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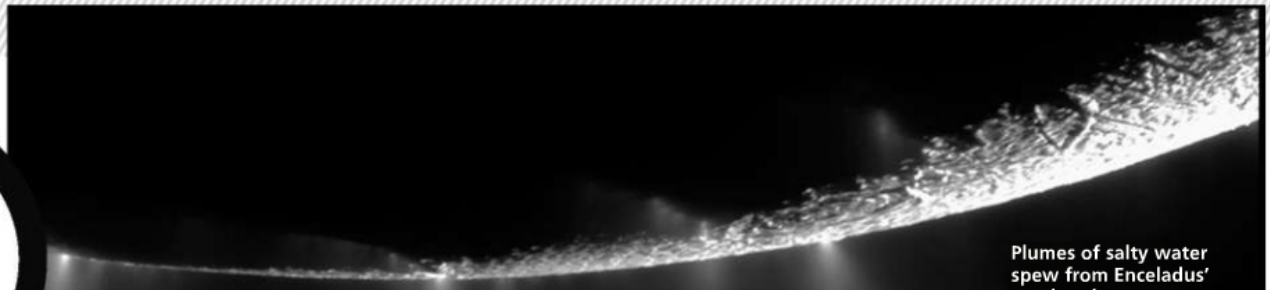


Plumes of salty water spew from Enceladus' south pole.

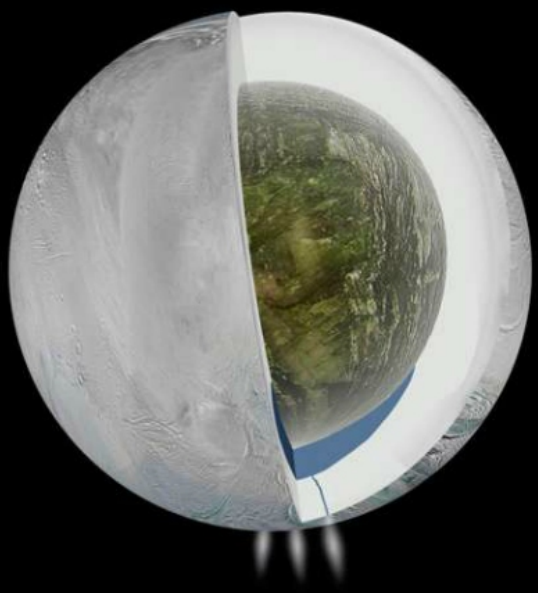
Saturn's Moon Hides Liquid Water

In the search for life, astronomers follow the water. Ten years ago, the search led them to Saturn's moon Enceladus, where they discovered several plumes on the south pole spewing water into space. In 2014, scientists finally found their source: a huge lake about 20 miles under the surface ice.

Luciano less of the University of Rome La Sapienza and his colleagues suspected such an underground reservoir might exist, so they used NASA's Cassini probe to investigate. The spacecraft measured Enceladus' gravitational tug at various points during three passes just 30 to 60 miles from the surface. The stronger gravity's pull, the more mass lay directly below.

When less and his team spotted an unusually massive area near the south pole with no corresponding topography (a mountain, say), they realized that a denser material — liquid water — lurked below. The results showed this frozen world hardly the size of the Gulf of Mexico holds a 5-mile-deep reservoir about the size of Lake Superior.

A few months later, other Cassini researchers identified 101 distinct geysers on the moon. Those spouts offer many pathways for the water — and any other ingredients for life — to burst up through the surface. — LIZ KRUESI



A large lake likely lies between the outer icy shell of Enceladus and its rocky core.

45

Blood Test Could Predict Suicide Risk

Suicide ravages freely, claiming old and young, rich and poor, famous and unknown. But some people face increased risk, and current tests don't spot them early enough to intervene effectively.

In July, molecular biologist Zachary Kaminsky of Johns Hopkins University and his team reported a simple way to detect people with suicidal tendencies — with a blood test. They examined DNA from brain tissue of people who died by suicide and those who died of other causes and measured its methylation — levels of chemicals called methyl groups on DNA that alter gene expression. They found that a stress-mitigating gene called SKA2 was less active in those who died by suicide and was more likely to be methylated. Experts believe that when SKA2 is too sluggish, some people can't stop their negative thoughts and fears.

Kaminsky's team then developed a blood test that measured SKA2 activity and levels of methyl groups, then fed its results, plus data on demographics and stress level, into a statistical model. In a small test, that model predicted suicidal thoughts or suicide attempts with a remarkable 80 percent accuracy.

The team still needs to run larger trials before this test will be ready for doctors' offices, but Kaminsky has high hopes for its potential. It's "another way to ask for help," he says. — BRENDA POPPY

FROM TOP: NASA/JPL/SPACE SCIENCE INSTITUTE; NASA/JPL-CALTECH

Mammography Wars Reignite

For more than two decades, the power of mammograms to save lives has remained a point of controversy. The debate reignited in February with a study published in the journal *BMJ* showing that screening mammography failed to reduce breast cancer deaths.

The study enrolled nearly 90,000 Canadian women, age 40 to 59, and followed them for 25 years. Although women who got mammograms had more breast cancers detected than those who didn't, this increase in detection did not translate into lives saved. Researchers used statistical analysis to calculate that 22 percent of the invasive cancers found would never show symptoms. Women received unnecessary treatment for cancers that did not threaten their lives. "There are all harms and no benefits," says study author Anthony Miller, a physician and epidemiologist at the University of Toronto.

A study that followed Canadian women over 25 years found that more mammograms and cancer detection did not result in more lives saved.

A. BENOIST/BSIP/CORBIS

The emphasis on harms represents a new shift in the public discourse about mammography's value. Since it began in the early 1990s, the debate over mammography has centered on how many lives the test could save. But recently, the conversation has widened to include the growing recognition that screening mammography may also needlessly transform healthy people into cancer patients.

Mammography proponents, such as the American College of Radiology, contend that the study is fatally flawed because outdated mammography machines didn't find as many breast cancers as more advanced machines would.

But the traditional "look harder/find smaller" approach assumes that cancer is a universally progressive disease that always metastasizes and kills unless it's stopped in an early stage. Research now shows that not every cancer progresses this way, says H. Gilbert Welch, a professor of medicine at Dartmouth College and author of the book *Should I Be Tested for Cancer?: Maybe Not and Here's Why*. Some cancers metastasize before they're discernible, while others grow so slowly that they won't turn invasive in the person's lifetime.

It's now clear that mammography is very good at finding slow-growing, harmless cancers, says Welch. What remains contentious is the extent to which it also finds early cancers that could become deadly yet still respond to treatment.

The *BMJ* study is one of several trials that have quantified the benefits of screening mammography. These studies estimate mammography decreases the number of deaths by anywhere from 35 percent to 0 percent, says Otis Brawley, chief medical officer at the American Cancer Society. Despite that wide range, he says the takeaway is similar: Mammograms cannot prevent every breast cancer death. If mammograms reduce deaths by a third (as the rosiest estimates suggest), Brawley says, that still means regular high-quality mammograms won't save the lives of about two-thirds of women with deadly breast cancers.

The Canadian study is especially important because newer, more effective treatments for breast cancer were available during the 25 years when study participants were followed. A 2010 study published in the *New England Journal of Medicine* calculated that about two-thirds of the recent reductions in breast cancer mortality did not come from screening but from other causes, such as better treatments.

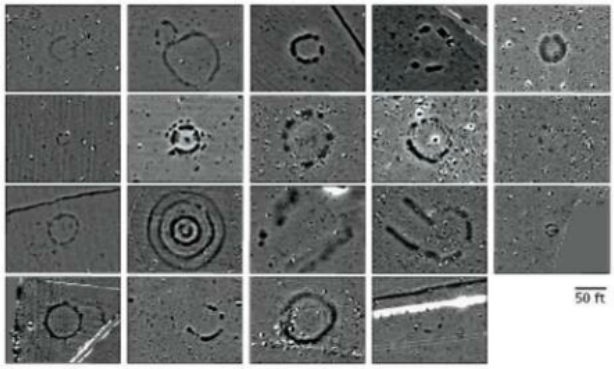
The February study in *BMJ* was published with an editorial arguing that it's time for policymakers to reassess mammography recommendations. The U.S. Preventive Services Task Force was already doing so when the study results came out, says Michael LeFevre, chairman of the task force and a physician at the University of Missouri. He predicts the task force's draft of updated recommendations will be published in late 2015. Until then, he's following the 2009 guidelines, which call for individualized decision-making for women in their 40s and biennial screening for women 50 to 74. – CHRISTIE ASCHWANDEN

47

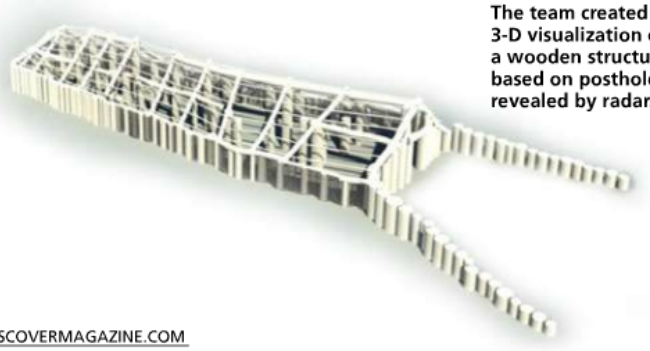
The iconic Stonehenge monument has captivated humans for five millennia, but a new digital map of its surroundings reveals the stones are just one small part of a massive network of Neolithic sites.

Stonehenge's Buried Secrets Uncovered

Stonehenge is the 5,000-year-old gift that keeps on giving. Using ground-penetrating radar and 3-D laser-mapping techniques, British scientists identified 17 additional Neolithic shrines hidden beneath a 4.5-square-mile swath of land surrounding the iconic site, 90 miles west of London. The new geophysical survey, released in September, includes several previously unidentified burial mounds and an earth and timber chamber, called a long barrow, that was likely used for excarnation: the act of removing flesh from the bones of the deceased in preparation for burial. – CARL ENGELKING



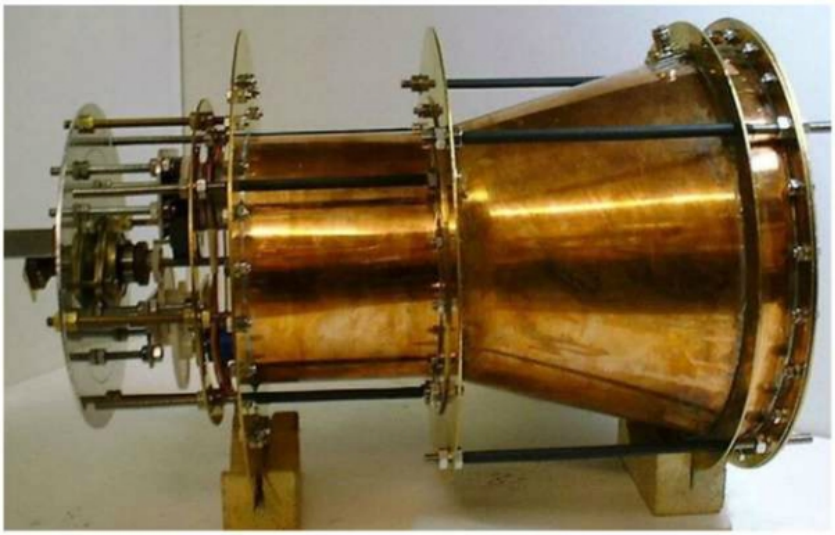
The new digital map of Stonehenge's environs shows details of numerous still-buried sites that had never before been identified, including pits, burial mounds and additional stone circles (above). Researchers used a motorized ground-penetrating radar array (below) to find the hidden archaeological treasures.



The team created a 3-D visualization of a wooden structure based on postholes revealed by radar.

CLOCKWISE FROM TOP: LBI ARCHPRO/GEERT VERHOEVEN; LBI ARCHPRO/MARIO WALLNER; VERHOEVEN; LBI ARCHPRO/JOACHIM BRANDTNER

This Space Drive Might Defy Physics



The Cannae Drive could revolutionize space travel and our understanding of physics itself — if it really works. So far, physicists remain skeptical.

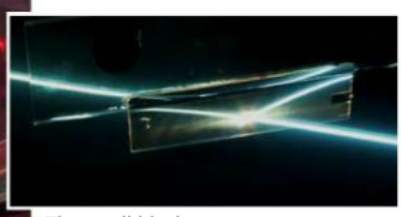
In 2014, five engineers at NASA's Jet Propulsion Laboratory tested independent inventor Guido Fetta's Cannae Drive, a prototype space engine that's basically a microwave emitter within a small metal cone. In July, they reported their incredible conclusion: The device moved, despite lacking propellant or producing exhaust of any kind.

It was a doubly bold claim, one that seemed to contradict conservation of momentum (a foundational principle of physics) and to promise a new era of fast, cheap space travel. The Internet was abuzz with excitement.

The physics community was less enthused. "Nonsense," physicist Sean Carroll at Caltech bluntly put it. "They claim to measure an incredibly tiny effect that could very easily just be noise." In their paper, the NASA researchers did not provide a full accounting of possible sources of error, but they did include a speculative outline for a Cannae Drive-powered trip to Mars.

More testing is necessary to show whether the Cannae Drive really has any potential; history is full of examples, from antigravity effects to cold fusion, of researchers fooling themselves when they know the desired outcome.

The Cannae Drive also calls attention to a growing crisis in space travel. NASA's upcoming deep-space rocket, the Space Launch System, uses the same engine design as the space shuttle launcher of the 1980s. If they hope to boldly go where nobody has gone before, scientists need to explore radical ideas in propulsion. Next time, though, they might want to test twice before they announce results. — COREY S. POWELL



The small block appears transparent to light approaching at 55 degrees from vertical, but reflects all other angles.

A New Angle on Light Control

Humans know how to filter light: Stained glass only allows through light of a certain color, and polarized sunglasses block certain light waves. But filtering light based on the direction it's traveling has eluded scientists for decades.

But now, scientists at MIT devised a tiny block that can do just that. It's smaller than a stick of gum and made of 84 thin, alternating layers of glass and tantalum oxide (a compound often found in electronics). Viewed from most angles, the block reflects light like a mirror. At exactly 55 degrees from vertical (35 degrees from the block itself), however, it appears transparent, totally clear. That's because each of the 83 interfaces between the two materials filters some of the incoming light; only the light traveling at the correct angle makes it through the block (rendering it transparent). The rest bounces back as a reflection.

The March discovery could make computer screens more secure and help astronomers better filter light from stars and planets. Yichen Shen, a Ph.D. student who worked on the project, calls it "an essential step in achieving control over light." — SHANNON PALUS

TOP: SATELLITE PROPULSION RESEARCH LTD. BOTTOM: WEISHUN XU AND YUHAO ZHANG/MIT (2)

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A prototype of Google's new self-driving car has built-in sensors designed to "read" city streets.

Google Car Moves Into Fast Lane

John Leonard watched spellbound from the back seat as the Lexus he was riding in drove through downtown Mountain View, Calif., one July day. The steering wheel spun right and left without a driver touching it. The car stopped at lights, switched lanes and even punched its accelerator as it merged into traffic.

For Leonard, a roboticist at MIT, riding in a car outfitted with Google's self-driving technology reminded him of another iconic moment in transportation: when the Wright brothers ushered in the age of air travel 111 years ago. "Honestly," he says, "I felt like I was on the beach at Kitty Hawk."

In 2014, it became more credible than ever that all cars will drive themselves someday. Google began building 100 more prototypes over the summer — this time, without steering wheels — and several mainstream car manufacturers, including BMW and Audi, demonstrated their own self-driving prototypes.

A Google car senses its surroundings through radar, cameras and range-finding lasers spinning atop the vehicle to create a 360-degree view of pedestrians, vehicles and intersections.

A self-driving Lexus navigates its way through Mountain View, Calif.

But Google's real trick is the map stored in the car's computer. The sensor-loaded cars are driven manually to scan roads in advance, revealing potholes, stop signs and other features that are then processed into a detailed map and downloaded to the autonomous car. This pre-mapping vastly simplifies the computing that a Google car has to do in real time, potentially reducing its price tag.

The challenge will be to create these centimeter-scale maps for thousands of roads worldwide and constantly update them as they change, says Alberto Broggi, an engineer developing self-driving cars at the University of Parma in Italy. "If you have wrong data, it would kill you," Broggi says. Autonomous cars will also need to read gestures and other cues from cyclists, pedestrians and traffic cops.

The mapping challenge, in particular, could take 30 years to address, says Leonard, though he admits, "Sometimes you need younger people who don't know how hard something is." — DOUGLAS FOX

Ride along in a test drive of the car at DiscoverMagazine.com/Self-driving

BOTH IMAGES: GOOGLE

Arctic Answer to Long-Lost British Ships

After nearly two centuries, a team of underwater archaeologists cracked one of the greatest maritime mysteries in Canadian history. In September, the team announced the discovery of a British vessel — identified in October as the HMS *Erebus* — that was one of a pair to disappear while attempting to chart the Canadian Arctic's Northwest Passage in 1845.

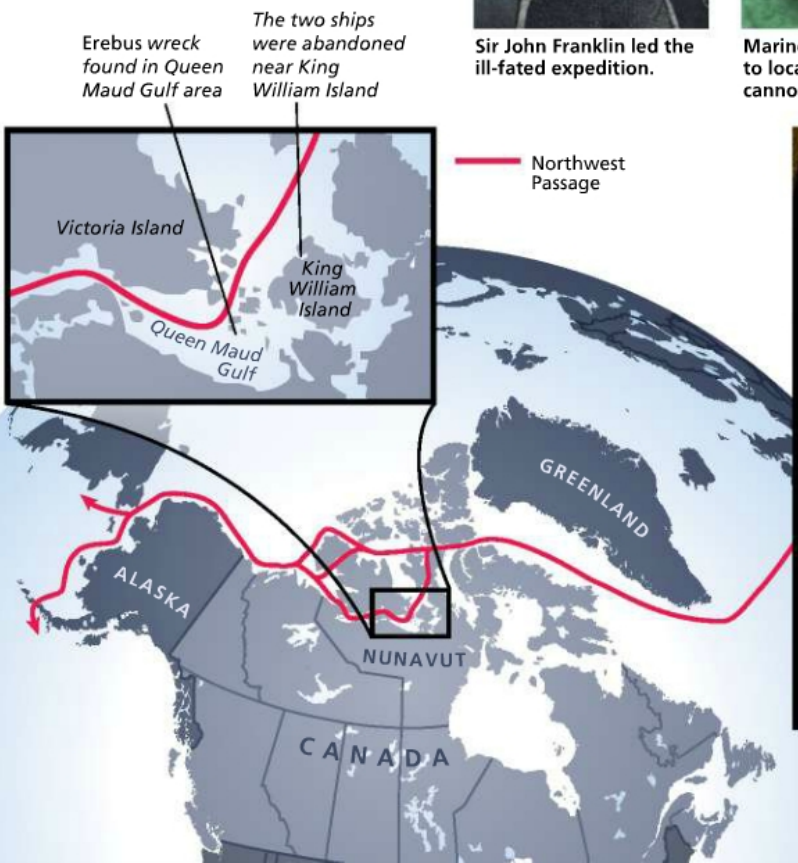
Experts believe ice trapped the *Erebus* and the HMS *Terror* in 1846, dooming the 128 crewmen and their leader, explorer Sir John Franklin. Parks Canada researchers finally located the vessel with a remotely operated underwater vehicle.

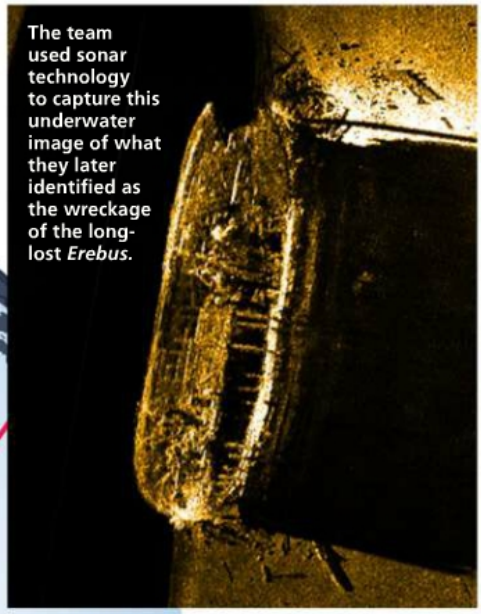
Although the *Terror* has yet to be found, the well-preserved *Erebus* wreckage could provide clues to its location, as well as offer insight into the crews' last days. – BRENDA POPPY

This painting, from H.E. Marshall's 1905 book *Our Island Story*, depicts some of the more than 100 crew members who abandoned the HMS *Erebus* and HMS *Terror* after nearly two years of being trapped in ice in the Canadian Arctic. No one survived.

Sir John Franklin led the ill-fated expedition.

Marine archaeologists used a remotely operated vehicle to locate *Erebus*' wreckage, which included these two cannons scattered amid the ship's timbers.





The team used sonar technology to capture this underwater image of what they later identified as the wreckage of the long-lost *Erebus*.

COUNTERCLOCKWISE FROM BOTTOM RIGHT: PARKS CANADA (2); PRINT COLLECTOR/GETTY IMAGES; WELLCOME LIBRARY, LONDON; ROEN KELLY/DISCOVER

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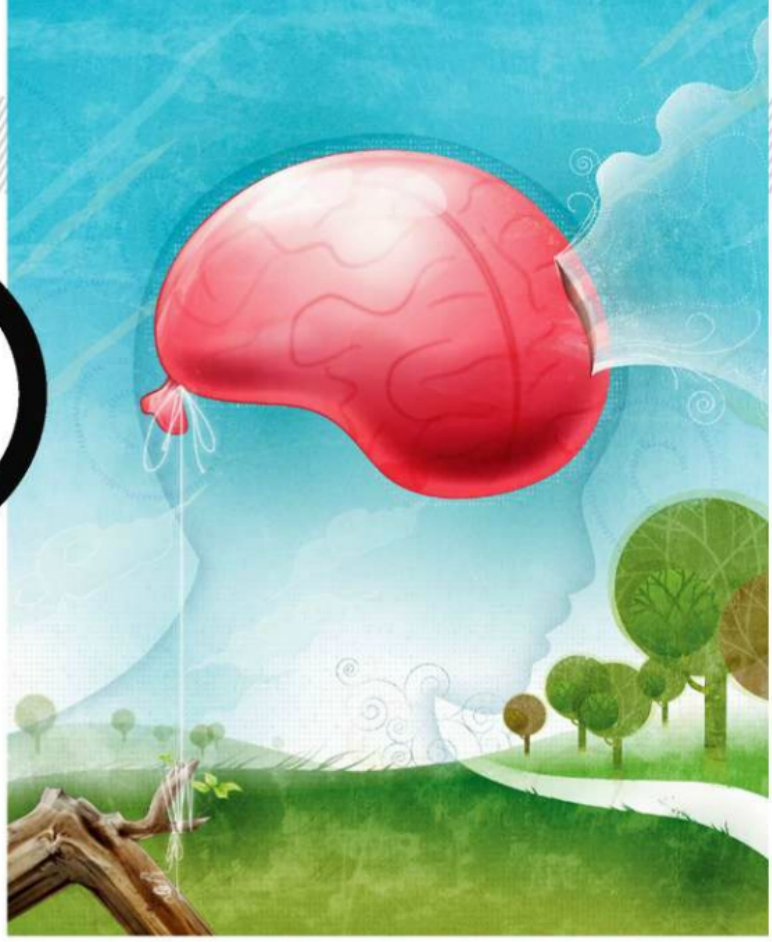

How Was My Childhood? I Forget.

What's your earliest memory? Most people can't remember events before about age 3, a phenomenon called infantile amnesia. In May, researchers announced they finally might have pinpointed the cause.

As neurons form rapidly during infancy and early childhood — through a process called neurogenesis — new neurons rearrange connections and destabilize existing memories. Mice, like humans, display infantile amnesia. To explore why, researchers trained mice to fear a particular environment, then gave some mice access to running wheels, since exercise is known to stimulate neurogenesis. Afterward, researchers found, the exercisers had largely forgotten their fear, whereas the sedentary mice still remembered it.

The researchers then examined the opposite effect: slowing neurogenesis in infant mice by giving them a drug. They found that mice whose neuron growth was stunted were much more likely to remember their earlier fear a week later.

All this hints that a similar mechanism may be at work in humans' early childhood.

The group plans to study the utility of forgetfulness next. Normally people think forgetting something is bad, but certain types of forgetting can be helpful, study author Paul Frankland says: "It works better to forget lots of details. You don't want your mind cluttered up with that stuff."

So don't fret your forgotten youth. You may have it to thank for lots of memories gained since then. — LISA RAFFENSPERGER

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Waking a Sleeping Giant (Virus)

Locked deep in 30,000-year-old Siberian permafrost, a sleeping giant lay in wait — a giant virus, that is. *Pithovirus sibericum*, a newly discovered giant virus, was still viable when virologists Jean-Michel Claverie and Chantal Abergel thawed the permafrost around it.

Waking *P. sibericum* marks the first time researchers sidestepped complicated lab techniques typically used to revive dormant viruses. Instead, the team announced in March, they simply warmed the frozen soil and added amoebas, common hosts for giant viruses. Once they observed *P. sibericum* replicating in its new host, they knew the ancient virus was still viable.

The virus is also physically bigger than members of the *Pandoravirus* genus, formerly the largest, by about 30 percent. (Yet Pandoraviruses still have bigger genomes than *P. sibericum* — about 2.5 million base pairs versus *P. sibericum*'s 600,000 base pairs.) Its resilience raises concern over what other unknown viruses humans might encounter as large-scale mining and drilling projects, not to mention increasingly warm temperatures, thaw more permafrost. — LACY SCHLEY

Giant virus *Pithovirus sibericum*, shown here in an electron microscope image, is large enough to be seen even under an optical microscope. It was named for the Greek word *pithos*, the type of container famously given to Pandora by the gods.

LEFT: HUAN TRAN/KOH IMAGES/CORBIS. RIGHT: JULIA BARTOLI AND CHANTAL ABERGEL/INFORMATION GÉNOMIQUE ET STRUCTURALE, CNRS-AMU

E-Cigarette Use Draws Health, Regulatory Attention

54

Their popularity soaring, electronic cigarettes came under intense scrutiny by health researchers and regulators in 2014, even as the world's biggest tobacco companies made moves to profit off them.

E-cigarettes deliver nicotine by vaporizing a nicotine-loaded liquid rather than burning tobacco. Sales of the product had already jumped from a mere 50,000 sold in 2008 to 3.5 million in 2012. By 2014, a British study found that just over half of smokers there had used e-cigarettes.

Liquid nicotine in e-cigarettes is vaporized and inhaled. The devices have been shown to produce more ultrafine particles than cigarettes.

But despite the claim that e-cigarettes offer a healthier alternative to smoking, the Centers for Disease Control and Prevention reported in April that the number of calls to poison centers involving e-cigarettes jumped from a single call per month in September 2010 to 215 calls per month in February 2014. Nearly 6 in 10 of those calls involved people younger than 20, and 51 percent of the total calls involved kids younger than 5.

Even when properly used by adults, e-cigarettes have been shown to have immediate adverse effects on respiratory function. They produce more ultrafine particles than cigarettes do, and they cause the same reduction in the amount of nitric oxide exhaled by users — a consequence long associated with smoking's harmful cardiovascular effects.

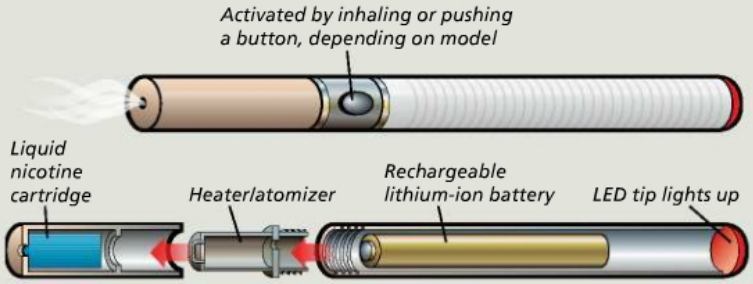
Not all the health news was bad: A survey of smokers who tried to quit found they were 63 percent more likely to succeed if they switched to e-cigarettes than if they used either nicotine gum or patches, or relied on willpower alone. In all, 20 percent of the smokers reported that they had stopped smoking conventional cigarettes if they used e-cigarettes, compared with 10.1 percent using over-the-counter nicotine replacement aids and just 15.4 percent who went cold turkey.

Still, the overall picture looks bleak to researchers like Stanton Glantz, director of the Center for Tobacco Control Research and Education at the University of California, San Francisco. "We're on a very bad trajectory," he says. "They're being marketed extremely aggressively in ways that are rapidly penetrating the youth market."

But just as the world's two largest tobacco manufacturers, Reynolds American (maker of Camel) and Altria (maker of Marlboro) were entering the market, the FDA announced its intention in April to regulate e-cigarettes as it does traditional cigarettes — including age restrictions and health warnings. – DAN HURLEY

HOW IT WORKS: ELECTRONIC CIGARETTES

A battery activates a heating device inside the e-cigarette, vaporizing the liquid inside the nicotine cartridge to create a "smoke" the user can inhale.



TOP: SEBASTIEN NOGIER/EPA/CORBIS. BOTTOM: JAY SMITH

55

Futuristic Contact Lens in Sight

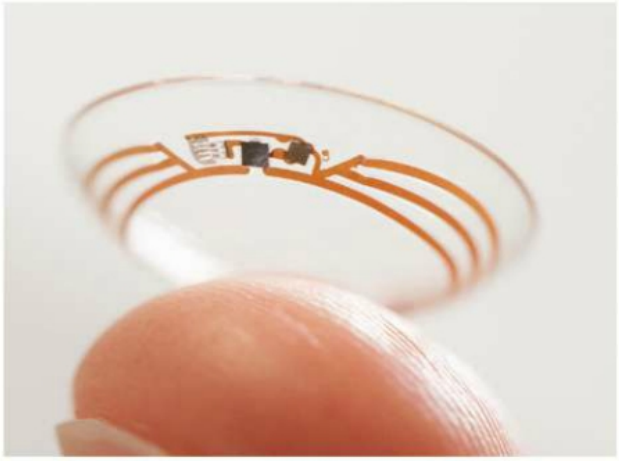
Smart technology makes tracking personal health metrics — from posture to sleep quality — easier than ever. But one new device could be more medically useful than any yet on the market: a smart contact lens.

Developed by Google's secretive Google X arm, the initial prototype is designed to monitor glucose for diabetics. It sports a tiny sensor that measures glucose in tears and an antenna that wirelessly transmits the data to a connected device.

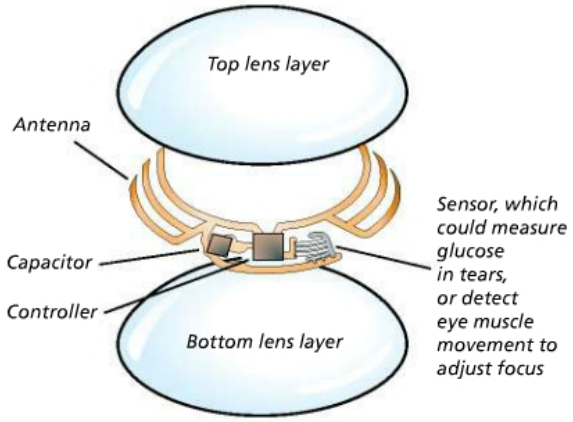
Google's clinical research studies demonstrate the device can take one reading per second, promising a constant, noninvasive alternative to diabetics' routine finger pricks throughout the day. The lens could also immediately alert patients, doctors or caregivers to abnormal glucose levels.

A different twist on the same technology could produce lenses that work better than current bifocal contact lenses. By detecting eye muscle movements and automatically adjusting focus — similar to an automatic camera lens — the new lens could replicate the eye's natural functioning.

In July, pharmaceutical giant Novartis announced it would license and commercialize the lenses, initially focusing on these two applications. CEO Joseph Jimenez said the company wants a prototype available for research-and-development reviews by early 2015, though Novartis says it's too early to say which version of the lens will be available first. —LISA RAFFENSPERGER



Google's smart contact lens can monitor glucose levels.



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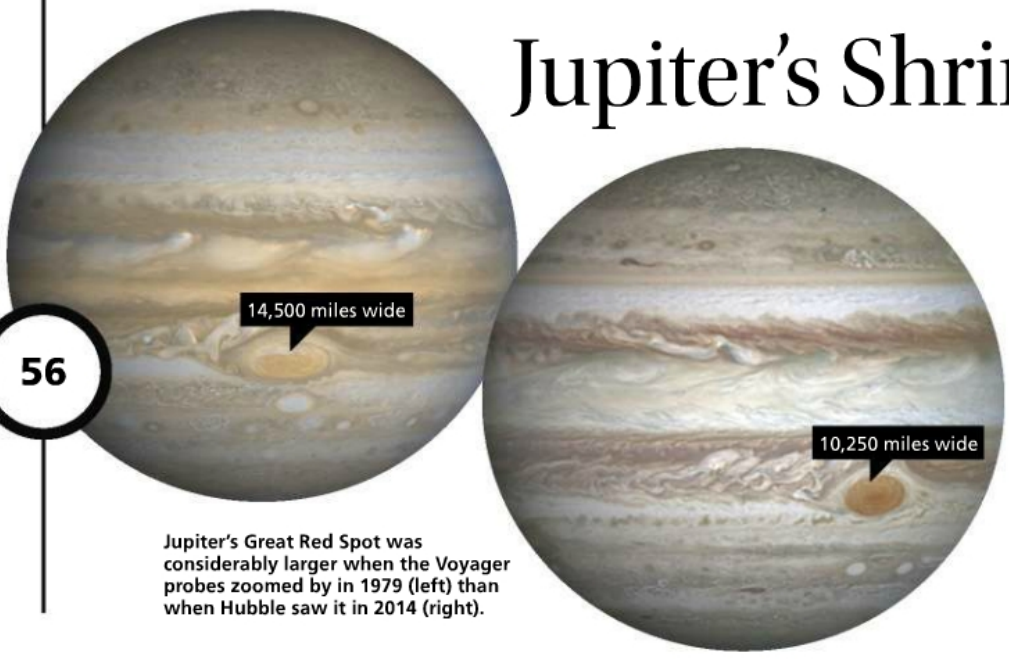
Jupiter's Shrinking Spot



Jupiter's Great Red Spot was considerably larger when the Voyager probes zoomed by in 1979 (left) than when Hubble saw it in 2014 (right).

Astronomers have known for decades that Jupiter's trademark weather pattern — the stormy Great Red Spot — is shrinking. But in May, after taking a closer look with the Hubble Space Telescope, they learned that lately the spot has been shrinking at a faster rate. In 1979, when Voyager 1 and Voyager 2 flew by, the Great Red Spot was 14,500 miles wide. Now it's just 10,250 miles wide and shrinking by 580 miles per year. The cause of the big shrink remains a mystery. —LIZ KRUESI

FROM TOP: GOOGLE; JAY SMITH AFTER GOOGLE PATENT; 1979 JUPITER, NASA/JPL/BJORN BJORN JONSSON; 2014 JUPITER, NASA, ESA AND AMY SIMON (GODDARD SPACE FLIGHT CENTER)

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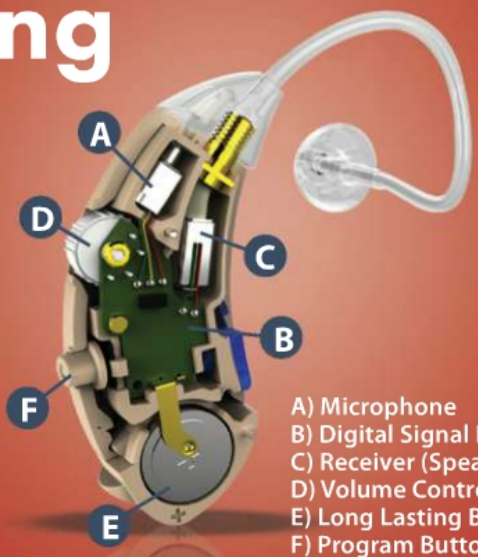

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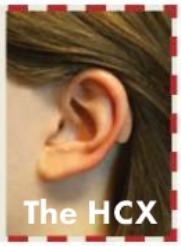
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FDA Approves First Powered Exoskeleton

A powered exoskeleton, long an object of fascination for science fiction writers and researchers alike, won federal approval last summer. Now paraplegics can use the device to sit, stand and walk.

The ReWalk first made headlines in 2012 when the device, then experimental, helped a woman with paraplegia complete the London Marathon. On June 26, the FDA gave the go-ahead to market it directly to consumers, and two weeks later, a retired U.S. Army sergeant became the first patient in the U.S. to take one home. A Veterans Affairs official said the agency would pay the $69,500 price tag, but it's unclear whether private insurers or Medicare will cover the device.

The ReWalk includes a metal brace supporting the legs and upper body; motors at the hips, knees and ankles; and a backpack containing a computer and battery. Buttons on the wrist command the device to sit down, stand up or walk. When activated for walking, a sensor detects when the wearer leans forward and then initiates a step.

The paralyzed creator of ReWalk, mechanical engineer Amit Goffer, will not benefit from his invention, however. He's a quadriplegic, so he cannot control it. But, he says, "this is only the beginning." His company is developing similar systems for quadriplegics and those with neurodegenerative illnesses.

— DAN HURLEY

Retired U.S. Army Sgt. Theresa Hannigan demonstrates the ReWalk for Pennsylvania congressman Chaka Fattah in May.

Wrist device commands the exoskeleton to sit, stand or walk

The ReWalk exoskeleton

Watch a video of the ReWalk exoskeleton in action at DiscoverMagazine.com/Walk

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Laser Technique Reverses Tooth Decay

The drill-and-fill approach to fixing cavities may eventually have new competition, thanks to Harvard University biomedical engineer David Mooney and National Institutes of Health assistant clinical investigator Praveen Arany. The pair, along with colleagues, reported in May that they had developed a new technique that stimulates the growth of dentin, the hardened tissue below tooth enamel, through the use of a simple, low-powered laser.

Arany drilled holes in the teeth of rats, shined a light similar to a laser pointer into the false cavities for five minutes, then capped them. Twelve weeks later, the dentin inside had grown back. By studying the same process in cultured cells, the scientists found that the light stimulated a molecular chain reaction that activated a normally dormant protein called TGF-beta 1. That protein, in turn, prompted nearby dental stem cells to differentiate into dentin-forming cells, which then differentiate into mature dentin. The protein also activates other kinds of stem cells, which means the method could be used to regenerate other tissues.

The technique could combat tooth sensitivity and cavities. "It's not going to replace the root canal," Arany says, but you might be able to prevent one in the first place with dentin regeneration.

— GREGORY MONE

FROM LEFT: PRNEWSFOTO/OFFICE OF CONGRESSMAN FATTAH; REWALK ROBOTICS (2)