SN
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NOVEMBER 2, 2013

The Upside to Feeling Down

Nature's DEET

Lunar Biological Clocks

Nobels 2013

Solar Fizzle

Learning from the sun's recent doldrums

Chicago Doctor Invents Affordable Hearing Aid
Outperforms Many Higher Priced Hearing Aids

Reported by J. Page

CHICAGO: A local board-certified Ear, Nose, Throat (ENT) physician, Dr. S. Cherukuri, has just shaken up the hearing aid industry with the invention of a medical-grade, affordable hearing aid. **This revolutionary hearing aid is designed to help millions of people with hearing loss who cannot afford—or do not wish to pay—the much higher cost of traditional hearing aids.**

"Perhaps the best quality-to-price ratio in the hearing aid industry" – Dr. Babu, M.D.
Board-Certified ENT Physician

Dr. Cherukuri knew that untreated hearing loss could lead to depression, social isolation, anxiety, and symptoms consistent with Alzheimer's dementia. **He could not understand why the cost for hearing aids was so high when the prices on so many consumer electronics like TVs, DVD players, cell phones and digital cameras had fallen.**

Since Medicare and most private insurance do not cover the costs of hearing aids, which traditionally run between $2,000-$6,000 for a pair, many of the doctor's patients could not afford the expense. Dr. Cherukuri's goal was to find a reasonable solution that would help with the most common types of hearing loss at an affordable price, not unlike the **"one-size-fits-most" reading glasses** available at drug stores.

He evaluated numerous hearing devices and sound amplifiers, including those seen on television. Without fail, almost all of these were found to amplify bass/low frequencies (below 1000 Hz) and not useful in amplifying the frequencies related to the human voice.

Inspiration From a Surprising Source

The doctor's inspiration to defeat the powers-that-be that kept inexpensive hearing aids out of the hands of the public actually came from a new cell phone he had just purchased. **"I felt that if someone could devise an affordable device like an iPhone® for about $200 that could do all sorts of things, I could create a hearing aid at a similar price."**

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The high cost of hearing aids is a result of layers of middlemen and expensive unnecessary features. Dr. Cherukuri concluded that it would be possible to develop a medical grade hearing aid without sacrificing the quality of components. The result is the MDHearingAid® PRO, starting well under $200. **It has been declared to be the best low-cost hearing aid that amplifies the range of sounds associated with the human voice without overly amplifying background noise.**

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The MDHearingAid® PRO has been rigorously tested by leading ENT physicians and audiologists who have unanimously agreed that the **sound quality and output in many cases exceeds more expensive hearing aids.**

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"I have a $2,000 Resound Live hearing aid in my left ear and the MDHearingAid® PRO in the right ear. ***I am not able to notice a significant difference in sound quality between the two hearing aids."*** —Dr. May, ENT Physician

"We ordered two hearing aids for my mother on Sunday, and the following Wednesday they were in our mailbox! Unbelievable! Now for the best part—they work so great, my mother says she hasn't heard so good for many years, even with her $2,000 digital! ***It was so great to see the joy on her face.*** *She is 90 years young again."* —Al Peterson

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Features

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There are benefits to feeling blue. Recent studies find that a negative mood increases accuracy of recall, attention to detail and sensitivity to others' feelings. *By Bruce Bower*

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COVER STORY Now at the peak of its 11-year cycle, the sun should be roiling with magnetic disturbances and throwing off repeated blasts of high-energy particles. But this solar maximum has been surprisingly silent. *By Alexandra Witze*

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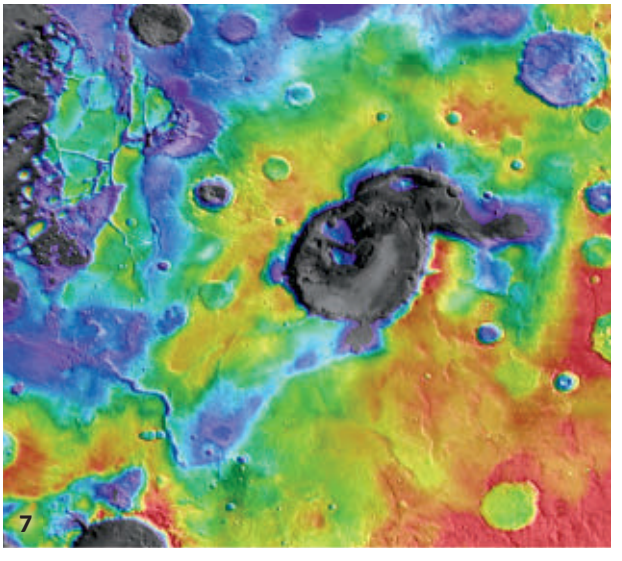

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COVER An October 11 image of the sun taken by the Solar Dynamics Observatory reveals only a handful of sunspots. The dark blotches indicate magnetic activity on the sun. *SDO/NASA*

Don't worry, be grumpy and take nature's cycles in stride

Next time you're in a bad mood, don't fight it. Put it to work, and thank evolution for giving you such a flexible cognitive toolbox.

That's one of the take-home messages in behavioral sciences writer Bruce Bower's article (Page 18) about the unexpected benefits of negative moods. Gloomy moods just make people better suited to certain tasks. Years of laboratory studies show that a low mood — a diffuse, lingering and largely unconscious state distinct from an intensely experienced burst of emotion — can improve memory, judgment, motivation and consideration of others. Some research suggests that a bad mood promotes shifting to alternative ways of thinking about a problem, while a good mood encourages people to stay the course. Of course, happy moods have their advantages too: creative, big-picture thinking is one. Psychologist Joseph Forgas of the University of New South Wales in Sydney believes that that's as it should be, and worries that "our current cultural epoch is characterized by a unilateral emphasis on the benefits of happiness." Moods, good or bad, give humans important clues about how to best respond to a situation, he says.

And if being positive about feeling sad doesn't fulfill all of your needs for embracing opposites, how about a sun that has reached its 11-year peak of activity with barely a whimper? On Page 22, contributing correspondent Alexandra Witze provides a full account of Solar Cycle 24, from its lackluster number of sunspots to the new discoveries scientists are making about the magnetic flows that power solar tempests. The latest solar cycle, Witze reports, underscores just how hard it still is to predict the behavior of our nearest star.

Scientists have long known that the sun influences the behavior of life on Earth by syncing up circadian clocks with daylight. Now, two studies reveal the moon's pull on animal rhythms. On Page 6, molecular biology writer Tina Hesman Saey reports that a marine worm's newly discovered biological clock uses moonlight to time its monthly spawning. She also describes a 12-hour biological clock that enables sea lice to time their foraging with the rise and fall of the tides. The findings raise the tantalizing possibility that many animals, including perhaps humans, have multiple biological clocks attuned to a variety of cues from the natural world. A moon clock could explain some cycles observed in people, from menstruation to a report linking changes in sleep patterns to phases of the moon. So far, though, there is nothing to report about the moon's influence on bad moods.

— Eva Emerson, Editor in Chief

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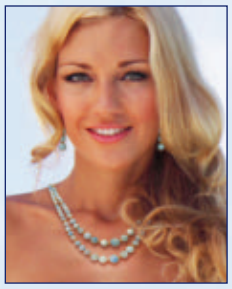
SANDY SCHAEFFER

Send in the Aquamarines

Claim your share of the legendary "sailor's gem" that was once considered more valuable than diamonds or gold!



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Excerpt from the November 2, 1963, issue of *Science News Letter*

50 YEARS AGO

Comet Belt Predicted Near Farthest Planet

A belt of yet-to-be-seen comets lies near the pathway of the farthest planet, Pluto, predicted by Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, Cambridge, Mass.... The belt extends out to an undefined distance [and] is distinct from the great cloud of comets that is more than twice as far off and that accounts for the occasional comets we see.... Dr. Whipple said the gravitational pull of the comet belt probably is responsible for disturbances in the planet Neptune's orbit. This would mean that the belt would be ten times heavier than earth.

UPDATE: The 1992 discovery of an icy object beyond Neptune confirmed the existence of the Kuiper Belt, named for Gerard Kuiper, who predicted its existence in 1951. NASA's New Horizons spacecraft will fly into the Kuiper Belt after its 2015 flyby of Pluto, now recognized as a Kuiper Belt Object instead of a planet.

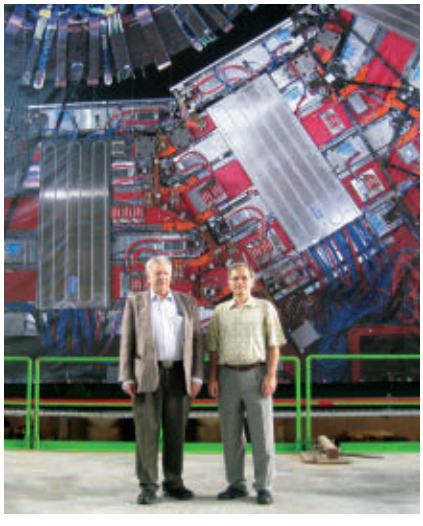
IT'S ALIVE

The colorful lives of squid

Your calamari, it turns out, may have come from a temporary transvestite with rainbows in its armpits.

Well, not armpits, but spots just below where the fins flare out. "Finpits," cell biologist Daniel DeMartini nicknamed them. He and his colleagues have documented unusual color-change displays in female California market squid, popular in restaurants.

Squids, octopuses and cuttlefishes are nature's iPads, changing their living pixels at will. DeMartini, of the University of California, Santa Barbara, saw so many sunset shimmers, blink-of-an-eye blackouts and other marvels



PEOPLE

Nobel's sharp cuts

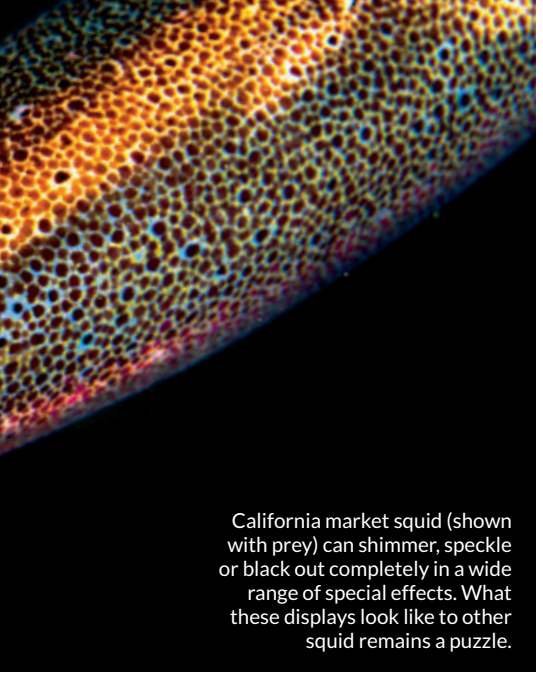
On July 4, 2012, Gerald Guralnik was in a packed room at CERN savoring the discovery of the Higgs boson, which confirmed a theory he proposed nearly 50 years ago. (Guralnik shown left, on the day of the announcement.)

No such celebration occurred Oct. 8. Guralnik was home when he learned online that physicists François Englert and Peter Higgs had won the Nobel Prize in physics for formulating the same theory. "I'm happy for Englert and Higgs, but it does sting a little bit," he says. "Physicists are only human."

Presumably, Englert and Higgs got the nod because they published their 1964 theories of a mass-bestowing field first, before Guralnik and two colleagues. (Nobels have a maximum of three recipients.) Guralnik had come up with the gist of the Higgs field in 1962, during his doctoral research, but an adviser forced him to take that portion out, saying "I don't know what's the matter with it, but it's not right."

Guralnik later revisited that research, but faced yet more skepticism. He sat on the paper for months, incessantly searching for mistakes, before finally submitting it to *Physical Review Letters*. The day he mailed the manuscript, he received advance mimeographed copies of Higgs' and Englert's papers — the ones that would garner a Nobel Prize 49 years later. — *Andrew Grant*

IT'S ALIVE, FROM LEFT: DAMIAN DAVALOS/FLICKR; D. DEMARTINI (INSETS); PEOPLE: BROWN UNIV.

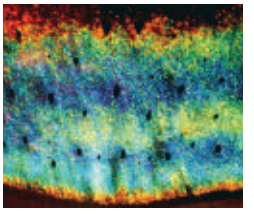


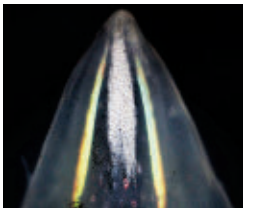
California market squid (shown with prey) can shimmer, speckle or black out completely in a wide range of special effects. What these displays look like to other squid remains a puzzle.

in California's *Doryteuthis opalescens* that it took him a while to notice that only females shimmered the finpit stripe (right, top image). It shows up now and then during life, and reliably for about 24 hours after decapitation, DeMartini found.

The squid are color-blind, and what prompts their display is known only to them. But the researchers have figured out how it works.

The squid make rainbows when color-change cells called iridocytes lose water. Other kinds of color-change cells work their magic via pigments, but not iridocytes. "If you take a bunch of iridocyte cells in red, blue, green or yellow and you grind them up, then you wouldn't see any color," DeMartini says. Instead, little stacks of protein plates inside the cells turn colorful only when water rushes out of the stack. How closely the plates snug together determines whether the stack looks blue, scarlet or anything in between.





Another kind of cell called a leucophore makes a different girls-only special effect, a white streak between the fins (right, bottom image). "I kind of ignored it for a long time," DeMartini says. "I thought it was decaying or dying tissue." He examined squid that were collected during a sexual gathering. Millions draw near shore for frenzied grappling, gripping and mating. In the fray, females get "pretty thrashed," he says. "Maybe they need a break." So displaying a white streak that could look like a male's white testis showing through the transparent body may deflect male attention, he and his colleagues speculate in the Oct. 1 *Journal of Experimental Biology*.

How such fabulous colors evolved in the color-blind squid is "still kind of a brainteaser," DeMartini says. The California species has only one visual pigment, he says, and mainly detects patterns of darks and lights. — *Susan Milius*

THE -EST

Oldest pitch-drop experiment

Grass grows quicker. Paint dries faster. Yet there's something irresistible about watching the glacial flow of pitch.

And now a long-forgotten experiment with pitch has come to light, probably the oldest known of its kind. In a small display case at Aberystwyth University in Wales sits a glass funnel filled with a heap of ultra-viscous pitch, dated April 23, 1914. That's 13 years older than a similar setup at the University of Queensland in Australia, which *Guinness World Records* lists as the longest continually running laboratory experiment.

The allure of pitch — a black tarlike hydrocarbon by-product of distilling petroleum, wood or coal — comes from its split personality: It shatters from a quick hit with a hammer, but flows if set aside for long periods. For more than a century physicists have showcased that contradictory behavior with the pitch-drop and other experiments, in which a seemingly solid mass of pitch displays its liquid nature. At right is a sampling of multigenerational investigations of pitch. — *Andrew Grant*

Experiments in flowing pitch

1. **Sinking bullets** In an 1882 experiment, Scottish physicist Lord Kelvin put corks below and bullets above a block of pitch. Over time the corks floated to the surface and the bullets sank. Pitch was the only earthly material Kelvin knew of that could simultaneously behave as a solid and a fluid. He and other physicists of his era believed that a similar substance called the ether permeated the cosmos. Ether needed to be rigid enough to propagate rapidly oscillating light waves, yet fluid enough for planets and other objects to travel through it. Pitch was a great analog.

2. **Kelvin's ramp** In 1887, Lord Kelvin built a glacier-simulating experiment by placing pitch atop a wooden ramp. Over the years the pitch slithered down; today the ramp is on display at the Hunterian Museum in Glasgow.

3. **Modern day** Physicist John Mainstone (left), who died in August after overseeing the Queensland pitch experiment for 52 years, never saw a fall. In fact, nobody had ever witnessed a drop of pitch falling until July of this year, when a camera captured a drip in a 69-year-old experiment in Dublin. More than a million people have watched the Dublin pitch-drop video online, while groupies keep an eye on a live webcast of Queensland's experiment.

4. **A new record** Despite its head start, the newly rediscovered 1914 pitch experiment in Wales has not produced a single drop. The funnel stem is about 80 millimeters long, Aberystwyth lab technician Stephen Fearn says, yet the pitch has descended a mere 6 millimeters in the century since physicist G.T.R. "Taffy" Evans set it up. At that rate, the pitch won't emerge from the funnel — let alone form a drop — for another 1,300 years. It's unclear what type of pitch Evans used and why it flows so slowly.

THE -EST, FROM TOP: THE HUNTERIAN MUSEUM AND ART GALLERY, UNIV. OF GLASGOW © 2013 (TOP TWO); UNIV. OF QUEENSLAND; STEPHEN FEARN

GENES & CELLS

Biological clocks set by the moon

Organisms have rhythms dictated by tides, lunar cycle

A newly discovered biological clock times the spawning of a marine worm, *Platynereis dumerilii* (shown), to phases of the moon.

BY TINA HESMAN SAEY

The sun exerts hegemony over biological rhythms of nearly every organism on Earth. But two studies now show that the moon is no slouch. It controls the cadence of at least two biological clocks: one set by tides and the other by moonlight.

The clocks, both discovered in sea creatures, work independently of the circadian clock, which synchronizes daily rhythms with the sun. The studies demonstrate that the moon's light and its gravitational pull, which creates tides, can affect animal behavior.

"The moon has an influence, definitely," says Steven Reppert, a neurobiologist at the University of Massachusetts Medical School in Worcester who was not involved with either study. "Clearly for these marine organisms, it's very powerful and important."

Scientists established decades ago that circadian clocks govern people's daily cycles of such things as hormone levels, blood pressure and body temperature. Nearly all organisms, including single-celled creatures, have some version.

Circadian clocks are composed of protein gears. In a loop that takes roughly 24 hours, levels of some proteins rise and then fall, while others fall and then rise. Sunlight sets the clocks, but once a clock is set it will keep running even when scientists keep organisms in constant darkness.

Other rhythmic behaviors occur on longer time frames, such as reproductive cycles that seem to follow the moon, annual patterns such as hibernation and blooming cycles, and multiyear events including the emergence of cicadas every 13 to 17 years. There are also periodic activities that follow shorter timescales, such as behavior of coastal organisms coordinated with tides. Researchers have debated whether these behaviors were really timed by an internal clock that would keep ticking if the cues used to synchronize it disappear.

"What is biologically true and what is myth needs to be carefully untangled," says Kristin Tessmar-Raible, a molecular neurobiologist at the University of Vienna. She and colleagues describe a lunar clock in a marine worm in the Oct. 17 *Cell Reports*.

That unraveling of fact from fiction can take a long time. It took about nine years for Charalambos Kyriacou of the University of Leicester in England and his colleagues to establish that the speckled sea louse, *Eurydice pulchra*, has a clock that times the tides. Before the tide goes out, the creatures bury themselves in the sand to keep from being swept out to sea. When water levels rise a little more than 12 hours later, the sea lice emerge to forage. When kept in dark, still water in the lab, the animals' swimming patterns still followed the rise and fall of the tides. The result indicates that the rhythm is under control of a tidal clock within the sea lice, the researchers report in the Oct. 7 *Current Biology*.

Some researchers had speculated that *Eurydice*'s tidal rhythms might stem from a pair of out-of-phase circadian clocks generating the roughly 12-hour tidal rhythms. So the researchers disabled molecular gears in the crustacean's circadian clock. "It doesn't matter what you throw at the circadian clock — you can hit it with a hammer — and the tidal rhythm is unaffected," Kyriacou says. That is evidence that the tidal clock uses different protein gears than the circadian clock does.

Meanwhile, Tessmar-Raible and her colleagues were simultaneously reporting their discovery of a lunar clock in a marine worm, *Platynereis dumerilii*. The worms spawn on a monthly cycle set by moonlight, the team found.

Like the tidal clock in the crustaceans, the worms' lunar clocks kept on ticking when researchers dismantled the circadian clock; the cycles are under control of an independent timing mechanism.

The discoveries raise the possibility that many other organisms, including humans, may have multiple timers, says Charlotte Helfrich-Förster, who studies biological clocks at the University of Würzburg in Germany. Such clocks could be behind women's monthly menstrual cycles; recent studies have also shown that sodium levels have a monthly rhythm and that people's sleeping habits may follow lunar cycles (*SN: 8/24/13, p. 15*).

The researchers are now trying to find the molecular gears that run the new clocks. ■

ATOM & COSMOS

Sphere bends light like a big star

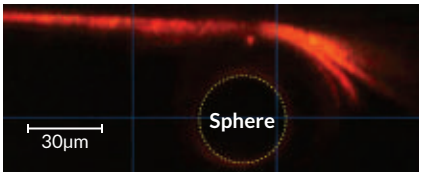
No longer megascale, gravitational lensing goes micro

BY ANDREW GRANT

Light rays bend around a microscopic sphere much as they would around a gargantuan black hole thanks to a new chip-sized device. The experiment, detailed September 29 in *Nature Photonics*, demonstrates physicists' newfound ability to mimic and miniaturize cosmic-scale physical processes in the lab.

"It's a nice little demonstration that can bend light around 360 degrees, just as gravity can around a black hole," says William Unruh, a physicist at the University of British Columbia in Vancouver.

Einstein's general theory of relativity defines gravity as the curvature of space and time around objects with mass: The more massive the object, the more drastically it warps space and time. As a result, the trajectory of light bends as it whizzes past the universe's densest, most massive objects, including black holes.



A beam of light curves around a tiny glass sphere embedded in plastic. Light making a close encounter with a massive star would take a similar path.

Astronomers have confirmed this phenomenon, called gravitational lensing, by observing galaxies that distort light coming from behind them.

Scientists can't experiment with massive stars and galaxies in the lab, but they are getting good at manipulating light. Dentcho Genov, a physicist at Louisiana Tech University in Ruston, and colleagues from Nanjing University in China set out to build a miniature star on a chip that could bend light using optics rather than gravity. Their stars come in the form of tiny glass spheres, each 32 micrometers in diameter, embedded in molten plastic. The researchers poured that mixture onto a silver chip and let it harden. The result was a roughly micrometer-thick layer of plastic, with thicker areas sloped up around the spheres.

Light shined horizontally through the plastic layer moved in a straight line if it encountered no spheres. But light that came close to a sphere got bent. Any beam that came within about 10 micrometers of a sphere was whipped around it. Some light even seemed to get forced into orbit.

The behavior is consistent with the path that light takes around a massive star, Genov says. "It's a perfect analog to astronomical observations." Similar devices could help astrophysicists understand conditions near black holes, he says.

Unruh is impressed with the optics but not the potential to clarify the cosmos. Just because the experiment mimics the influence of gravity doesn't mean it's a perfect simulation, he says. ■

ATOM & COSMOS

Supervolcanoes once erupted on Mars

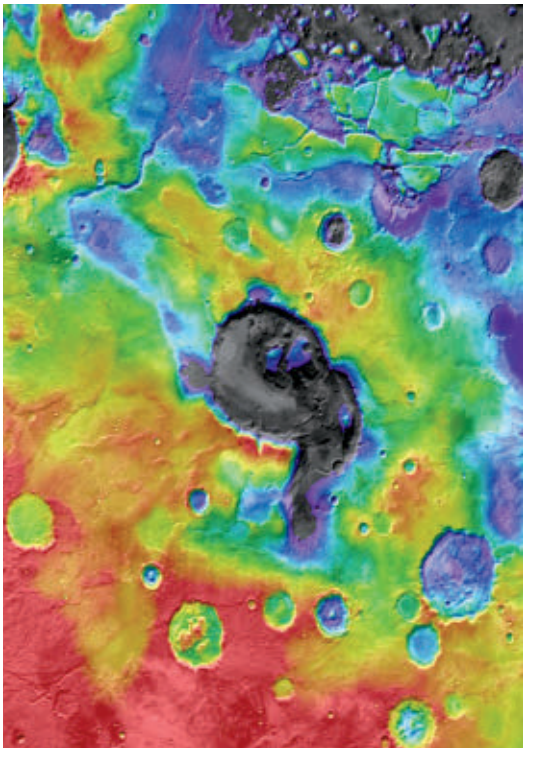
Lava-spewing supervolcanoes ripped through Mars' dusty red surface billions of years ago, a new analysis suggests.

Scientists have identified Martian volcanoes before, but none as violently explosive as the ones Joseph Michalski of the Planetary Science Institute in Tucson and Jacob Bleacher of the NASA Goddard Space Flight Center in Greenbelt, Md., report in the Oct. 3 *Nature*. "What we're looking at is a very different beast," says Bleacher.

When supervolcanoes erupt, they blow their lids completely, ejecting massive amounts of molten rock. Instead of leaving behind mountains of rubble, supervolcano explosions gouge giant craters into a planet's surface. Because asteroid craters also pockmark Mars, scientists had assumed most of the pits were caused by impacts.

But some craters looked suspicious (one shown; low elevation, purple-gray): They lacked typical impact signatures and were surrounded by ridges of ancient lava. Michalski and Bleacher pieced together topographic and other data from Mars-orbiting spacecraft to sketch a picture of the planet's past surface. Their work is the first to find Martian supervolcanoes.

Because volcanoes belch gas and particles, the findings could help illuminate the history of Mars' atmosphere, a step toward figuring out whether the planet was ever habitable. — *Meghan Rosen*



FROM TOP: C. SHENG *ET AL*/*NATURE PHOTONICS* 2013; JPL-CALTECH AND GSFC/NASA, ASU

ATOM & COSMOS

Proton-boron nuclear fusion returns to spotlight

Technique fuses nuclei without producing harmful neutrons, but is far from power plant–ready

BY ANDREW GRANT

A laser-driven technique could reignite research into fusing protons and boron nuclei, creating what has been the most seductive and challenging fuel for generating energy from nuclear fusion.

While the researchers acknowledge that this type of fusion won't be used to make energy any time soon, their work opens new avenues for exploring what many physicists consider the ideal fusion fuel. "The holy grail of holy grails is proton-boron fusion," says Steven Cowley, a fusion physicist at Imperial College London who was not involved in the new work.

> "The holy grail of holy grails is proton-boron fusion."
> STEVEN COWLEY

Since the Manhattan Project in the 1940s, scientists pursuing nuclear fusion have primarily focused on combining two varieties of hydrogen nuclei, deuterium and tritium. That's the fuel of choice for hydrogen bombs and energy production experiments that try to squeeze more energy out of fusion reactions than they take to get started. Physicists have never reached this break-even point in controlled fusion. Plus hydrogen has drawbacks, including the scarcity of tritium (any potential fusion power plant would have to manufacture it) and the production of neutrons. Neutrons can make ordinary materials radioactive, and their energy is difficult to capture.

Decades ago, those shortcomings inspired scientists to explore fusing protons with boron-11, a nucleus of five protons and six neutrons. The reaction produces no stray neutrons, and boron is much easier to obtain than tritium.

But while the National Ignition Facility in Livermore, Calif., and other research centers cultivate fusion reactions by crushing and heating hydrogen in the hopes of creating a self-sustaining burn (*SN: 4/20/13, p. 26*), that approach won't work for proton-boron reactions; they require much higher temperatures to ignite. No other techniques coaxed protons and boron to fuse in significant numbers, so research stalled.

Three years ago Christine Labaune, a plasma physicist at the National Center for Scientific Research in Palaiseau, France, teamed with Johann Rafelski, a theoretical nuclear physicist at the University of Arizona in Tucson, to try a different approach. They set up two lasers. One accelerated a torrent of protons and electrons toward a small lump of boron. Just before the particles arrived, the other laser zapped the lump, heating it and stripping electrons away from the boron nuclei to form a plasma.

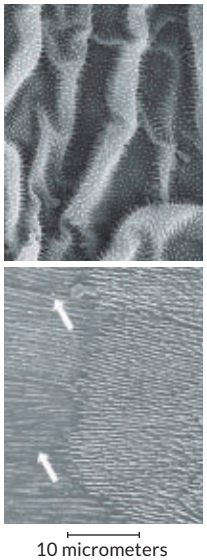
Labaune, Rafelski and colleagues report October 8 in *Nature Communications* that about 80 million protons fused with boron nuclei during the 1.5 nanoseconds that the second laser fired. That's at least 100 times the reaction rate of any previous proton-boron experiment, they say.

Unfortunately, all those fusion reactions add up to only millijoules of energy — about a millionth of the lasers' energy. Samuel Cohen of the Princeton Plasma Physics Laboratory points out that because the new approach requires so much energy to accelerate protons, nearly 10 percent of those protons would have to fuse to produce an energy surplus; in the experiment, no more than 1 in 300 protons fused with boron.

Labaune and Rafelski stress that they are not proposing to use their scheme as the basis of a nuclear reactor design. But they say their approach gives physicists a new way to look at an old problem. Cohen agrees that the technique warrants further exploration.

Rafelski says the team has seen much higher reaction rates in follow-up experiments. In the meantime, he says that clashes of protons and plasma similar to those in the experiment occurred frequently during the first several minutes after the Big Bang. Astrophysicists could use lasers to simulate how the first elements heavier than hydrogen formed. ■

M. SPINNER *ET AL/ PROCEEDINGS OF THE ROYAL SOCIETY B* 2013



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LIFE & EVOLUTION

How legless geckos slither

A belly carpeted in raised ridges may help legless lizards slide along. Some geckos have only two tiny tabs for legs, so they wriggle like snakes. These geckos may propel themselves with microscopic corduroy-like ribs on their skin, researchers suggest in the Dec. 7 *Proceedings of the Royal Society B*. Unlike geckos with legs, which owe their sticky grip to spiky spines on the skin, *Lialis jicari* has spiky spines only where skin doesn't touch the ground (top, left). Skin that does slide against the ground has raised ridges (bottom, left), which could help the reptiles slither. Tiny remnants of spines run along the ridges (arrows), the team discovered by examining freshly shed skin under a microscope. — *Meghan Rosen*

HUMANS & SOCIETY

2013 Nobels decades in the making

Prizes show that discovery takes inspiration plus perspiration

The 2013 Nobel Prizes in chemistry, physics and physiology or medicine are all potent reminders that science, though studded with the occasional brilliant flash of insight, almost always takes years of persistent toil to move forward.

This year's physics laureates, Peter Higgs of the University of Edinburgh and François Englert of the Université Libre de Bruxelles, proposed in 1964 that a field permeating the universe confers mass on particles that interact with it. That insight, also reached at about the same time by others who didn't share the prize, became instrumental in developing the standard model, a theoretical framework that encompasses all known fundamental particles and all but one of its forces (gravity).

Though deep, Englert and Higgs' insight wasn't enough to merit a Nobel on its own. It took almost 50 years for experimental physicists — thousands of them — to develop a particle collider powerful enough and detectors sensitive enough to demonstrate the existence of the Higgs boson (*SN: 7/28/12*). (Higgs got his name on the particle because his 1964 paper predicted its existence as a consequence of the mass-giving field.)

There have been complaints that the Nobel committee too often favors those who find new particles over those who anticipate their discovery. But this time, the committee chose not to reward the persistent hard work of the experimenters in favor of the theorists who set them to their task.

"Every year is a new year," says Lars Bergström, secretary of the Nobel physics committee. "Nominations that come in next year may well propose the experimentalists who actually made the discovery."

The three chemistry winners earned their prize not so much for following up on a brilliant insight as for possessing a vision and making it real over decades of research. More than 40 years ago, Martin Karplus of the Université de Strasbourg and Harvard, Michael Levitt of Stanford and Arieh Warshel of the University of Southern California started developing mathematical methods and computer simulations to predict the interactions of individual molecules in chemical reactions. Their stroke of genius was to develop a way of marrying relatively simple and easily simulated classical physics with the quantum physics that describes the behavior of matter at an atomic scale. Rudimentary at first, their efforts have now been adopted widely by their colleagues to predict the outcomes of complex reactions that would once have required painstaking laboratory work.

"We save a lot of money, we save a lot of time and we save a lot of effort by doing the theoretical work first," says Sven Lidin, chair of the Nobel chemistry committee.

In physiology or medicine, the winners spent years refining their understanding of how cells use bubble-like organelles called vesicles to package and deliver molecular cargo. In the 1970s, Randy Schekman of the University of California, Berkeley and James Rothman of Yale gradually identified various components of the intracellular shipping system by breaking it in different ways and then observing the result. Later, Thomas Südhof of Stanford found a molecular clamp in brain cells that quickly releases chemical messages.

Rothman noted in a news conference that he had to endure five years of frustration before his work started producing results, a delay that might not be tolerated in today's tight funding climate.

"It's much more difficult for young scientists to get started today," Rothman said. "In a relative sense, they get less money than we got." *— Andrew Grant, Beth Mole, Gabriel Popkin, Meghan Rosen, Tina Hesman Saey and Nathan Seppa*

For more in-depth Nobel coverage visit www.sciencenews.org/nobels2013

2013 Nobel Laureates

PHYSIOLOGY OR MEDICINE

James Rothman
Yale University

Randy Schekman
University of California, Berkeley

Thomas Südhof
Stanford University

CHEMISTRY

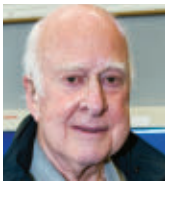
Martin Karplus
Université de Strasbourg; Harvard University

Michael Levitt
Stanford University

Arieh Warshel
University of Southern California

PHYSICS

François Englert
Université Libre de Bruxelles



Peter Higgs
University of Edinburgh

FROM TOP: YALE UNIV.; PEG SKORPINSKI; STEVE FISCH/STANFORD UNIV. SCHOOL OF MEDICINE; STEPHANIE MITCHELL/HARVARD PUBLIC AFFAIRS & COMMUNICATIONS; STEVE FISCH; USC PHOTO/GUS RUELAS; J. JOTTARD/UNIV. LIBRE DE BRUXELLES; © CERN

GENES & CELLS

Cancer mutations found outside genes

Genetic variants in noncoding DNA associated with disease

BY TINA HESMAN SAEY

Parts of human DNA that do not contain genes but instead turn genes on and off may play an important role in causing cancer, a new study finds.

Using computer programs to comb through the DNA of 88 cancer patients, researchers identified 98 mutations in gene-regulating parts of the genome that may be causing the patients' breast, prostate or brain tumors, the team reports in the Oct. 4 *Science*.

The findings may help researchers better understand which genetic alterations lead to disease and which are harmless. "It helps to clarify a confusing question in human variation: What variants are important?" says Douglas Levine, a surgeon at Memorial Sloan-Kettering Cancer Center in New York City who was not involved with the work.

Finding one or a handful of variants that lead to disease is a daunting task because it requires sorting through more than 3 billion bases — the information-carrying chemicals that make up DNA — in each person. As a result, many scientists have narrowed their search to the 1 to 2 percent of the genome that contains protein-producing genes.

But many genetic variants implicated in common conditions such as diabetes and heart disease fall in the no-protein land between genes. Rare disease-causing mutations, such as those that spark cancer, may also fall in that vast, mysterious territory known as noncoding DNA.

"When it comes to cancer, those regions have been neglected so far," says Jan Korbel, a geneticist at the European Molecular Biology Laboratory in Heidelberg, Germany. Cancer researchers didn't have enough data to allow a search, says Korbel, who was not involved in the research. "This study shows how you can find these candidates."

To narrow down which noncoding parts probably contain important variants, Yale computational biologist Ekta Khurana and her colleagues examined DNA from 1,092 volunteers in the 1,000 Genomes Project, an effort to uncover human genetic variation. The team also used information from the Encyclopedia of DNA Elements, known as ENCODE. That project maps stretches of noncoding DNA that are important for switching genes on and off. Some switches control when one or a small number of genes turn on; others govern many genes.

To find the switches most likely related to disease, Khurana and colleagues reasoned that if a stretch of noncoding DNA were particularly important for health, natural selection would have weeded out variants. So the team looked for regions that contain fewer mutations than would be expected by chance. A mutation in one of those sensitive places is about 40 times as likely to cause disease as is a mutation elsewhere in the genome, the researchers found.

Even fewer mutations showed up in a small subset of those sensitive regions, indicating that those switches may be "ultrasensitive" to change. A mutation in one of these glass-jawed pieces of DNA is about 400 times as likely to cause disease as is one in an average stretch of DNA.

The team used these data to create a computer program that identifies mutations in noncoding parts of the genome and scores how detrimental changes are likely to be. The researchers then used the program to analyze the cancer patients' DNA. Of 98 mutations the researchers identified, 90 of them damage switches that control networks of genes and 68 fall in sensitive noncoding areas.

One day doctors might use similar tools to find variants that contribute to their patients' diseases. "It's a long way to get to possible treatments from here," Khurana says, "but it's important to understand the biological mechanisms that are driving cancer." ■

GENES & CELLS

Carcass microbes identify mice's time of death

Bacteria accompany body's decomposition in consistent time sequence

BY TINA HESMAN SAEY

Microbes might help crime scene investigators pinpoint a person's time of death.

In a step toward using bacteria and other microbes as forensic evidence, Jessica Metcalf of the University of Colorado Boulder and colleagues tracked how microbial populations changed as mouse carcasses decomposed. Knowing the type and abundance of bacteria on the body, the researchers could determine when the mice died to within about three days, the team reports September 23 in *eLife*. Populations of microscopic worms called nematodes also bloomed at predictable times.

Using microbes to investigate when an animal died makes sense. "Microbes play a huge role in how we live," says Jeffery Tomberlin, a decomposition ecologist at Texas A&M University in College Station.

"And how we decompose," chimed in Eric Benbow, a community and disease ecologist at the University of Dayton in Ohio, during a joint Skype interview.

Tomberlin and Benbow have used insects to investigate how bodies break down. With insects and other clues, CSI teams can often narrow time of death to a several-day window, but microbes could potentially pinpoint death to within hours, Benbow says.

And microbes have other advantages. "Sometimes insects aren't around, so you can't use them," says forensic scientist and study coauthor David Carter of Chaminade University of Honolulu. "But the microbes are already there."

Metcalf, Carter and colleagues created graves for 40 mice. Each mouse corpse rested in a plastic container on top of soil from a local creek bed. As the

bodies broke down over the next 48 days, the researchers swabbed microbes from skin on the mice's heads and torsos, and took samples of the animals' intestinal microbes and the soil around the bodies. The team examined DNA from each sample to determine which microbes were present and the abundance of each type.

About six to nine days into decomposition, the number of anaerobic, or oxygen-hating, microbes in the gut increased, causing the body to bloat. Around day nine, the abdominal cavity ruptured, allowing oxygen-loving bacteria to take over. When the corpses broke open, ammonia-rich fluids spilled into the surrounding dirt, making the soil more alkaline and killing microbes, such as Acidobacteria, that grow better in more acidic soil. Alphaproteobacteria flourished in the fluid-soaked soil after rupture. These bacteria's abundance did not change in mock graves with no corpses.

Once the corpses were in an advanced stage of decomposition at about day 20, a nematode called *Oscheius tipulae* dominated the soil. The worms eat bacteria, so their numbers increased along with bacterial growth.

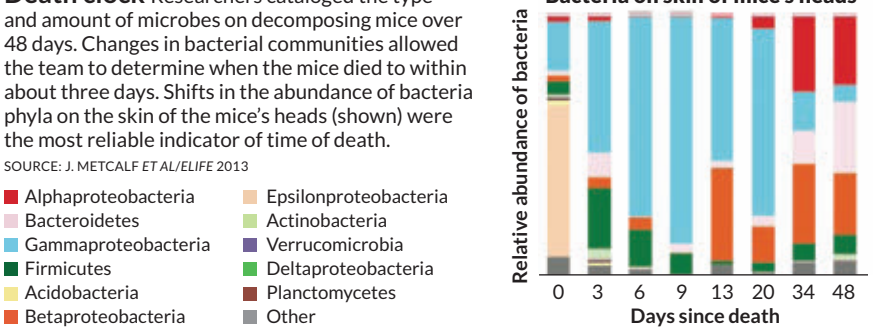
The dramatic shifts in the gut's microbial makeup weren't the best signs of time of death, because each corpse broke open at a different time. Instead, bacteria on the skin of the mice's heads were the most reliable. In the early stages of decay, the abundance of Pseudomonadaceae bacteria, a type of Gammaproteobacteria, on the head increased, peaking and then declining shortly before the body cavity ruptured. During advanced stages of decomposition, soil microbes became prominent on both the skin and in the surrounding dirt. Because skin bacteria are found in low numbers to begin with, they might be easily overwhelmed by more abundant microbes from the surroundings, the researchers say.

Demonstrating the reliability of microbes as death timers is necessary if investigators ever hope to use the technique, Tomberlin says. That's something the team did well, he says. "They created the foundation; now it's time to take it out and implement it." ■

E. OTWELL

Death clock Researchers cataloged the type and amount of microbes on decomposing mice over 48 days. Changes in bacterial communities allowed the team to determine when the mice died to within about three days. Shifts in the abundance of bacteria phyla on the skin of the mice's heads (shown) were the most reliable indicator of time of death.

SOURCE: J. METCALF *ET AL/ELIFE* 2013



BODY & BRAIN

On-off switch for eating discovered

Deactivated brain cells made hungry mice stop feeding

BY LAURA SANDERS

By hijacking connections between neurons deep within the brain, scientists forced full mice to keep eating and hungry mice to shun food. The results, which identify precise groups of cells that cause eating and others that curb it, begin to clarify the intricate web of checks and balances in the brain that controls feeding.

"This is a really important missing piece of the puzzle," says neuroscientist Seth Blackshaw of Johns Hopkins University. "These are cell types that weren't even predicted to exist." A deeper understanding of how the brain orchestrates eating behavior could lead to better treatments for disorders such as anorexia and obesity, he says.

Scientists led by Joshua Jennings and Garret Stuber of the University of North Carolina at Chapel Hill genetically tweaked mice so that a small group of neurons would respond to light. When a laser shone into the brain, these cells would either fire or, in a different experiment, stay quiet. These neurons reside in a brain locale called the bed nucleus of the stria terminalis, or BNST. Some of the message-sending arms of these neurons reach into the lateral hypothalamus, a brain region known to play an important role in feeding.

When a laser activated these BNST neurons, the mice became ravenous, voraciously eating their food, the researchers report in the Sept. 27 *Science*. "As soon as you turn it on, they start eating and they don't stop until you turn it off," Stuber says. The opposite behavior happened when a laser silenced BNST neurons' messages to the lateral hypothalamus: The mice would not eat, even when hungry.

The results illuminate a complex network of neuron connections, in which some cells boost other neurons' activity while other cells apply brakes. In the experiment, stimulating BNST neurons with light — which consequently shut down the activity of neurons in the lateral hypothalamus — led to the overeating behavior, the team found. That result suggests that these lateral hypothalamus neurons normally restrict feeding.

By stimulating neurons with a laser, scientists forced mice to eat, even when the animals were full.

That finding is surprising, says Blackshaw. Earlier experiments hinted that these hypothalamic cells would encourage eating behavior, but the new study suggests the exact opposite.

The researchers don't know whether, if they controlled the neurons for long periods, the mice would ultimately starve or overeat to the point of illness. Stuber and colleagues used the laser technique, called optogenetics, in roughly 20-minute bursts. Longer-term manipulations of these neural connections — perhaps using a drug — might cause lasting changes in appetite and, as a result, body mass, Stuber says.

This precise control of feeding behavior underscores the fact that eating disorders occur when brain systems go awry, Stuber says. "We think of feeding in terms of metabolism and body stuff," he says. "But at the end of the day, it's controlled by the brain." ■

HUMANS & SOCIETY

Early farming populations often shrank

Agriculture didn't always lead to rises in numbers of Europeans

BY BRUCE BOWER

Europe's ancient embrace of farming took the continent on a demographic roller-coaster ride. Regional booms and busts in human numbers occurred between 8,000 and 4,000 years ago, a new study finds.

From southern France to Scotland and Scandinavia, 10 of 12 regions with early farming sites experienced substantial population ups, downs or both, say archaeologist Stephen Shennan of University College London and his colleagues. Known climate changes from the period show no relation to the timing of the shifts, the researchers report October 1 in *Nature Communications*.

"Diminishing natural resources due to agricultural practices may partly have caused population busts," says anthropologist and study coauthor Sean Downey of the University of Maryland in College Park. He and his colleagues reported in 2012 that as ancient Britain's population increased following the introduction of farming, the region's forests shrank in size — consistent with a reduction in available wood and food products needed to sustain a large population.

Researchers already knew that agriculture appeared in modern-day Turkey around 8,500 years ago and spread west over the next 2,500 years.

J. JENNINGS

HUMANS & SOCIETY

Mental rotation gears up by age 5

Math-related visualization skill emerges rapidly in preschool

BY BRUCE BOWER

Cartoon ghosts have scared up evidence that the ability to visualize objects in one's mind materializes between ages 3 and 5.

When asked to pick which of two mirror-image ghost cutouts or drawings fit in a ghost-shaped hole, few 3-year-olds, a substantial minority of 4-year-olds and most 5-year-olds regularly succeeded, say psychologist Andrea Frick of the University of Bern in Switzerland and her colleagues. Girls performed as well as boys on the task, suggesting that men's much-studied advantage over women in mental rotation doesn't emerge until after age 5, the researchers report September 17 in *Cognitive Development*.

Mental rotation is a spatial skill regarded as essential for science and math achievement. Most tasks that researchers use to assess mental rotation skills involve pressing keys to indicate whether block patterns oriented at different angles are the same or different. That challenge overwhelms most preschoolers. Babies apparently distinguish block patterns from mirror images of those patterns (*SN: 12/20/08, p. 8*), but it's unclear whether that ability enables mental rotation later in life.

Frick's team studied 20 children at each of three ages, with equal numbers of girls and boys. Youngsters saw two ghosts cut out of foam, each a mirror image of the other. Kids were asked to turn the ghosts in their heads and choose the one that would fit like a puzzle piece into a ghost's outline on a board. Over seven trials, the ghosts were tilted at angles varying from the position of the outline. Researchers used three pairs of ghost cutouts, for a total of 21 trials per child.

The number of kids who chose the correct ghost on at least 14 trials rose from two at age 3 to eight at age 4 and 19 at age 5. The average percentage of correct choices increased from 54 percent at age 3 to 69 percent at age 4 and 83 percent at age 5.

A similar experiment with 4- and 5-year-olds using drawings of ghosts rather than puzzle pieces also found improvements with age. This finding suggests that a paper-and-pencil test of mental rotation can be used to gauge preschoolers' spatial abilities, Frick says.

"This is an interesting new way to measure mental rotation ability," says University of Chicago psychologist Susan Levine. It's unclear, though, whether 3-year-olds were unable to mentally rotate objects or failed to understand the task, she notes.

A larger study is needed to confirm that preschool-age girls and boys mentally rotate objects equally well, Levine adds. ■

Farming led to more plentiful, stable food supplies, fueling population growth. But little is known about long-term population trends among ancient European cultivators.

Shennan's group used nearly 8,000 radiocarbon dates from archaeological sites across Western Europe to calculate rises and falls in numbers of sites before, during and after agriculture's introduction. The researchers took fluctuations in the numbers of sites as signs of population changes, reasoning that more sites in a region at a particular time meant more people were living there.

In most sections of Europe, populations at some point declined by as much as 30 to 60 percent compared with peaks achieved after farming began, Shennan's team concludes. That population plummet is similar to the continental devastation wreaked by the Black Death, an epidemic that peaked in Europe between 1348 and 1350.

The new results illuminate two major population booms in Europe that preceded declines, remarks archaeologist Ron Pinhasi of University College Dublin. An initial boom around 7,500 years ago marked the start and spread of Europe's earliest known farming culture, recognized by its distinctive lined pottery. A second boom around 6,000 years ago — perhaps driven by a rise in the use of livestock for dairy products (*SN: 2/1/03, p. 67*) — occurred as farmers expanded into Northern Europe, Pinhasi says.

Shennan's team designed a valuable procedure for estimating ancient population fluctuations, says archaeologist Jean-Pierre Bocquet-Appel of the National Center for Scientific Research in Paris. ■

D. OCCIATO

JUST THE FACTS

Alpine swifts

200

Number of days the Alpine swift can fly without stopping

SOURCE: F. LIECHTI *ET AL*/ *NATURE COMMUNICATIONS* 2013

"Our data imply that all vital physiological processes, including sleep, can be perpetuated during flight."

F. LIECHTI *ET AL*

BODY & BRAIN

Sweet-smelling molecules repel pests

The compounds drive mosquitoes away as well as DEET does

BY LAURA SANDERS

A newly discovered batch of bug repellents works just as well as DEET, scientists report October 2 in *Nature*. As an added bonus, these new bug dopes smell faintly of grapes.

In addition to identifying the bug-repelling compounds, the scientists also uncovered the elusive cells and proteins that let mosquitoes detect and avoid DEET. This knowledge "gives you another whole set of tools" in the search for new insect repellents, says neuroscientist Mark Stopfer of the National Institutes of Health in Bethesda, Md.

DEET has been around for more than 60 years without scientists knowing how insects detect the molecule. "It's remained a mystery for so long," says entomologist Anandasankar Ray of the University of California, Riverside. Using a genetic trick, Ray and colleagues engineered fruit flies — a proxy for mosquitoes — so that the insects' neurons would glow when active.

After exposing the flies to DEET, the team identified responsive neurons in a pit in the antenna called the sacculus. These cells harbor a protein called Ir40a, a receptor present in many other insects. When the scientists silenced these Ir40a neurons, the flies grew impervious to DEET.

> Knowing which cells make insects abhor DEET allows scientists to test other possible bug repellents.

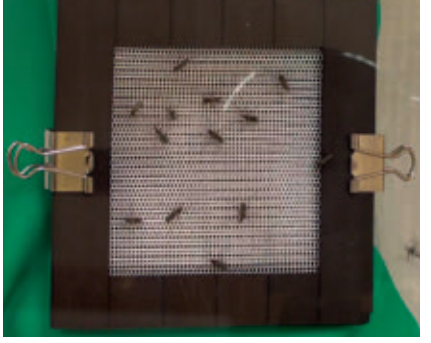
Knowing which cells make insects abhor DEET allows scientists to test other possible bug repellents by applying them to those neurons, Ray says.

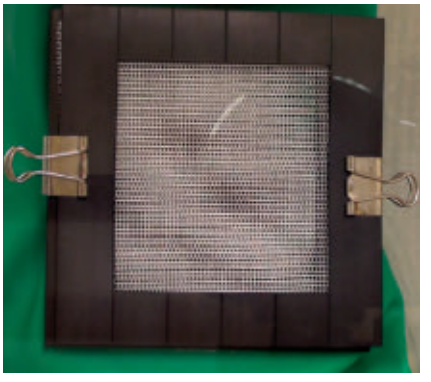
He and his colleagues tested candidates after using a computer algorithm to comb through thousands of compounds, looking for those that had chemical features similar to DEET and other known repellents. To restrict their search to molecules that were likely to be safe to humans, the scientists restricted the search to chemicals that either originate from plants or animals or are already approved as fragrances, cosmetics or flavors.

Three molecules suggested by the algorithm — chemicals known as anthranilates — activated these Ir40a cells and repelled mosquitoes. What's more, these compounds, which occur naturally in grapes, plums and orange flowers, are approved for human consumption or oral inhalation by the Food and Drug Administration. And unlike DEET, these compounds don't dissolve plastics.

With further testing these compounds might be useful in regions that struggle with mosquito-borne illnesses such as malaria, Ray says. DEET must be slathered on repeatedly, may harm health and is expensive. "Cost stops it from being used in the areas of the world where it is most needed," he says.

Because many insects have the Ir40a receptor, the new repellents might prove noxious to other insects such as bedbugs, cockroaches, ants and agricultural pests. The team plans to test the compounds on more insects, and Ray may start a company to develop and distribute these new repellents. ■



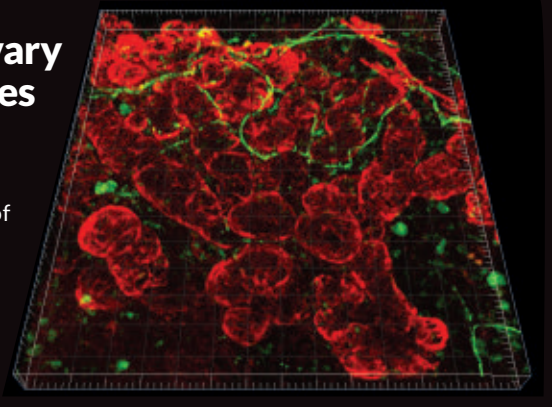


Screens coated with an anthranilate chemical (bottom) keep female mosquitoes away. The chemical smells like grapes and is considered safe for humans.

FROM TOP: P. KAIN ET AL/NATURE 2013; T. TSUJI ET AL

GENES & CELLS

Engineered salivary glands keep juices flowing



Salivary glands engineered in the lab wet the mouths of mice after transplantation, researchers report October 1 in *Nature Communications*. Takashi Tsuji of the Tokyo University of Science in Noda, Japan, and colleagues extracted clusters of immature cells from mouse embryos and grew nascent salivary glands in a gel-like substance for three days. Then the researchers implanted the incipient organs in mice that lacked salivary glands. The engineered glands (red) took up residence in the mice and pumped out saliva. Mouse nerve fibers (green) infiltrated the transplanted tissue. The team hopes that the technique will pave the way toward treatments of salivary gland disorders in people. In another paper in the same journal, Tsuji and colleagues also report having grown functioning tear glands in the lab. — *Jessica Shugart*

GENES & CELLS

Halting hormone prevents jet lag

Brain molecule steadies the beat of circadian clock in mice

BY JESSICA SHUGART

A molecular timekeeper called vasopressin steadies the daily rhythms of the body and may hamper acclimatization to new time zones. Mice rapidly recover from a lab form of jet lag when researchers block the hormone in the brain.

Fluctuations in physiology and behavior move to the beat of the circadian clock. Crossing time zones or working night shifts throws the body out of sync, leading to sleep and digestive problems, says neuroscientist Hitoshi Okamura of Kyoto University in Japan, who led the study. "When we face this situation," he says, "we are forced to suffer."

The tick-tocks of the mammalian circadian clock emanate from a tiny cluster of cells called the suprachiasmatic nucleus, located deep in the brain. Neurons in the suprachiasmatic nucleus communicate those rhythms to the rest of the brain and the body by pumping out the hormone vasopressin in daily cycles. So Okamura and colleagues genetically engineered mice to lack cell-surface proteins that detect the hormone in the brain.

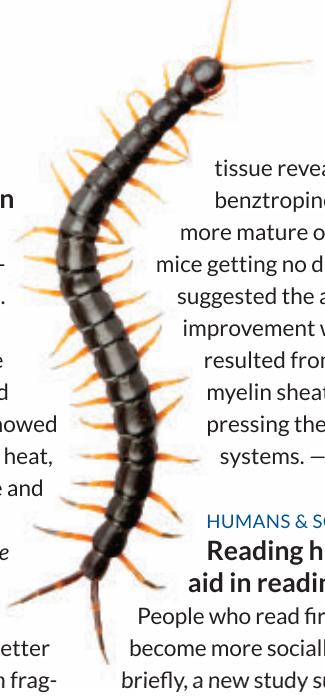
Then the team shifted the animals' schedule of light and darkness forward by eight hours. Normal mice took eight to 10 days to adjust to the new regimen. But the engineered mice acclimated in just two to four days, the researchers report in the Oct. 4 *Science*.

> "Evolution didn't expect jet lag."
>
> HITOSHI OKAMURA

The team noted that genes that normally turn on or off with circadian rhythms also realigned to the new day-night schedule much faster in the engineered mice than in normal mice. This quick readjustment occurred in genes in the brain as well as in the liver and kidney. The findings give an extraordinarily detailed view of circadian oscillations throughout the body, says neuroscientist Joseph Takahashi of the University of Texas Southwestern Medical Center in Dallas. "This is a beautiful experiment," he adds.

The team also examined neurons in the suprachiasmatic nucleus. Neurons from the normal mice adhered to a strict, highly coordinated firing schedule, whereas the timing of those from the engineered mice was more easily perturbed. "Vasopressin maintains a strong order," Okamura says, "and this is why we get jet lag."

The researchers could also hasten mice's recovery from jet lag with experimental drugs that block the effects of vasopressin in the brain. Okamura envisions using such inhibitors to treat jet lag. While temporarily weakening the circadian clock with drugs is not natural, neither is international travel, he says. "Evolution didn't expect jet lag." ■



BODY & BRAIN

Centipede venom fights pain

A chemical in centipede venom wipes out pain just as well as morphine does, a study in mice shows. When researchers injected mice with a molecule isolated from the venom of the Chinese red-headed centipede (shown), the animals showed fewer signs of pain in response to heat, acid and nasty injections, Chinese and Australian scientists report September 30 in the *Proceedings of the National Academy of Sciences*. In some tests the compound, called Ssm6a, erased pain as well as or better than morphine. Ssm6a is a protein fragment that blocks a pain-sensing channel called $Na_V1.7$. Pharmaceutical companies are in hot pursuit of molecules that do the same thing in people (*SN: 6/30/12, p. 22*). Because the channel resides mainly in the body's peripheral nerves and not in the brain, compounds that block $Na_V1.7$ shouldn't cause dizziness, drowsiness or other side effects of current pain-relief drugs. — *Laura Sanders*

Old Parkinson's drug may have new tricks

A drug for Parkinson's disease might also work against multiple sclerosis, in which the immune system degrades fatty myelin sheaths coating nerve fibers. Luke Lairson of the Scripps Research Institute in La Jolla, Calif., and colleagues tested a host of compounds to see which might boost regeneration of oligodendrocytes, the brain cells that make myelin and which are often lacking in MS patients. Using the cells' forerunners, oligodendrocyte precursor cells, from rats and mice, the researchers found that benztropine can steer these cells to become myelin-making oligodendrocytes. The researchers then induced in mice a disease that mimics MS and gave some of the animals benztropine, others a standard MS drug (fingolimod or interferon beta) and some no drug. Whether given before or after disease onset, benztropine reduced symptom severity and prevented relapses better than the MS drugs, the researchers report October 9 in *Nature*. A cell count of brain tissue revealed that mice getting benztropine had substantially more mature oligodendrocytes than mice getting no drug. Further analyses suggested the animals' symptom improvement with benztropine resulted from rebuilding of the myelin sheaths, not from suppressing the animals' immune systems. — *Nathan Seppa*

HUMANS & SOCIETY

Reading high-brow lit may aid in reading minds

People who read first-rate fiction become more socially literate, at least briefly, a new study suggests. Researchers randomly assigned nearly 700 volunteers to read excerpts of "literary" novels by recent National Book Award finalists and other celebrated authors, to read parts of fiction best sellers or popular nonfiction books, or to not read anything. Those who read literary works then scored highest on several tests of the ability to decipher others' motives and emotions, say David Kidd and Emanuele Castano, psychologists at the New School for Social Research in New York City. One test asked volunteers to describe the thoughts or feelings of one or two individuals shown surrounded by various items in a series of images, based on written and visual clues. In another test, participants tried to match emotion words to facial expressions shown for two seconds on a computer screen. By prompting readers to ponder characters' motives and emotions, literary fiction recruits mind-reading skills used in daily encounters, Kidd and Castano propose October 3 in *Science*. The researchers don't know whether regularly reading literary fiction has lasting effects. — *Bruce Bower*

MATH & TECHNOLOGY

3-D printing builds bacterial metropolises

Using a laser beam "printer" and globs of jelly as ink, scientists can now print tiny 3-D cities of bacteria in virtually any shape. Bacteria can stick together to form slimy sheets called biofilms that yellow people's teeth, line the lungs of cystic fibrosis patients and often resist antibiotics. Building 3-D models of bacterial communities could reveal how the microbes work together and evade drugs, says bioengineer Jason Shear of the University of Texas at Austin. Shear and colleagues mixed bacteria with a drop of gelatin and a light-activated chemical glue. Then they hit the droplet with a laser to bind the gelatin together, forming a thin skin. Parts not touched by the laser washed away, leaving behind a hollowed-out space where microbes could grow. Researchers sealed bacteria inside gelatin boxes, doughnuts and pyramids — shapes that could mimic real biofilm structures. Shear's team even nested one type of bacterium within a shell composed of another. When the team dosed the complex with an antibiotic, the exterior bacteria acted like a shield: They broke down the drug and protected the interior microbes from harm, the team reports October 7 in the *Proceedings of the National Academy of Sciences*. — *Meghan Rosen*

ATOM & COSMOS

Water spotted in rubble around distant star

For the first time, astronomers have discovered the watery building blocks of Earthlike planets whirling around a star outside the solar system. The star, GD 61, is a white dwarf, a dying star with a gravitational pull strong enough to suck in surrounding asteroids and planets. As GD 61 gobbles up orbiting bodies, it shreds them into a dusty cloud of rubble, says astronomer Jay Farihi of the University of Cambridge. Using data from the Hubble Space Telescope, Farihi and colleagues found rock-forming elements such as iron and magnesium in the cloud, but also a wealth of oxygen. Only one possibility can explain the oxygen, Farihi says: "It has to be water." The water and rocky material were part of a large asteroid before GD 61 ripped it to pieces, the researchers report in the Oct. 11 *Science*. Just a few water-bearing asteroids smashing into a rocky planet could deliver enough water to fill oceans and lakes. The findings suggest that habitable planets may have once orbited GD 61, a star just 150 light-years away in the constellation Perseus. — *Meghan Rosen*

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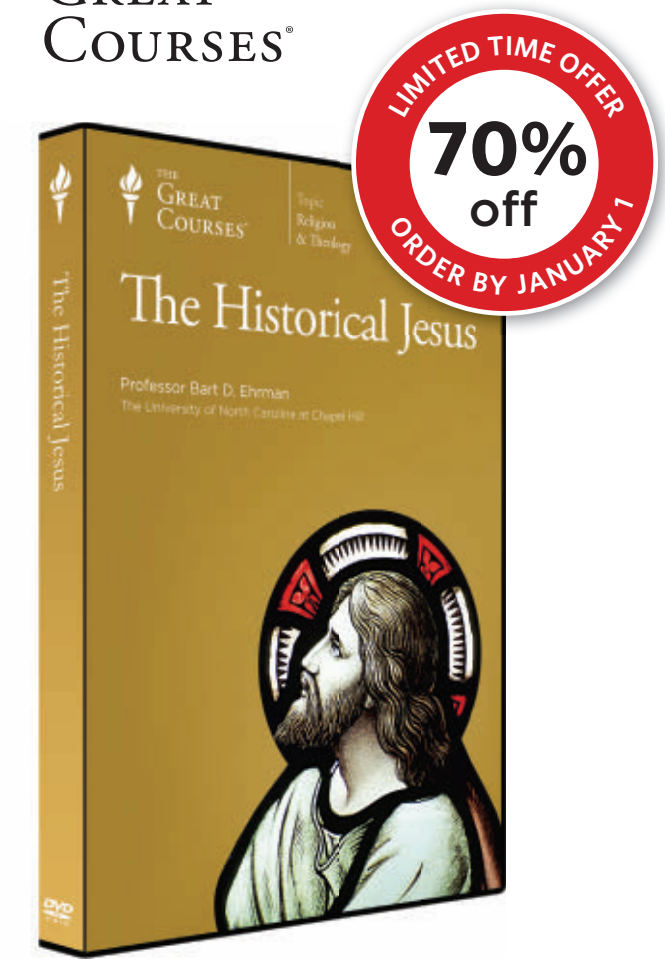

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THE BRIGHT SIDE OF SADNESS

Bad moods can have unappreciated mental upsides

By Bruce Bower

Thomas Jefferson defended the right to pursue happiness in the Declaration of Independence. But that's so 237 years ago. Many modern societies champion everyone's right to be happy pretty much all the time.

Good luck with that, says psychologist Joseph Forgas of the University of New South Wales in Sydney. A lack of close friends, unfulfilled financial dreams and other harsh realities leave many people feeling lonely and forlorn a lot of the time. But there's a mental and social upside to occasional downers that often goes unappreciated.

"Bad moods are seen in our happiness-focused culture as representing a problem, but we need to be aware that temporary, mild negative feelings have important benefits," Forgas says.

Growing evidence suggests that gloomy moods improve key types of thinking and behavior, Forgas asserts in a new review paper aptly titled "Don't worry, be sad!" For good evolutionary reasons, positive and negative moods subtly recruit thinking styles suited to either benign or troubling situations, he says. Each way of dealing with current circumstances generally works well, if imperfectly.

New and recent studies described by Forgas in the June *Current Directions in Psychological Science* illustrate some of the ways in which periods of sadness spontaneously recruit a detail-oriented, analytical thinking style. Morose moods have evolved as early-warning signs of problematic or dangerous situations that demand close attention, these reports suggest.

One investigation found that people in sad moods have an advantage remembering the details of unusual incidents that they have witnessed. And a little gloominess could help job applicants; lousy moods cut down on the tendency to

VERTES EDMOND MIHAI/SHUTTERSTOCK

stereotype others, thus boosting the accuracy of first impressions. People in sad moods also show a greater willingness to work on demanding tasks, communicate more persuasively and are more concerned with being fair to others than are peers in neutral or happy moods.

Alternatively, good moods trigger a loose mode of thought conducive to creativity and seeing the big picture. Happiness signals that a situation is safe, or at least not immediately threatening, Forgas suggests. As a result, people in a cheery state have the luxury of focusing on themselves rather than on their environments.

A good mood or a bad mood can spontaneously shape how people think.

Whether good or bad, moods are relatively low-intensity, background feelings that can last for anywhere from a few minutes to the whole day. A person may feel somewhat good or bad, happy or sad, without knowing why or even being aware of such moods. Sad moods fall far short of clinical depression's constant feelings of helplessness and hopelessness. But moods linger much longer than emotions, which typically flare up and burn out fairly quickly. In contrast to a mood, joy, anger and disgust feel intense and are experienced as having definite causes.

Feelings as information

Like Forgas, psychologist Norbert Schwarz of the University of Michigan in Ann Arbor sees mental value in sadness. "It's shallow and untrue to assume that positive feelings can only have positive consequences and negative feelings can only have negative consequences," he says.

When Schwarz was a graduate student in the late 1970s, an influential line of research held that happy moods make people more likely to remember positive events and sad moods more often revive memories of negative events. That account of how feelings influence thought seemed incomplete to the aspiring psychologist. On "good" days, he reasoned, everything just felt right without any past triumphs coming to mind. On "bad" days, life felt lousy in the moment, without any tragic memories returning for an encore.

Schwarz launched a series of studies indicating that people use low-intensity moods as a source of information when forming judgments. Good and bad moods are usually experienced as being about whatever problem or situation a person currently faces, he and his colleagues found. Treating moods in this way often works out, as when a supervisor recommends someone for a raise based on feeling good about that person's recent job performance. Feelings can mislead if, say, a boss feels happy because it's a sunny Friday and thus approves a raise for someone who pleads for a salary hike but doesn't deserve it.

By 1990, Schwarz and his colleagues had conducted a few studies suggesting that positive and negative moods spontaneously shape how people think. Sad moods fostered attention to details, they discovered, whereas happy moods promoted playfulness and creativity. More work was needed, though, to confirm those results and explore their implications for making decisions in various situations.

Individuals aren't slaves to their moods, Schwarz cautions. A sad person can think outside the box if necessary, say, to solve problems at work. And a happy person can accurately fill out tax forms or complete other detail-heavy tasks.

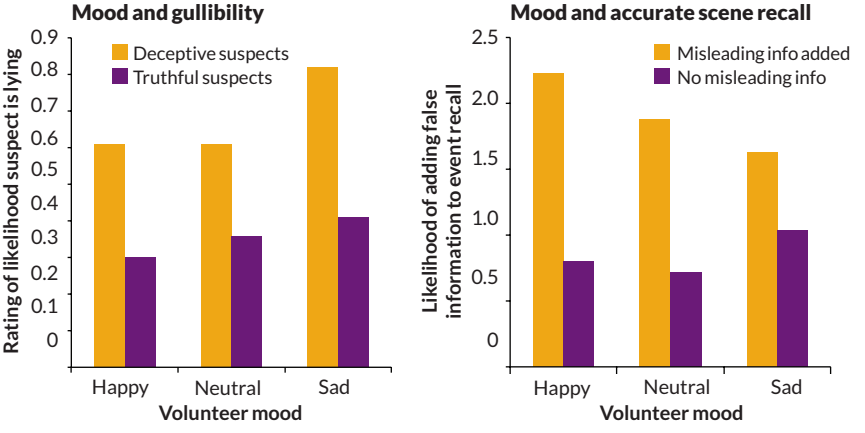
Evidence from many labs supports Schwarz's view that moods inform people's judgments, often advantageously and outside of awareness, psychologist Rainer Greifeneder of the University of Basel in Switzerland and his colleagues reported in the May 2011 *Personality and Social Psychology Review*.

Moods provide surprisingly keen insights into one's environment, the team concluded. Provocative support for that idea appeared in the October 2012 *Journal of Consumer Research*. A team led by business professor Michel Tuan Pham of Columbia University in New York City found that volunteers who trusted their feelings did better at predicting events such as how the stock market would perform in the next week and how upcoming movies would fare at the box office than volunteers who mistrusted their feelings.

By embracing their moods, superior forecasters gained unconscious access to a vast amount of learned information that informed their predictions, Pham speculated.

"In natural situations, feelings provide mostly valid information about whether there is a problem or not and how to respond to current tasks," Schwarz says.

Mind on mood Bad moods may make for better juries and eyewitnesses. Volunteers watching interviews with accused thieves were more likely to label liars as guilty, but those in a sad mood were best at detecting deception (left). Being happy upped the chance of being misled by researchers into inserting false details into descriptions of a car crash or wedding scene (right). SOURCES: J.P. FORGAS AND R. EAST/*J. EXP. SOCIAL PSYCH.* 2008; J.P. FORGAS/*J. EXP. SOCIAL PSYCH.* 2005



S. EGTS

Positively moody Different moods may trigger distinct thinking styles that allow people to respond appropriately to whatever situation they find themselves in, scientists speculate. There are likely benefits, and costs, to each thinking style.

Good mood benefits

1. Creativity
2. Multitasking advantage
3. Ability to delay gratification

Bad mood benefits

1. Detail-orientation
2. Accurate recall
3. Fairness to others

Power of sad

Many emotion theorists now agree that negative moods direct attention to tasks at hand and promote analytical thinking, whereas positive moods broaden attention and prompt original thinking. Researchers in a field dubbed "positive psychology" have put a lot of recent focus on exploring how happiness profits mind and body.

Forgas sees no need for a special field of research to study "negative psychology." He would settle for "more awareness that negative feelings are so common and widespread that they must have adaptive functions." Reports of specific ways in which sadness benefits thinking are beginning to accumulate.

Consider memory. In the January 2009 *Journal of Experimental Social Psychology*, Forgas and his colleagues found that shoppers in a suburban store remembered more details about what they saw in the store when they reported being in bad moods on rainy, cold days than when they felt happy on sunny, warm days.

> "Negative feelings are so common and widespread that they must have adaptive functions."
> JOSEPH FORGAS

Sad moods also improve eyewitness memory, apparently by lowering the tendency to incorporate false and misleading details into accounts of what was observed. In a 2005 study in the *Journal of Experimental Social Psychology*, college students witnessed a staged altercation between a lecturer and a woman who angrily interrupted the talk.

One week later, while in happy or sad moods induced by watching emotional film clips, participants read questions about the incident that included misleading information. Those in sad moods remembered what had happened much more accurately than their happy peers, Forgas and his colleagues reported. Fewer pieces of false information twisted the memories of sad students.

Sad moods can also make first impressions of others more reliable, Forgas says. People often judge those that they meet for the first time by assuming that obvious but often irrelevant traits, such as physical attractiveness, reflect intelligence, agreeableness and other as yet unknown traits. Psychologists refer to this much-studied phenomenon as the halo effect.

Negative moods topple the halo effect off its cockeyed perch, Forgas reported in the December 2011 *European Journal of Social Psychology*. After reminiscing about happy, sad or neutral personal experiences, volunteers read a one-page philosophical essay. Forgas attached a photograph of the writer to each copy of the essay, showing either a casually dressed young woman or a middle-aged man wearing a suit and glasses.

Happy participants rated the essay far more positively when they thought it was written by the academic-looking man. This halo effect largely disappeared among sad participants. Those in a neutral mood preferred the man's essay, but not to the extent that happy volunteers did.

Sad folks took longer to read and rate the essays than happy and neutral participants did. That's probably because feeling sad fostered a more careful appraisal of essays and photos, Forgas suggests. As a result, he proposes, sad volunteers largely rejected the stereotype of philosophers as tweedy, professorial men, helping to minimize the halo effect.

Cheerless cooperators

Sadness also confers some surprising social benefits. "While a positive mood may increase self-focus and selfishness, a negative mood can increase concern for others and the quality of communication," Forgas says.

When asked to divide raffle tickets or other prizes with a partner shown in a photo on a computer screen, sad volunteers handed out nearly even portions while happy volunteers kept the bulk for themselves, Forgas and a colleague reported in the January *Computers in Human Behavior*.

In another computer game, participants were informed that a partner seen only in a photo could accept or reject offers of how to divvy up prizes. No partner actually existed, but players were told that a vetoed offer would leave them empty-handed.

Again, sad volunteers shared valuables more evenly than their happy cohorts did. Sad players took longer to reach their decisions, consistent with having thought more carefully about how to make fair offers.

A gloomy mood also increased participants' concern with fairness when the tables were turned and they had to evaluate offers from a player who didn't really exist. Relative to the happy crowd, a substantially greater proportion of sad volunteers rejected unfair divisions of prizes, such as being offered two out of 10 lottery tickets.

In these experiments, moods were induced either by having participants watch happy or sad film clips or by falsely telling volunteers that they had scored extremely well or poorly on a test of spatial abilities.

Another study by Forgas and his colleagues, published in the August *European Journal of Social Psychology*, indicates that sad moods also prompt people to share information with others particularly effectively.

In one set of trials, volunteers watched clips of ambiguous, unemotional movie scenes. While in happy, sad or neutral moods, the volunteers then either verbally described the episode while pretending to talk with a friend or wrote a

brief description of the scene for a friend.

In both conditions, raters determined that sad volunteers communicated more information relevant to the movie scenes and less unrelated information than the other two groups did, especially the happy folks. Those in a sad mood were especially good at keeping accounts brief, clear and to the point.

Moods were induced after participants watched movie clips but before they described the scenes, ensuring that the clips didn't sway their manipulated moods.

Sad feelings may influence communication differently in situations where conversation partners don't expect to share all relevant information, such as diplomatic negotiations or sales encounters. Still, Forgas contends, "everyday moods have a subtle but reliable influence on communication strategies."

That's something that mental health workers and medical personnel should keep in mind, he advises. Being somewhat sad may enable better communication with sick or troubled individuals. A jovial mood could promote creative insights into a patient's condition or needs.

Gloomy payoffs

Fittingly, happiness researchers such as psychologist Sonja Lyubomirsky of the University of California, Riverside take a positive but measured position on evidence that sadness has an upside. "Transient negative moods are absolutely beneficial when orientation to detail is warranted," Lyubomirsky says.

Problems occur when sad moods become so frequent that they blend into an extended downer, she holds. "Happy people experience a lot more positive than negative moods, and their negative moods are not chronic."

Chronic happiness creates its own discontents. Yale University psychologist June Gruber has reported that the sustained, one-note joy of people experiencing the manic phase of bipolar disorder leads to all sorts of personal and social misjudgments (*SN Online: 2/2/11*).

Even brief sad moods such as those studied by Forgas sometimes provoke bad decisions, says Harvard University psychologist Jennifer Lerner. Mild sadness tends to make people more impatient and thus more apt to focus myopically on taking money now rather than waiting for a bigger financial payoff in the not-too-distant future, Lerner and her colleagues reported in the January *Psychological Science*.

In one experiment that involved real payoffs, sad participants typically required $37 immediately to forgo receiving a mailed check for $85 in three months, whereas neutral-mood volunteers usually held out for $56 in hand. Participants who reported feeling mildly disgusted by the topics of film clips and writing assignments needed about as much money as neutral individuals to pass up a delayed, $85 windfall. So unlike sadness, being briefly disgusted didn't make people more likely to snap up immediate, low-ball payoffs.

Sadder isn't wiser when it comes to making prudent financial decisions, Lerner concludes. A sad person may urgently need a shot of self-esteem, stoking a preference for instant over delayed gratification. If that's the case, then people may make particularly rash and ill-informed financial decisions after job losses, loved ones' deaths and other distressing events.

From Forgas' perspective, a take-the-money-and-run approach seems reasonable if sadness accurately alerts a person to a dangerous or unstable environment.

But moods may not engage specific mental strategies as proposed by Forgas, says psychologist Jeffrey Huntsinger of Loyola University Chicago. Several recent investigations, described by Huntsinger in the August *Current Directions in Psychological Science*, suggest that positive moods prompt individuals to double down on any current thinking style, while negative moods trigger a shift to an alternative thinking style.

Among neutral-mood volunteers focusing broadly on an experimental task, those induced to be happy thought even more expansively about the task, whereas those prodded into sadness switched to concentrating on details. When already in a detail-oriented frame of mind, volunteers who became happy maintained that perspective, while those who became sad moved to a broad focus.

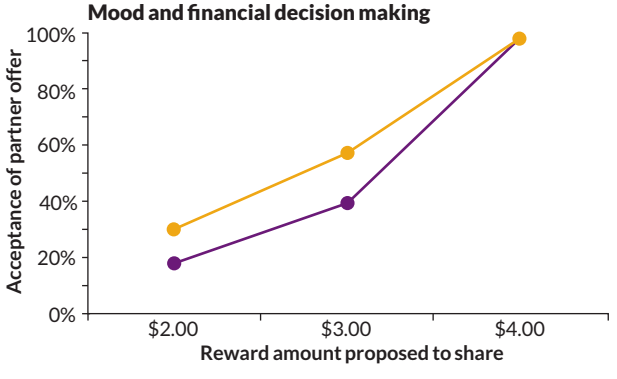
If these findings hold up, happy and sad moods simply signal whether or not to change one's current thinking style, Huntsinger says, rather than indicating whether to adopt an analytical or playful thinking style. Researchers have yet to test which of these two possibilities best explains mood-related behaviors.

Forgas acknowledges that much remains unknown about precisely how moods influence thought. If moods work as Huntsinger suggests and not as orchestrators of specific thinking styles, Forgas says, it won't get him down.

Not that there would be anything wrong with that. ■

Fair share A gloomy attitude may make a person more discriminating in deciding what counts as a square deal. Volunteers in a bad mood (purple) were more likely to reject an unfair split of a reward, such as $2 out of $10, than their cheerier peers (yellow).

SOURCE: J.P. FORGAS AND H.B. TAN/*COMPUTERS IN HUMAN BEHAVIOR* 2013



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Explore more

- Joseph Forgas. "Don't worry, be sad! On the cognitive, motivational and interpersonal benefits of negative mood." *Current Directions in Psychological Science*. June 2013.

Quiet MAXIMUM

The current solar cycle is a snoozer, but that's not a bad thing

By Alexandra Witze

An image taken in September by the STEREO spacecraft shows the sun in a state of relative serenity compared with past solar maxima.

Matt Penn is grateful for whatever the sun will give him. These days, that isn't much. Penn's job, as a solar astronomer, is to track the waxing and waning of sunspots on the solar surface. These dark blots mottle the face of the sun, increasing in number to a peak every 11 years and then falling off again in a rhythmic march choreographed by magnetic activity inside the star.

2013 marks the maximum of this solar cycle, yet Penn doesn't have very much to look at. Atop Kitt Peak outside Tucson, Ariz., he often points his telescope at a barren orange orb. "Where are the sunspots?" he asks. "It's amazing to see such low activity at the peak of our sunspot cycle."

By almost any measure, this solar maximum has been pathetic. No more than 67 sunspots have appeared in a month so far; at the last peak, in 2000, that number was above 120. If the sun doesn't pick up soon — which it probably won't — the current solar cycle will be the wimpiest in a century.

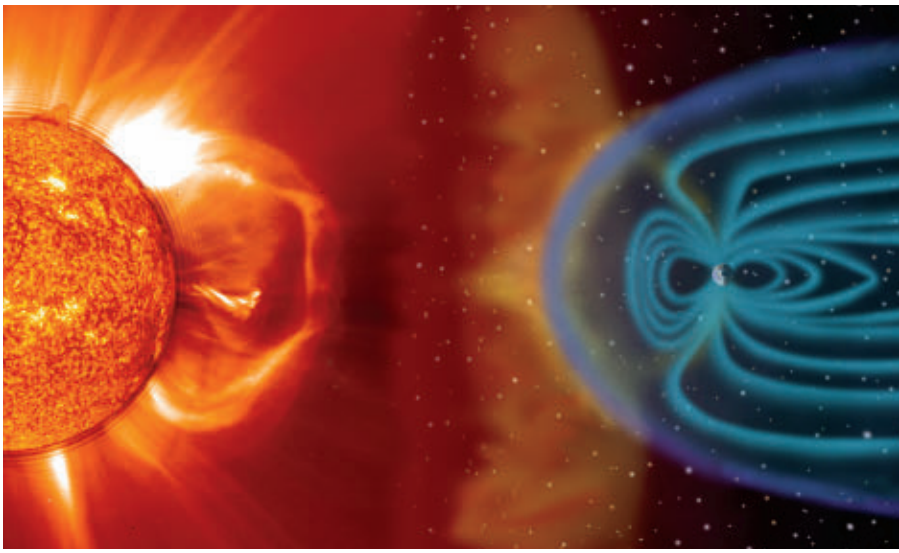
But a quiet sun is not necessarily a boring sun. The current cycle is "the weakest in the space age, but it's not so different from the turn of the 20th century," says Giuliana de Toma, a solar physicist at the National Center for Atmospheric Research in Boulder, Colo. "It's interesting for scientists because now we have instrumentation we didn't have 100 years ago. We have not observed a weak cycle like this one."

In fact, the sun's slumbers are helping scientists better understand our nearest star. Among other things, solar physicists are learning how superheated gas, flowing from the sun's equator to its poles, carries magnetic disturbances that help determine how strong the next solar cycle will be. That information may help researchers better predict what the sun's future holds.

Today, that's anyone's guess. Some, like Penn, argue that the sun could be headed for a long-term decline, similar to a period in the late 17th century that saw hardly any sunspots and coincided with the "Little Ice Age" that froze rivers across Europe (though most scientists don't think low solar activity caused the cold snap).

Other researchers say there's little evidence for a slide into solar somnolence, and suggest that in this particular cycle the sun could still unleash monster storms of energetic particles before it's done. That potential for sudden violent outbursts makes it important to learn about the sun even while it is in a quiescent phase.

However it ends, the current solar cycle will go down in the annals of astronomy as one of the most illuminating yet.



Planet under fire
During a solar maximum, the sun more frequently emits coronal mass ejections, blobs of charged particles like the one seen emerging from the sun (left). Though Earth's magnetic field (blue, at right) offers protection, powerful ejections can damage satellites and sometimes even ground-based electronics and electrical grids.

Seeing spots

Scientists want to understand the sun's activity patterns because they can dramatically affect life on Earth. At or around solar maximum, the sun is more likely to hurl clouds of charged particles off its surface and occasionally toward Earth. When one of these solar eruptions hits the planet's protective magnetic shield, most of the particles get funneled down toward Earth's polar regions. There they collide with atmospheric particles and produce the eerie glow of the northern and southern lights. Occasionally, though, the magnetic storms are powerful enough to fry satellite electronics and interrupt electricity grids on the ground. In 1989, a solar storm famously zapped a power grid in Quebec and turned the lights out on 6 million people.

All of this solar action traces back to the magnetism roiling the sun's guts. Electrical charges flowing through the star generate strong magnetic fields. Like Earth, the sun has a north magnetic pole and a south magnetic pole. But unlike Earth's, the sun's magnetic poles flip every 11 years or so, just as the sunspot number is peaking. Over a period of weeks to months, what was the north magnetic pole becomes the south magnetic pole, and vice versa. The flip may be underway right now, says Todd Hoeksema, a solar physicist at Stanford University.

Magnetic fields also help explain the presence of sunspots. These are dark regions, sometimes as big across as Earth, where powerful magnetic fields loop from deep in the sun up through the

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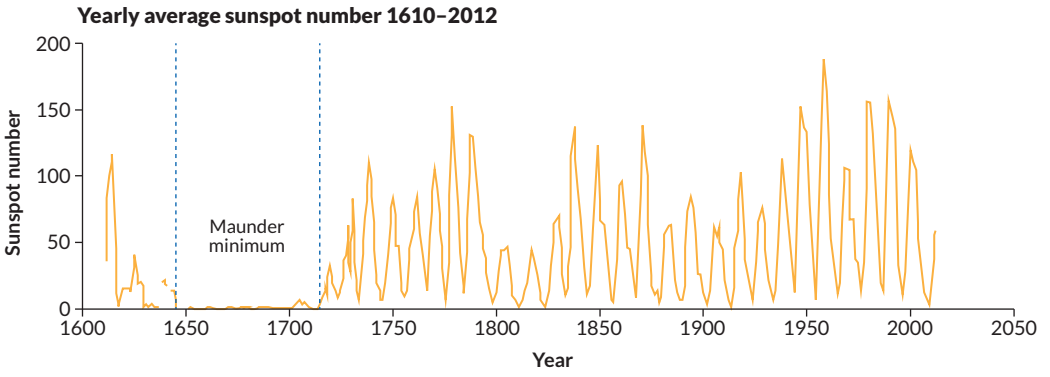


The long view In the four centuries that observers have been counting sunspots, there have been a number of periods with notably low activity. Some researchers argue that the sun appears to be entering a period of low activity analogous to the decades around 1800 and 1900. Some even predict the sun may be entering a period of essentially no sunspot activity similar to the Maunder minimum of the late 17th century.
SOURCE: D. HATHAWAY

surface and beyond. Sunspots look black or gray because they are cooler than the atmosphere around them, making them one of the easiest ways to observe changes in solar activity. Sunspots, solar eruptions and other solar phenomena generally act in concert; when there are more sunspots on the surface, the sun is more likely to spew out its particle blobs.

Galileo was among the first to observe sunspots through a telescope, in 1610, but it wasn't until 1826 that a German amateur astronomer, Heinrich Schwabe, began systematically cataloging their rise and fall. Schwabe's work caught the eye of professional scientists, including Rudolf Wolf of Switzerland, whose "Wolf sunspot number" calculation is still used to quantify how many sunspots are visible on any given day.

66.9
Peak monthly sunspot number to date in current solar cycle (February 2012)

120.9
Peak monthly sunspot number in 23rd solar cycle (April 2000)

For centuries, sunspot numbers were just about the only scientific measure of solar activity. Astronomers used them to learn how each 11-year cycle differed from the last. During the "Maunder minimum," between about 1645 and 1715, virtually no sunspots appeared on the sun's disk. By the middle of the 18th century, solar activity picked up, for reasons nobody understood. It then dropped off again, less dramatically, during two periods around the years 1800 and 1900.

Based on these data, Wolfgang Gleissberg suggested in 1939 that there could be a roughly 100-year cycle superimposed on the 11-year activity cycle. If so, then scientists might expect another drop-off in the early 2000s. That could well be the pathetic solar cycle of today, says David Hathaway, a solar physicist at NASA's Marshall Space Flight Center in Huntsville, Ala. "It's almost certainly going to be the smallest sunspot cycle in 100 years," he says.

Solar prognostication

Not everybody saw it coming. In 2007, a group of experts led by the National Oceanic and Atmospheric Administration took a stab at predicting what the current solar cycle — known as Solar Cycle 24, as it's the 24th recorded cycle — might look like. The team used a number of statistical techniques to analyze sunspot numbers, polar magnetic field strength and other possible predictors. The group split pretty distinctly into two camps. One faction relied heavily on polar magnetic field strength and predicted a relatively moderate cycle, with about 90 sunspots at its peak. A second group thought other signals, which persisted over several past cycles as opposed to just one, would be more significant; those scientists predicted a much higher peak of 140 sunspots.

Six years later, the conservative group turns out to have been closer to right. "The prediction techniques I work with were saying this would be a weak solar cycle almost 10 years ago," says Dean Pesnell, a solar physicist at NASA's Goddard Space Flight Center in Greenbelt, Md. "That was not the most popular thing to say back then, but it turns out to have been correct."

Polar magnetic fields are important because they serve as seeds for the upcoming solar cycle. They get their start in sunspots, where the churning solar plasma breaks magnetic fields apart into a morass of magnetic disturbances. Some of these fragments get caught up in a "meridional" flow of plasma that moves them away from the equator and toward the sun's poles. There the fragments combine, build up strength and contribute to the flipping of the magnetic poles. Finally, after the magnetic reversal, the polar fields keep growing

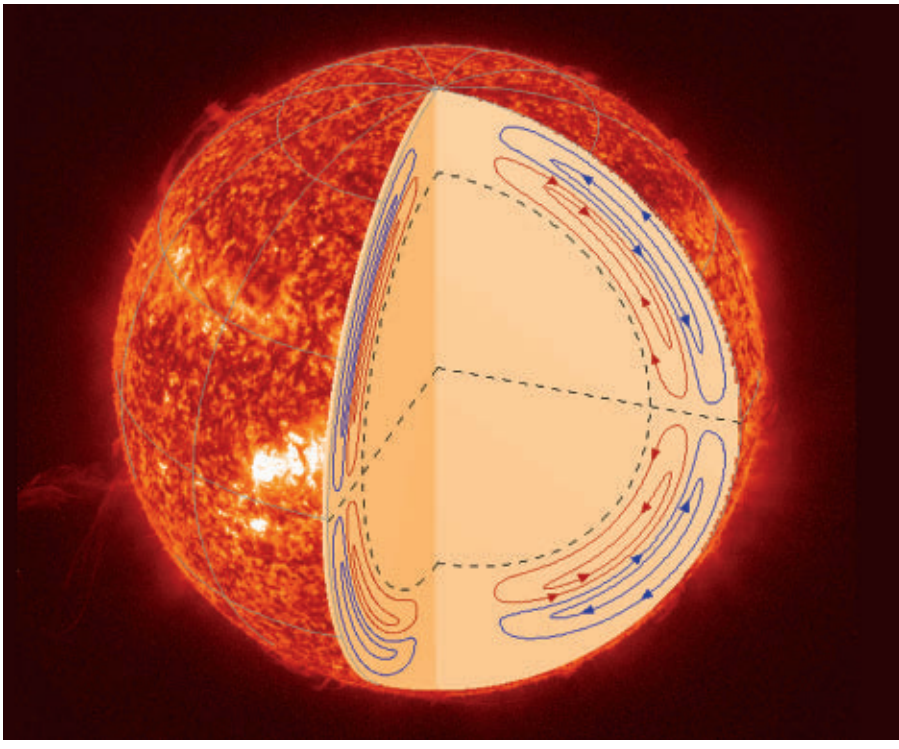
FROM TOP: E. OTWELL; SOHO/ESA AND NASA

and help regulate how big the next solar cycle will be.

This, at least, is the scenario laid out by polar-field advocates like Hathaway. New discoveries seem to bear him and his colleagues out. In 2012, he reported new details on how this meridional flow might regulate magnetic fields at the sun's poles.

For decades, scientists had assumed that the meridional flow traveled at a depth of about 200,000 kilometers below the sun's surface. It was just too deep to see directly. But Hathaway reported spotting faint signs of this flow, based on shifts in light given off by the element nickel as it moved within the sun's atmosphere. With these data, gathered by the European/U.S. Solar and Heliospheric Observatory during the last solar cycle, he calculated that the flows must be moving in much smaller cells — starting at about 50,000 kilometers deep. That shallower depth means that magnetic fragments can be carried to the poles faster than thought, since they don't need to travel deep in order to move. That, in turn, suggests that the meridional flow can strongly influence how the polar fields build up and how active the sun is likely to be.

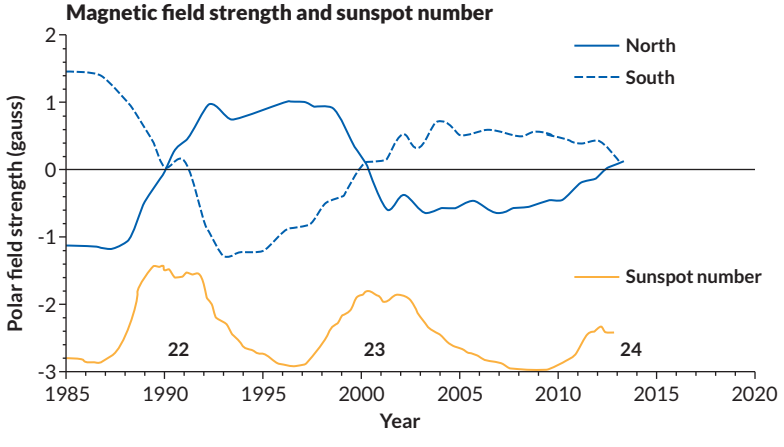
Not everyone believed Hathaway's conclusions, in part because of the way he traced the flow. This August, though, Stanford University scientists announced that they, too, had found that the meridional flow was happening at a relatively shallow depth. The team, led by Junwei Zhao, used NASA's latest and most sophisticated sun-watching satellite, the Solar Dynamics Observatory, to track sets of plasma waves moving across the sun's surface. With those data, the scientists could calculate how material was moving inside the sun in greater detail than Hathaway could, says Zhao. They found the meridional flow starting at about 60,000 kilometers deep, the team wrote in *Astrophysical Journal Letters*.



The flow below Observations suggest that the meridional flow, a poleward current tens of thousands of kilometers beneath the sun's surface (as well as a deeper return flow), plays an important role in regulating the strength and timing of the solar cycles.

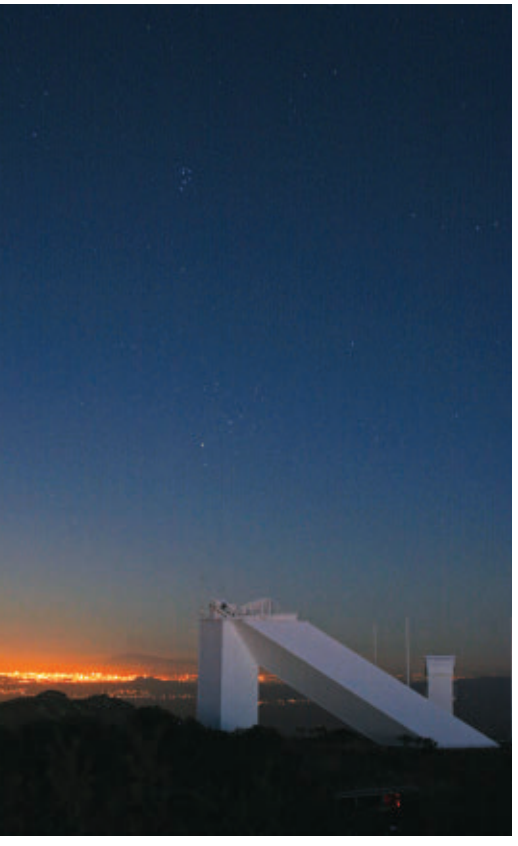
Together the studies confirm that flows are happening within the sun quicker than thought. And in July, Hathaway and Lisa Upton of the Marshall center reported new data from the SOHO and SDO satellites that further support the importance of polar magnetic fields. Between 1996 and 2013, the scientists see the poleward flow getting weaker as it approaches the poles. Like one river current encountering another, the flow might be running into a second internal movement running in the opposite direction, from the poles to the equator.

During the last solar cycle, the counterflow was stronger than during the cycle before it, the



Flipping fields The magnitude of each solar cycle is correlated with the strength of the sun's polar magnetic fields at the cycle's outset. Exceptionally strong polar fields in 1986 spawned a powerful solar cycle that peaked in 1989, while more moderate fields in 1996 resulted in a less dramatic peak in 2000. Even lower field strength in 2008 has led to the very weak solar cycle that is happening now. The sun's magnetic field flips direction at about the time of each solar maximum. SOURCE: D. HATHAWAY, WILCOX SOLAR OBSERVATORY

FROM TOP: SDO-HMI/NASA; E. OTWELL



Since 1998, the McMath-Pierce solar telescope (shown) has observed a steady decrease in sunspot magnetic field strength. Some researchers expect that sunspots may temporarily vanish in the near future.

scientists reported in July in Bozeman, Mont., at a meeting of the solar physics division of the American Astronomical Society. That could help explain why the current solar cycle is so weak: The meridional flow simply couldn't carry enough magnetic fragments to reach the poles, there to combine and build up strength for the ongoing solar cycle. The team hopes to learn more about these possible counteracting flows and eventually be able to predict the polar fields a couple of years in advance.

No sunspots

Meanwhile, another hot dispute centers around sunspots themselves and whether they are fundamentally changing over time.

The idea first cropped up in 2006, when Penn and William Livingston, both at the National Solar Observatory, claimed to detect a long-term change in sunspot brightness. Using the McMath-Pierce solar telescope at Kitt Peak — one of the world's biggest solar telescopes — Livingston has been measuring sunspot intensity and magnetism since 1998. He and Penn calculated that the maximum magnetic field in sunspots had been dropping as those solar blotches grew lighter by about 1.8 percent each year. That drop happens independently of the 11-year solar cycle.

If that trend continues, the scientists say, solar activity could decline to the point that there would be no sunspots at all by 2015. Other work seems to back up their general point; a new study looking at space-based measurements of sunspots' magnetic fields also suggests that they have weakened over time. "That's reassuring," says Penn.

But the idea of changing sunspots remains controversial. In response to the Penn and Livingston work, de Toma and her colleagues have looked at sunspot measurements taken from 1986 to 2012 by the San Fernando Observatory near Los Angeles. This telescope has a much blurrier view than the Kitt Peak one, but has the advantage of covering a longer time period. In July in *Astrophysical Journal Letters*, de Toma's team reported finding no dimming of sunspots. They point out that the Kitt Peak observations included only large sunspots early on, and added the smaller sunspots later. That change made the total sunspot trend look artificially lighter, says de Toma, because small sunspots are intrinsically fainter than big ones. "It's a selection effect," she says.

That would be good news for anyone worried about whether the sun is about to sink into another Maunder minimum, that 17th century slump that coincided with the Little Ice Age. While a drop in solar activity probably didn't cause the cold snap (weather patterns and volcanic eruptions played a far bigger role), changes in the sun's output do affect climate on Earth to a small degree.

Penn says he and Livingston have already corrected for any selection effects, and he questions whether smog from the 405 freeway might affect the San Fernando measurements. So the jury may remain out on a long-term sunspot dimming trend for a few years more.

For now, researchers are looking to see what tricks the sun may play in the waning years of the 24th solar cycle. "The fact that this one's lower than the last one is no big shock," says Scott McIntosh, a solar physicist at the National Center for Atmospheric Research. "The question is, where does it go from here? Will it rebound or continue to slide?"

To answer that, scientists will have to do what they always do: watch and wait. "We're aware that the sun is at maximum conditions," says Pesnell. "Everybody likes to assign a point for solar max, but it will rattle around for several years." The sunspot number may rise again to match or surpass the 66.9 already recorded. Or it may continue to drop, in which case February 2012 will go down in history books as the maximum.

Either way, the sun isn't necessarily done yet. The largest solar storms sometimes come after solar maximum, when the sun is on its downhill slide. The powerful Halloween storms of October 2003 hit several years after solar maximum, and still managed to blast satellites and deep-space communications.

As for what the next solar cycle will bring, it's far too early to tell. Hathaway says he won't have the nerve to even think about predicting solar cycle 25 until at least 2017. It all depends on how those polar fields build up, he says. "We've learned a lot this time around." ■

Explore more

- NASA solar cycle prediction website: solarscience.msfc.nasa.gov/predict.shtml
- National Weather Service Space Weather Prediction Center website: www.swpc.noaa.gov

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MUSEUM

Humans' living creations put on display

Center for PostNatural History examines genetic engineering, domestication

Freckles the silk-spinning goat joins laboratory rats, glowing fish and other displays at Pittsburgh's Center for PostNatural History. The small museum highlights the role humans have played, through both traditional breeding and engineering, in genetically shaping living things.

Some might say Freckles the goat was a freak. Others would say she was a modern wonder. She was genetically engineered by a Canadian company to produce milk that could be spun into spider silk. The superstrong fibers were intended for high-tech uses like bulletproof vests or artificial tendons, but in 2009 the company went bankrupt. A taxidermied Freckles now greets visitors to a tiny storefront in Pittsburgh.

Her new home is the Center for PostNatural History, a museum opened in 2012 by Richard Pell, who teaches electronic media art at Carnegie Mellon University. Pell curates the museum and also tends the front desk.

As visitors pass through a curtain to enter the darkened exhibition space, they see a spectacularly fluffy white ornamental chicken (below) and an aquarium full of glowing fish. Pell classifies both the silkie chicken and the GloFish®, genetically engineered to produce fluorescent jellyfish proteins, as "postnatural." The label includes any organisms intentionally and heritably altered by humans, whether through domestication, selective breeding or the modern tools of biotechnology.

To visit

Open Sundays 12–4 pm,
first Fridays of the month 5–8 pm
or by appointment
FREE ADMISSION

Other postnatural specimens include genetically modified corn, mutant fruit flies and a lonely pair of cat testicles in a jar. This oddball assortment of objects is tagged with handwritten labels and trapped under bell jars or pinned to boards.

But Pell does not intend the museum to be merely a cabinet of curiosities or a freak show. Visitors will not find rants that drum up fears of "Frankenfoods." Neither is this a celebration of science with grand promises about the future. Instead, Pell hopes it is a place where "activists and scientists can run into each other, feel comfortable and maybe even blow each others' minds."

Language used throughout the center is artfully neutral, and each specimen is accompanied by only a few basic facts and a brief story highlighting a social issue. One display shows dried leaves from a transgenic American chestnut, engineered with a wheat gene to resist the fungal blight that nearly eradicated wild populations of the tree. An audio guide recounts how researchers decided to use the wheat gene instead of one from frogs, for fear of controversy.

Some might think the scientists were pandering to irrational fears of "frog-trees." Others may say the scientists were manipulating the public into accepting the trees as more "natural" than they really are.

The museum's approach could frustrate science enthusiasts when social and ethical questions push interesting scientific details into the background. But there is much to learn and think about in this collection, which bursts with stories of strange human endeavors such as growing monstrously large pumpkins or creating hybrid brine shrimp to sell as "sea monkeys."

Visitors will get the most out of the experience if they bring a friend, preferably someone who will disagree about what it all means. — *Cristy Gelling*

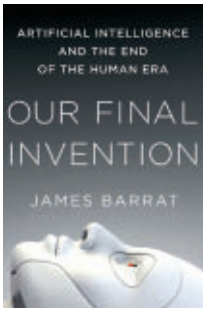
BOTH: CENTER FOR POSTNATURAL HISTORY

BOOKSHELF

Our Final Invention

Artificial Intelligence and the End of the Human Era

James Barrat



Computers already make all sorts of decisions for you. With little or no human guidance, they deduce what books you would like to buy, trade your stocks and distribute electrical power. They do all this quickly and efficiently using a simple form of artificial intelligence. Now, imagine if computers controlled even more aspects of life and could truly think for themselves.

Barrat, a documentary filmmaker and author, chronicles his discussions with scientists and engineers who are developing ever more complex artificial intelligence, or AI. The goal of many in the field is to make a mechanical brain as intelligent — creative, flexible and capable of learning — as the human mind. But an increasing number of AI visionaries have misgivings.

Science fiction has long explored the implications of humanlike machines (think of Asimov's *I, Robot*), but Barrat's thoughtful treatment adds a dose of reality. Through his conversations with experts, he argues that the perils of AI can easily, even inevitably, outweigh its promise.

By mid-century — maybe within a decade, some researchers say — a computer may achieve human-scale artificial intelligence, an admittedly fuzzy milestone. (The Turing test provides one definition: a computer would pass the test by fooling humans into thinking it's human.) AI could then quickly evolve to the point where it is thousands of times smarter than a human. But long before that, an AI robot or computer would become self-aware and would not be interested in remaining under human control, Barrat argues.

One AI researcher notes that self-aware, self-improving systems will have three motivations: efficiency, self-protection and acquisition of resources, primarily energy. Some people hesitate to even acknowledge the possible perils of this situation, believing that computers programmed to be superintelligent can also be programmed to be "friendly." But others, including Barrat, fear that humans and AI are headed toward a mortal struggle. Intelligence isn't unpredictable merely some of the time or in special cases, he writes. "Computer systems advanced enough to act with human-level intelligence will likely be unpredictable and inscrutable *all of the time*."

Humans, he says, need to figure out now, at the early stages of AI's creation, how to coexist with hyperintelligent machines. Otherwise, Barrat worries, we could end up with a planet — eventually a galaxy — populated by self-serving, self-replicating AI entities that act ruthlessly toward their creators. — *Sid Perkins*
Thomas Dunne Books, $26.99

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SCREENTIME

Brainy videos

T. GRENIER, SOCIETY FOR NEUROSCIENCE

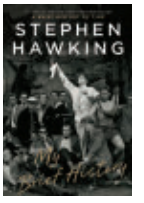
A short film that uses humor and science to explain congenital anosmia has won the Society for Neuroscience's 2013 Brain Awareness Video Contest. In the video, Travis Grenier (above right), a film student at Full Sail University in Winter Park, Fla., and a 12-year-old friend explain that Grenier was born without the ability to smell and show how the brain is responsible. In one segment, the friend tests Grenier's lack of sniffing power by dangling a dirty sock near his nose. Other contest honorees explored memory, the support role of brain cells called glia and how science can read minds. Watch the winning videos or submit your own to the 2014 contest at www.brainfacts.org/bavc. — *Sarah Zielinski*

BOOKSHELF

My Brief History

Stephen Hawking

If all physicists could explain their work as well as Stephen Hawking explained black holes in his 1988 best seller *A Brief History of Time*, science writers would have to find other work. The British theorist's new book proves that he is nearly as adept at writing about himself.



Still going strong at age 71 despite amyotrophic lateral sclerosis, Hawking can write only three words a minute using a computer that senses his cheek movements. He wastes few of his 20,000 words, breezily recounting his inquisitive childhood and some lucky scientific breaks. He touches on the heartache of two divorces and his many moments at the brink of death. Yet even recalling his darkest days, he injects humor. After mentioning that a physician once told his wife that he was about to die, he writes: "I have since changed my doctor."

At 144 pages, the book will leave some readers wanting more. Several times Hawking claims that reporters exaggerated events in his life but neglects to correct the record. And he skims only the surface of his research.

Nevertheless, *My Brief History* is a fun read and a great window into the life of one of the most engaging scientists of our time. — *Andrew Grant*
Bantam Books, $22

SEPTEMBER 21, 2013

SOCIAL MEDIA

Tweeting on the Nobels

TINA HESMAN SAEY
@SN_saey

#NobelPrize winner James Rothman got the call at 4:30. "It made me feel awake and rather good."

NATHAN SEPPA
@nathanseppa

Good call. Scientist Sudhof pulls over when Nobel committee rings. bit.ly/1cn9ehP

LILA GUTERMAN
@lilaguterman

Bet Nobel helps him hit 10K: Karplus, a Chemistry #nobel laureate today, wrote a paper in 1983 that's been cited 9,593 times.

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When birds collide

In "Collision course" (*SN: 9/21/13, p. 20*), **Susan Milius** told the stories of two ornithologists working to develop windows that birds won't fly into.

With few exceptions, readers were sympathetic to the plight of birds that either don't see windows or incorrectly interpret reflections. **William Thompson** e-mailed about his Colorado home: "At the height of bird activity, we see about five such collisions per month with a 20 percent mortality rate. These collisions usually occur when there are a large number of birds flying, and the level of aggression/agitation is heightened. We suspect a significant number of these collisions result from the bird essentially attacking [its own reflection]." His response to the problem was to consider the underlying cause: "We readily admit that as the owners of an overly large house we are complicit in the more fundamental problem, faced by all species other than humans, which is loss of habitat. How about fewer people and fewer buildings?" **Patricia Williams** e-mailed that she was surprised when she moved from country to city to find that mourning doves would swoop onto her window ledge to eat birdseed without ever hitting the windows. "Maybe evolution will let the smart ones survive to reproduce, so none will require special windows anymore," she suggested. But evolving window smarts sounds like a monster of a challenge, **Milius** says: "Glad to hear your doves coped, since mourning doves are among the species that surveys report finding dead at windows. Perhaps your window isn't prone to tricky reflections, or the birds are aiming for the seeds on the ledge."

Singing in focus

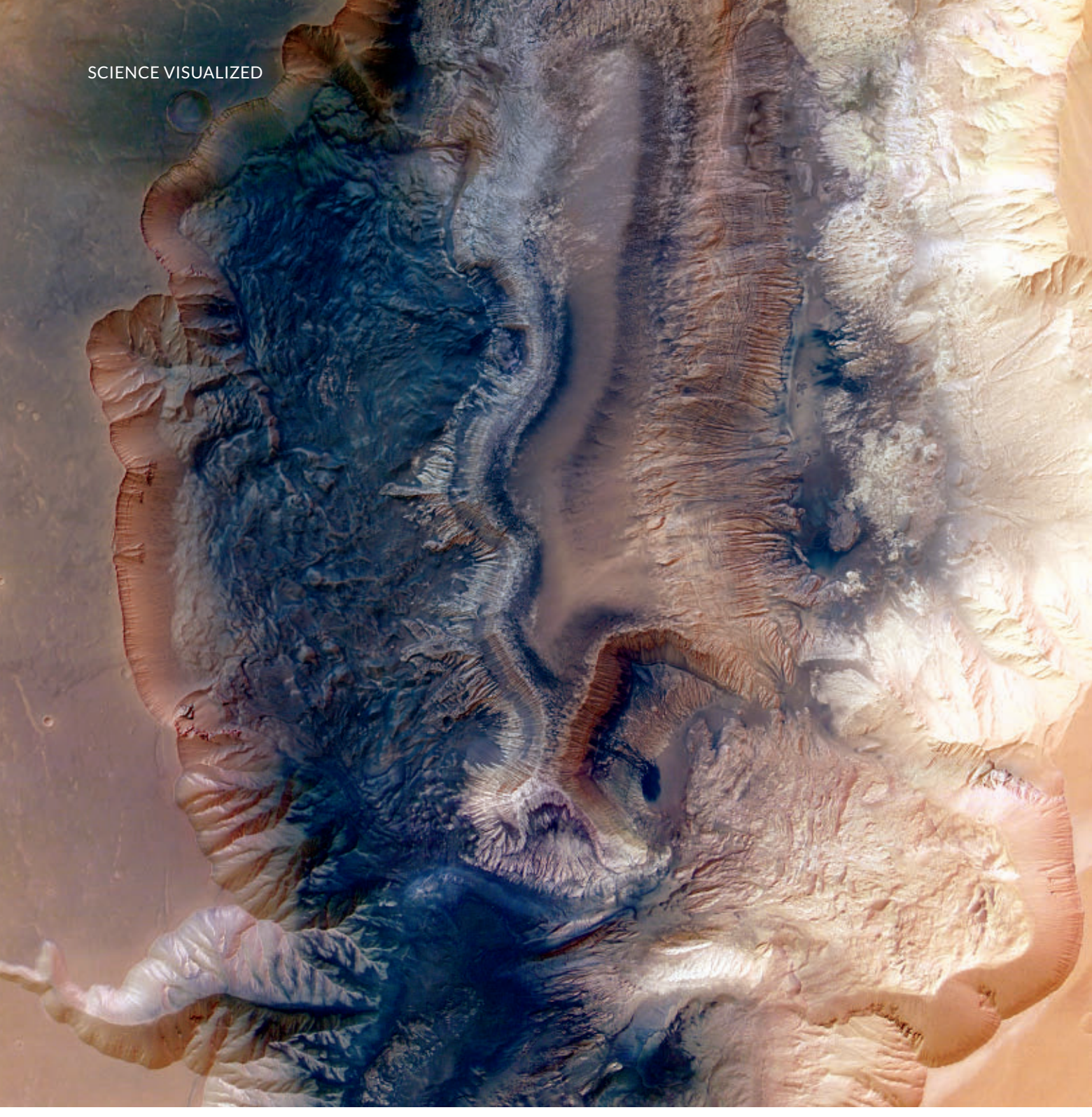
Bruce Bower explored the mental mechanics of off-key singing in "The tune wreckers" (*SN: 9/21/13, p. 26*).

Singers seemed especially fascinated by this story. "I wonder what the role of vibrato is," e-mailed **Jose Alonso**. "I often find well-known and respected operatic voices to sing with such a high degree of vibrato that it is difficult to even establish the pitch of the note being sung." **Bower** replies that a vocalist or instrumentalist produces vibrato by creating rapid fluctuations in the pitch of musical notes. "When done well," he says, "this technique adds emotional punch to a musical performance. Vibrato may contribute to the tendency of listeners to allow for more mistuning from singers than from violinists, but researchers have yet to test for that possibility." More research could also address a question e-mailed by reader **Nathan Meleen**, who asks how speakers of tonal languages, which use changes in pitch to distinguish between otherwise identical words, might fare in identifying off-key crooning compared with speakers of nontonal languages.

New website keeps getting better

Science News launched a new website on October 3, part of a larger effort to better link the online presence of the magazine with its publisher, Society for Science & the Public, and the organization's science competitions and other educational programs. The new site allows subscribers (now also members of the Society) to use a single username and password to access content on the website and in the tablet edition on the iPad.

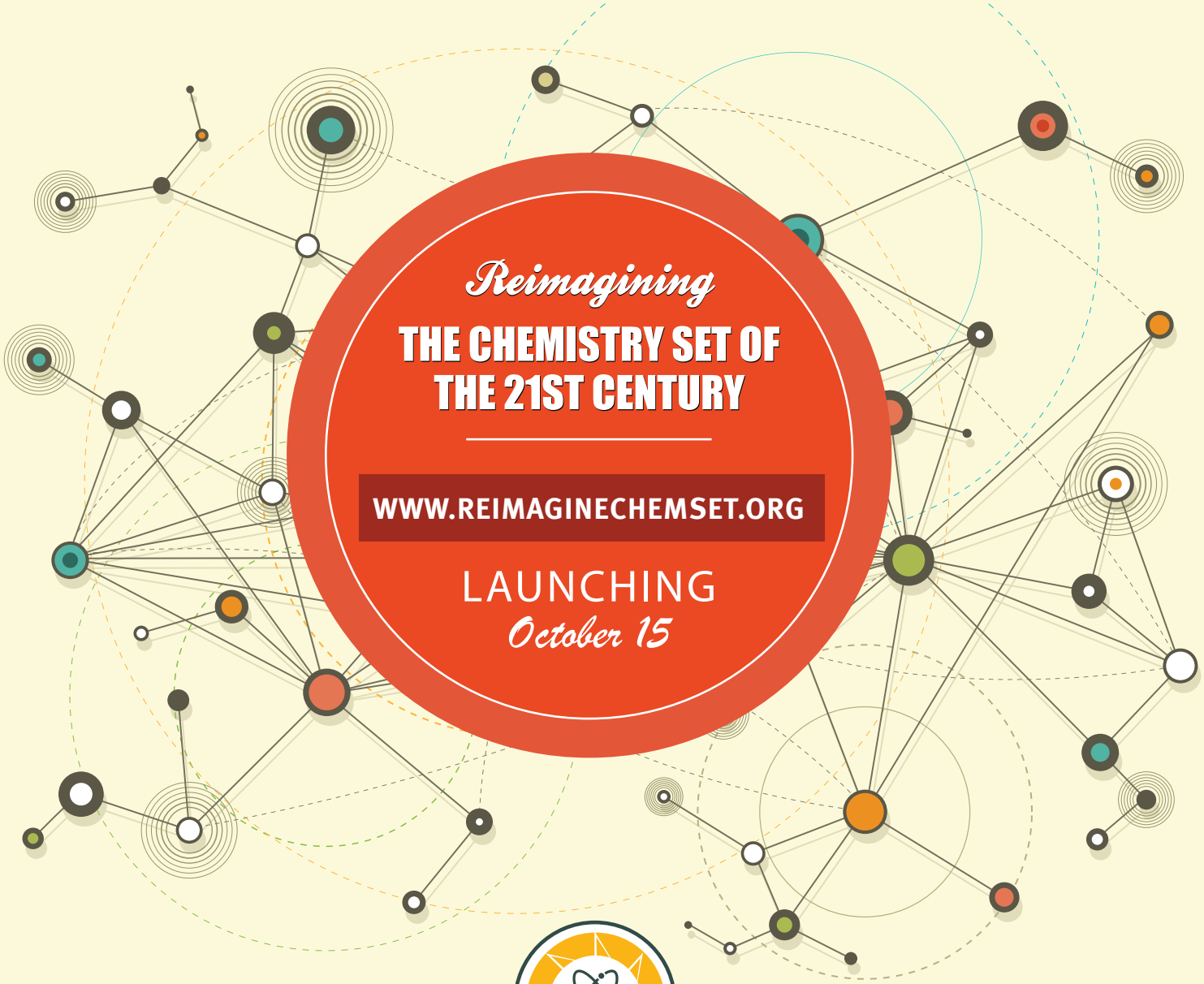
Editor-in-Chief **Eva Emerson** said after the launch: "You can't make a new website without a few hiccups." We knew going in that the most difficult technical feat would be linking our subscriber database with the website and the Apple App Store to allow a seamless sign-in process. And unfortunately, many subscribers did run into problems that first week. Now, the technical gurus assure us, the log-in system is working, though you may need to create a new password. Other fixes, such as a way to e-mail favorite stories, are high on the "fix-it" list. In the meantime, keep the feedback coming!



A grander canyon on Mars

Hebes Chasma, a huge trough on Mars, reflects the Red Planet's tumultuous and varied past. During the planet's first billion years, the nearby Tharsis Region bulged with magma, then burst apart, forming enormous chasms such as Hebes (a portion of its 315-kilometer length shown). More than four times as deep and wide as the Grand Canyon, Hebes may have once been filled with water; some areas have minerals that could have formed only in water's presence. New images from the European Space Agency's Mars Express spacecraft show that massive landslides may have shaped and widened the trench since its violent birth. —*Sarah Zielinski*

ESA, DLR, G. NEUKUM/
FREIE UNIVERSITÄT BERLIN



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