, the kok-saghyz dandelion.

Kok-saghyz produces rubber-rich latex in its roots, which can be harvested only by uprooting the whole plant. But the dandelion can be harvested the same year it is planted, rather than after the five to seven years it takes a rubber tree to mature. So, though fiddly to cultivate, kok-saghyz had obvious advantages for a nation seeking an immediate source of emergency rubber.

Soviet scientists were the first to pursue kok-saghyz as a rubber crop, creating a huge network of experimental farms and rubber factories. After the Nazis captured Soviet rubber research facilities in 1941, German scientists began their own kok-saghyz projects, including a major cultivation facility staffed by prisoners from Auschwitz.

The U.S. government negotiated in 1942 with the Soviet Union for kok-saghyz seeds to kick-start its own dandelion research. Around 200 scientists worked on the project, planting test plots in 41 U.S. states and Canada.

But the U.S. scientists were unable to coax much rubber from the dandelions, and within two years concluded that the Soviets had exaggerated their successes. In the summer of 1944, the United States ceased all kok-saghyz research, plowing most of that year's crop back into the soil. Much of the wartime knowledge of kok-saghyz eventually evaporated.

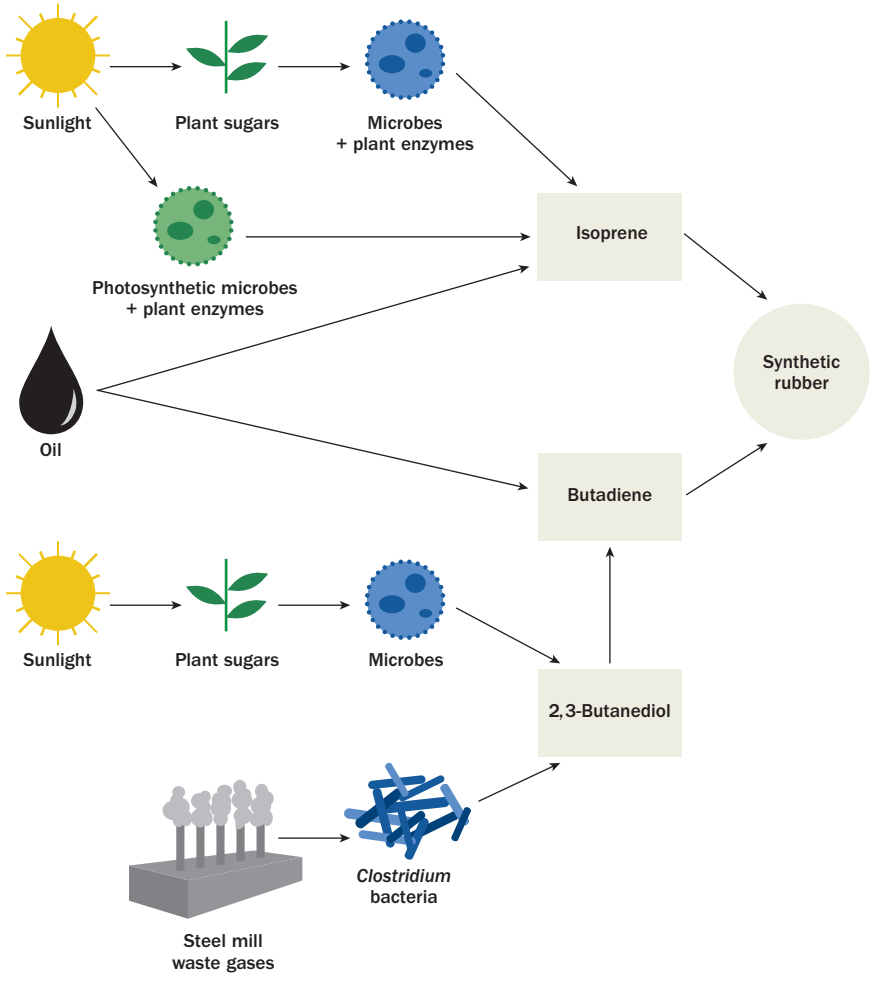
In the mid-2000s, the European Union became interested in alternative rubber plants as part of a push toward sustainable plant-based replacements for fossil fuel products. But their kok-saghyz project stumbled at the first hurdle. All the seeds they could get their hands on, from collections all over the world, proved useless. "Everything available was crap," says Peter van Dijk, a geneticist with the Dutch company Keygene, which led the EU kok-saghyz breeding program.

The seeds proved to be from a different dandelion species that produces very little rubber. Deciding that it would be better off starting from scratch, the consortium sent Kirschner, a taxonomist from the Institute of Botany of the Czech Academy of Sciences, to retrace the steps of Soviet seed hunters of the 1930s.

In an article published this year in *Genetic Resources and Crop Evolution*, Kirschner and van Dijk's team reported that although other researchers had previously found wild kok-saghyz to be rare in Kazakhstan, if you knew where and when to look, the dandelion flowered in abundance. In the same valleys where kok-saghyz grew, Kirschner and his team also found the weedy, rubber-poor cousin that had contaminated many seed bank stocks.

Ironically, both the Soviet and U.S. kok-saghyz projects of the 1940s were

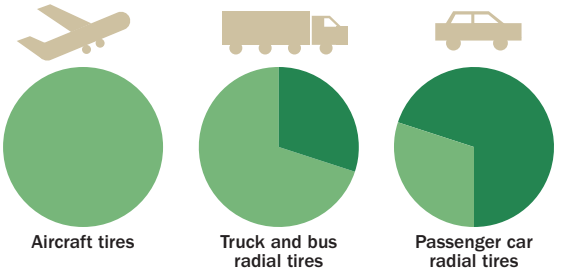
Rubber from microbes Chemists can mimic natural rubber by creating stretchy chains of hydrocarbons like isoprene and butadiene. Currently these hydrocarbons come from fossil fuels, but biotechnologists are working on ways to harness microbes to produce both isoprene and butadiene. These microbes can take energy from the sun, plant sugars or industrial waste to produce these useful rubber precursors. Different pathways are outlined below.



E. OTWELL

Imperfect imitation

Synthetic rubber made from oil has been tremendously helpful in providing raw material for the tire industry. But high-performance tires on planes and trucks are still mostly or entirely made of natural rubber.



SOURCE: JOSEPH WALTER/UNIV. OF AKRON

well acquainted with these rubber-poor imitators. The Soviets described the dandelion *T. brevicorniculatum* as a common weed of kok-saghyz plantations and had studied the contaminant's genetics and its breeding compatibility with kok-saghyz. The U.S. scientists struggled to control "rogue" dandelion species in the imported seed samples and had quantified the ability of the clonally reproducing rogues to take over their kok-saghyz plantings.

Now that they have the right species, scientists like van Dijk are just starting to achieve the dandelion rubber successes already reported by their predecessors over 50 years ago.

Lost knowledge

The darling of the American World War II emergency rubber project was not kok-saghyz but guayule (*Parthenium argentatum*). Wild guayule was the center of a thriving international rubber industry until the Mexican Revolution intervened, and the plant seemed a good choice for a domestic supply. But despite the successes and hard work of more than 1,000 scientists, including many Japanese-Americans working in internment camps, guayule research was almost completely abandoned after the war. Although the dream of guayule rubber was briefly revived during the oil crisis, it wasn't until the '90s, when concern about latex allergies began to surface among health care workers, that guayule research rebounded.

The latex allergy crisis brought guayule back into the spotlight because its rubber lacks the proteins that cause the most severe allergic reactions. It was not long before a boutique industry had sprouted up in Arizona to produce hypoallergenic rubber for gloves and medical devices.

Today, the promise of the guayule industry has reignited hopes that the plant could be used for many other products. Several of the largest tire companies have been pursuing guayule research in recent years. Researchers are rapidly breeding guayule plants that yield more rubber and mature earlier, says Dennis Ray, a crop scientist at the University of Arizona in Tucson.

But historically, slow-moving plant experiments haven't been able to match the pace of political interest. Government funding has typically come in two- or three-year increments. "But breeding is a long term thing. You need 10, 20 years in a row for consistency," Ray says. He thinks the constancy of the rubber plantation industry's breeding efforts explains why Asia is the commercial epicenter of natural rubber, while guayule is still an experimental crop. "They've had 85 years of breeding that have improved the yield," he says.

A 1944 *Science News* report detailed attempts to extract rubber from guayule.

For all of that time, guayule has been considered the next big source of natural rubber. "It's a crop that has had many futures," says rubber historian Mark Finlay of Armstrong Atlantic State University in Savannah, Ga. "In 1910 it was the crop of the future, and in 1940 it was the crop of the future."

But when guayule research was abandoned after the war, 23,000 acres of the rubber crop were destroyed. Despite the huge scale of wartime guayule research, the only seeds available to scientists restarting the program in the 1970s came from just 26 breeding lines.

"We have a culture in which it's possible for knowledge to be dismissed and tossed aside," Finlay says. "There was no foresight that the next crisis might be around the corner."

Back to the future

Today's researchers exude optimism about the future of rubber from both new natural sources and renewable synthetic ones. One sign that their optimism is warranted is that tire companies — the largest consumers of all types of rubber — are investing in alternatives to rubber trees and oil.

"This will come to fruition," says Chuck Yurkovich, vice president of global research and development at Cooper Tire & Rubber Co., which is working on guayule tires. "The technology is here. You have a number of companies competing to try to get there first. I do believe it will happen."

Yet the supply squeezes that drove the latest research surge are already starting to dissipate. Thanks to an economic recession and the spread of rubber plantations to more parts of Asia, rubber prices have been plummeting for two years. Butadiene prices are also slumping to new lows. Despite the recent advances in rubber research, the reality is that none of the proposed techniques can yet compete with either trees or oil.

The situation seems not much different than it was 83 years ago, when a *Science News* article concluded that "the low market offers no promise of profit in guayule rubber, and commercial prospects are very much those of the future." ■

Explore more:

- M. Finlay. *Growing American Rubber: Strategic Plants and the Politics of National Security*. Rutgers University Press, 2009.

FROM TOP: E. OTWELL; SOCIETY FOR SCIENCE & THE PUBLIC

The Attacking Ocean

Brian Fagan

The threat of rising seas is not new. Since the last Ice Age began winding down 15,000 years ago, the ocean has ascended 120 meters in a series of pulses. But when the world was thinly populated, small bands of hunter-gatherers could pick up and go when the sea surged. Now that hundreds of millions of people are settled in crowded coastal cities, the rising seas predicted for a warming world are more dangerous than ever, argues Fagan, an archaeologist.

Fagan chronicles the history of the climbing oceans and their influence on the development of early civilizations such as those of ancient Egypt and Mesopotamia. He also shows how modern societies from New Orleans to Shanghai continue to feel these effects. Without hyping the risks, Fagan provides solid geological, archaeological and historical evidence to support his arguments about what the future may hold.

Submerged land is but one hazard humanity faces as polar ice melts and oceans expand. Sea level rise will also exacerbate flooding from tsunamis and hurricanes. Wetlands, marshes and mangroves provide a natural barrier against these disasters by, for example, staving off erosion, Fagan notes. But humans are increasingly bulldozing this protection to make way for cities and industry. Of course, people have developed their own ways to fight back the seas, with levees, seawalls and the like. But these barriers aren't foolproof, and sometimes they create their own environmental problems.

Fagan offers no simple solutions for impending sea level rise over the next century — because there aren't any. But he warns that society has to start tackling the problem now. — *Erin Wayman*

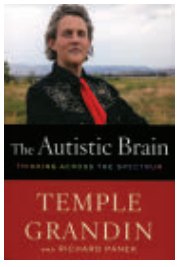
Bloomsbury Press, 2013, 265 p., $28

The Autistic Brain

Temple Grandin and Richard Panek

For one little girl profiled in Grandin's latest book, putting on pink sunglasses makes shopping trips tolerable. Like many with autism, she finds stores visually overwhelming: Shining lights appear to shoot streams of sparks, and words on signs jiggle. Tinted lenses can quell the sensory overload.

The lens trick is one of many that Grandin highlights in this review of autism science, an exhaustive survey that delves into her theories about the disorder. Grandin, an animal biologist famous for improving livestock handling, might be the most well-known autistic person in the United States. Together with science writer Richard Panek, she suggests that sensory problems may set off autistic behaviors. These problems vary: Some people with autism can't stand the sound of hand dryers in public restrooms; others hate the feel of wet newsprint. Grandin builds a strong case for more research. "Whatever form these sensory problems take, they're real, they're common and they require attention," she writes.



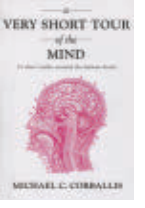
Researchers have instead focused on the genetics and neurobiology of autism, but these data aren't tidy. Autistic kids share hardly any genetic glitches, for example, and their brains look pretty normal. Scientists have picked out some intriguing differences, though, and Grandin packs in plenty. She seasons the story with tidbits from her past and from autistic people she's met. These bright spots put human faces on autism and help Grandin drive home an encouraging message: Instead of defining kids by their deficits, she suggests, we should all work with them to uncover their strengths. — *Meghan Rosen*

Houghton Mifflin Harcourt, 2013, 240 p., $28

The Strange Case of the Mad Professor

Peter Kobel

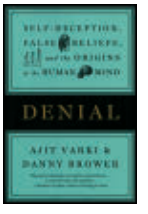
The true story of an anthropologist convicted of drug manufacture and attempted murder also explores academic culture. *Lyons Press, 2013, 274 p., $26.95*



A Very Short Tour of the Mind

Michael C. Corballis

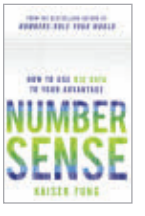
In 21 brief chapters, a psychologist explores what scientists have learned about the brain in the last 50 years. *Overlook Press, 2013, 106 p., $17.95*



Denial

Ajit Varki and Danny Brower

A pair of scientists argues that the ability to deny reality allowed the human species to flourish but now threatens its survival. *Twelve, 2013, 373 p., $27*



Numbersense

Kaiser Fung

Examples from college rankings to fantasy sports show how people are using the enormous datasets referred to as Big Data. *McGraw-Hill Education, 2013, 228 p., $24*

Spacefarers

Michael J. Neufeld, ed.

Scholarly papers examine how media and popular culture have portrayed astronauts and space exploration. *Smithsonian Books, 2013, 256 p., $29.95*

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Bohr no boor

As described in "When the atom went quantum," (*SN: 7/13/13, p. 20*), Bohr's willingness to travel both paths when different viewpoints seemed to clash, yet both seemed to fit the data, was crucial to the development of quantum mechanics. Yet that willingness cannot be equated with acceptance of all possible views. Having investigated the paths indicated by classical physics, he found them to be dead ends and did not persist in walking those while he followed various quantum paths. Too often, quantum uncertainty is invoked as supporting philosophical rejection of absolutes.
David Campbell, Boiling Springs, N.C.

Stormier weather

I was confused by the conclusion that "simulations suggest that the climate effects of greenhouse gases will again reduce tropical storm frequency later this century" in "Cleaner air may bring on storms" (*SN: 7/27/13, p. 15*). One of the effects of increased atmospheric greenhouse gas concentrations is higher ocean water temperatures. Wouldn't higher water temperatures increase the likelihood of tropical storms?
Jerry Kerrisk, Santa Fe, N.M.

Climate scientists are still debating whether global warming will increase or decrease tropical storm frequency in the North Atlantic later in the 21st century. Though the research described in the article was designed to tease out the effects of aerosols, the simulations did suggest that in the long term, a rise in greenhouse gases will result in less frequent tropical storms in the North Atlantic. Study coauthor Nick Dunstone warns, though, that sea surface warming may increase the intensity of hurricanes, since extra heat would provide more energy for storms to tap into. This could lead to more of the most destructive storms, even if the total number decreased. — Cristy Gelling

Humble reminders

The title of Eva Emerson's editorial "Be humble in the face of nature's awesomeness," (*SN: 6/29/13, p. 2*) reminded me of some advice a friend once gave me: Be humble, for you are made of Earth. Be noble, for you are made of stars. Both are true, and both are worthy efforts.
K.A. Boriskin, Bellingham, Mass.

I have been a subscriber to *Science News* for more than 20 years, and I hope that they put my last issue in my casket as they close the lid. I really enjoy the preview that Ms. Emerson gives us every two weeks. I always read the editor's comments first; they are so much fun and introduce me to the news in the magazine.
Paul Ebel, Aiken, S.C.

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

The Science Life

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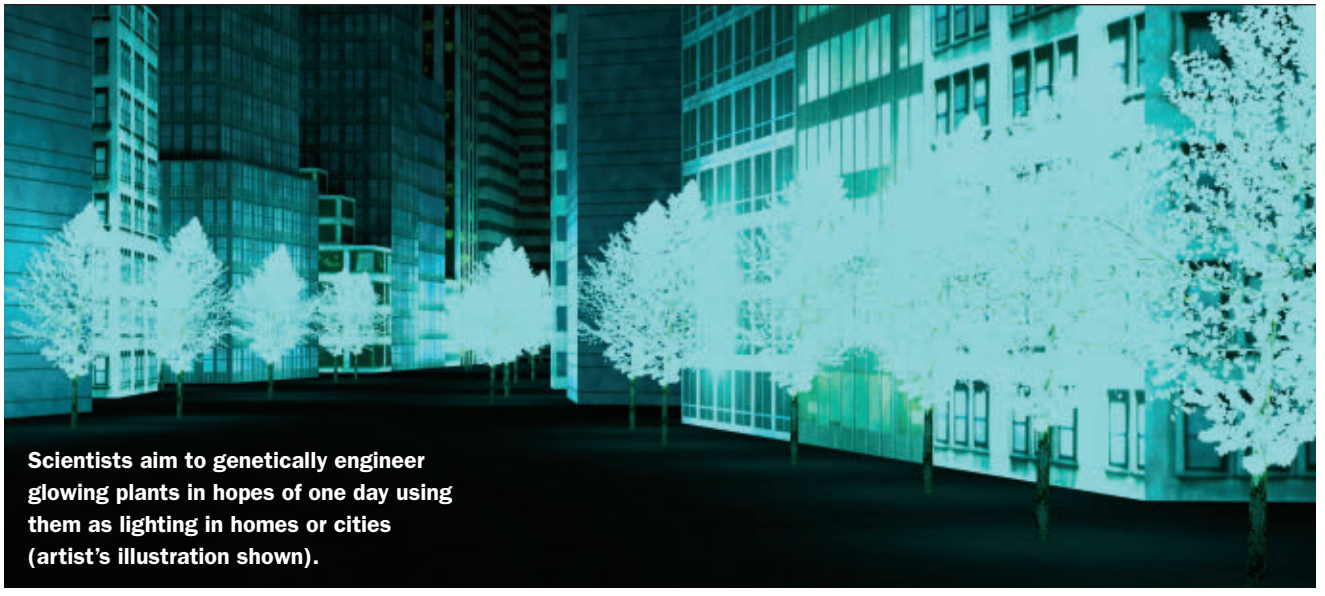

Scientists aim to genetically engineer glowing plants in hopes of one day using them as lighting in homes or cities (artist's illustration shown).

A glowing green thumb

After Neil Armstrong's small step onto the moon, generations of children played with toy rockets and dreamed of exploring space. Omri Amirav-Drory hopes a tiny glowing plant will inspire future generations of kids to play with genomes and dream up new forms of life.

Drory is a scientist and businessman leading a project to genetically engineer plants to make light-producing firefly proteins. He envisions a day when trees will replace street lamps to illuminate cities. "I think it will be a more interesting, beautiful world with glowing plants in it," he says.

At least 8,433 people agree with him. These backers collectively pooled $484,013 in a campaign that ended June 7 on the crowdfunding site Kickstarter, exceeding the project's initial $65,000 goal. The team even raised enough money to attempt its next step: making a glowing rose.

Next June, thousands of those supporters will get a shipment of seeds or plants to grow their own glowing *Arabidopsis* plants. More than 200 people pledged enough money to get a genetic toolkit allowing them to engineer their own glowing plant. People who missed the Kickstarter campaign but want a do-it-yourself project can buy one of the kits on the online marketplace Etsy. The researchers don't yet know how brightly the plants will glow; they are hoping to achieve something comparable to night-light wattage.

The plants may shine dimly, but Drory thinks they will radiate great influence. Students who grow up with luminescent plants might change their career plans and become biologists instead of lawyers, he suggests. And the project could be important for increasing acceptance of certain types of science. "Anyone with a glowing plant in their house won't be afraid of genetic engineering," he says.

But some people already fear these efforts. The ETC Group, a Canadian environmental organization, launched what they called a "kickstopper" campaign opposing the creation of glowing plants, saying the plants could escape into the wild and wreak havoc on the environment. Drory says his plants are likely to be at a disadvantage in nature due to the energy demands of generating light. He has no qualms about releasing the plants to the general public, he says. "It's legal. I think it's proper. It's beautiful." — *Tina Hesman Saey*

How they glow

Living things can give off light via either luminescence or fluorescence. Luminescent animals make their own light, while fluorescent ones absorb and re-emit it.

- **Fireflies** Fireflies generate light through luminescence. An enzyme called luciferase facilitates the reaction, in which another molecule (usually a protein called a luciferin) releases light. Plans to create glowing *Arabidopsis* plants and roses involve engineering the plants to produce both luciferin and luciferase.
- **Jellyfish** Some jellyfish glow via fluorescence, thanks to green fluorescent protein, or GFP. The protein absorbs light at one wavelength and emits it at a different wavelength. Scientists have created a rainbow of fluorescent hues for use in the lab by mutating GFP and similar proteins.
- **Genetically engineered organisms** Using various techniques, many glowing animals have already been created in the lab, including cats, mice, monkeys, fish and a beagle.

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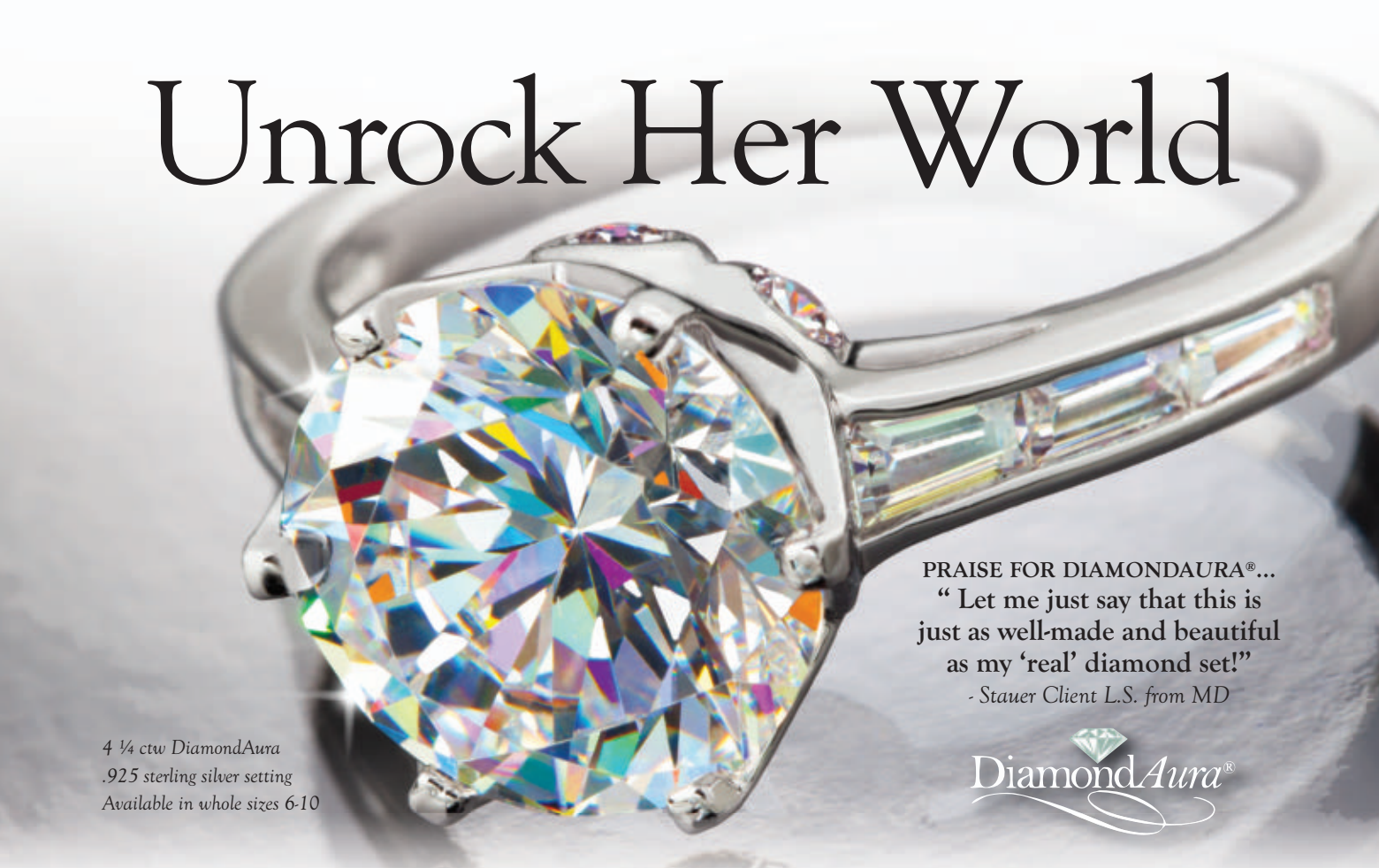

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