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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JULY 14, 2012

Diet Drinks Befuddle the Brain

Alzheimer's-Prion Link

Mystery Volcano Pinpointed

A better bite

Enlisting the mosquito in the fight against disease

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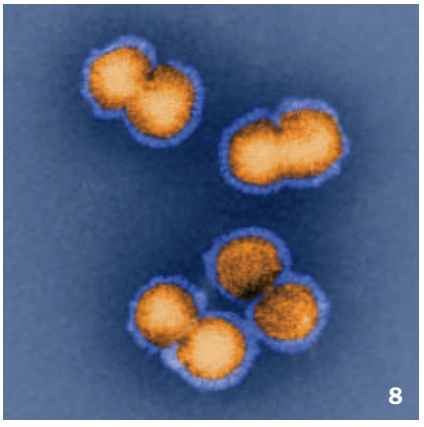

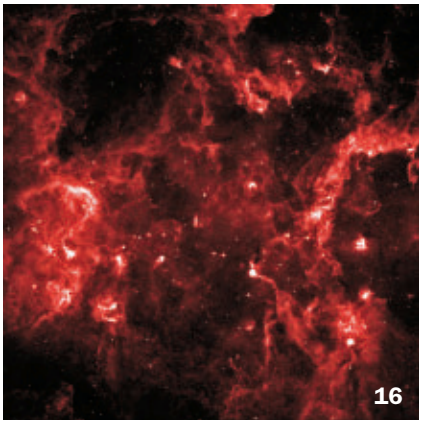

ScienceNews

In The News

Features

Departments

COVER An *Aedes aegypti* mosquito feeds on human blood. Employing disease-transmitting species to help control dengue and other health menaces may someday be possible. *James Gathany/CDC*

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FROM THE EDITOR

Mystery volcano's name revealed despite gag order

Breaking news in this issue: A volcano thought to have erupted in 1258 actually blew its stack in 1257.

That really is big news for volcano fans everywhere — not so much because of the new date, but because the site of the volcano has long been one of volcanology's biggest mysteries. Ice-core samples dated to 1258 contain unusual amounts of sulfur, a surefire signature that a huge volcanic eruption occurred somewhere shortly before. Scientists believe it was the most powerful volcanic blast since humans learned to write. But no one knew where on Earth the eruption occurred — the sulfur circulated throughout the atmosphere before coming to rest in polar ice.

But now, somebody knows — or at least, claims to have strong evidence for — the culprit volcano's identity. Franck Lavigne, at a geophysics meeting in Iceland, declared that he and his collaborators had "new and solid evidence" for the site of the 1258 eruption, with additional data indicating that the actual date was late spring or summer of 1257. Lavigne refused, though, to say just what volcano he was talking about.

Like many scientists, Lavigne was afraid to reveal a scientific discovery because he and his colleagues plan to publish the finding in a scientific journal. Some journals threaten scientists with refusal to publish their work if the results have already been reported in the news media. So the scientists consider themselves gagged, unable to share their knowledge with other experts at conferences held for just that purpose.

Journals that enforce such gag orders should be ashamed of themselves. Such policies impede the free flow of information among scientists and delay the delivery of interesting and important news from science to the public. It's bad for science and bad for science's efforts to gain the public's appreciation.

In this case, though, the public didn't lose out entirely. *Science News* contributing editor Alexandra Witze, on the scene, consulted experts at the meeting who agreed that the photos shown in Lavigne's presentation depicted Indonesia. Further information posted obscurely on the Internet (and since taken down) provided more clues. It's a very good bet that the mystery volcano is Rinjani, on the island of Lombok, as one outside expert has publicly speculated (see Page 12).

Sometime in the months ahead, a journal will publish, and other media will report, this conclusion. But, despite the current system's cumbersome efforts at scientific censorship, you read it here first. —*Tom Siegfried, Editor in Chief*

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Say What?

Amusia *ey-MYU-zee-ah*\ ***n.*** Tone-deafness. Amusia can show up after brain injuries, but about 3 percent of adults have a hard time from birth with processing music—distinguishing differences in pitch, remembering melodies or singing in key. Canadian researchers report May 11 in *PLoS ONE* that even after listening to MP3 players loaded with popular songs daily for a month, a group of amusic children still performed poorly on pitch detection tests compared with peers. Brain activity suggests that it's a neural disconnect between the auditory cortex and the rest of the brain, and not a lack of exposure to tunes, that causes these tin ears. —*Allison Bohac*

Science Past | FROM THE ISSUE OF JULY 14, 1962

DEFORMED BABIES BORN AS RESULT OF SEDATIVE — Some 800 deformed babies are expected to be born in the United Kingdom as a result of their mothers taking

a dangerous sleeping pill during early pregnancy. The drug, thalidomide, was previously reported in West Germany as causing some 400 abnormal births. It has now been withdrawn from the market.... Two Birmingham, England, investigators, Drs. Ian Leck and E.L.M. Millar, said that from the time thalidomide was put on the British market in April, 1958, till its ban in December, 1961, numerous deformities of limbs, absence of arms and legs or digits of the hands, webbed fingers and undersized ears had appeared in the offspring of mothers taking the drug.

Science Future

August 1
1970s-era Soviet space artifacts go on display at the new visitor center for the Space Foundation headquarters in Colorado Springs, Colo. See bit.ly/SFspace70s

August 4
The San Diego Zoo's Black and White Overnight event offers an evening talk by a panda researcher and an early morning visit to the panda exhibit, plus other fun with black-and-white animals. Learn more at bit.ly/SFzoonite

SN Online

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ENVIRONMENT
Snow layers warm northern soils, reducing how much climate-warming carbon the ground can hold. See "Arctic's wintry blanket can be warming."

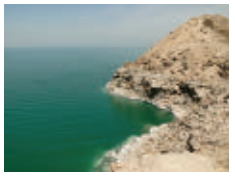
ON THE SCENE BLOG
A *Science News* editor visits Iceland's Eyjafjallajökull in "Icelandic volcanoes slumber today, but not forever."

GENES & CELLS
Sirtuin proteins, associated with longer life spans, also help sync the body's circadian clock. See more in "Antiaging protein helps set daily rhythms."

BODY & BRAIN
Untreated fevers during gestation may double the risk of having a child with autism. See "Fever in pregnancy linked to autism."

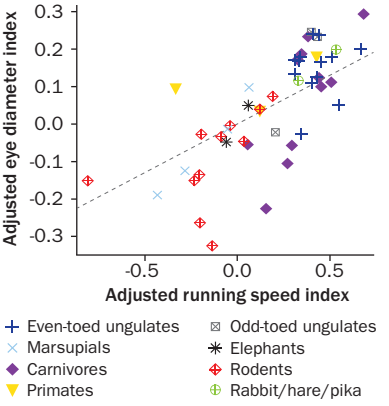
The –est | LOWEST POINT GETTING HIGHER

The lowest place on Earth is rising. Because of water diversions, the surface elevation of the Dead Sea has dropped by nearly a meter a year since 1993. As the overlying water weight lessens, part of the seafloor below is lifting—by up to 4.3 millimeters each year, new satellite data show. The Dead Sea won't be losing its title of lowest place on land anytime soon; its seafloor bottom is still around 730 meters



below mean sea level, compared with 240 meters for the next lowest, the Sea of Galilee. An international team reports the rise May 25 in the *Journal of Geophysical Research*. —*Alexandra Witze*

Science Stats | ALL THE BETTER TO SEE YOU WITH



An old maxim called Leuckart's Law holds that fast-running animals need larger eyes to navigate and avoid collisions. A new analysis finds that Leuckart's Law holds up, even when researchers use a statistic (shown) that adjusts for the effect of body size (larger animals tend to have bigger eyes and run faster).

SOURCE: A.N. HEARD-BOOTH AND E.C. KIRK/*ANATOMICAL RECORD* 2012

CLOCKWISE FROM TOP: GIANLUCABARTOLI/ISTOCKPHOTO; JEFF KANIPE; BERNARD GAGNON/WIKIMEDIA COMMONS

“There could be fundamental differences in how people respond to sweet tastes based on their experience with diet sodas.”
—SUSAN SWITHERS, PAGE 14

In the News

STORY ONE

Alzheimer’s may be handiwork of ‘prion’ proteins

A-beta moves from cell to cell, spreading destruction

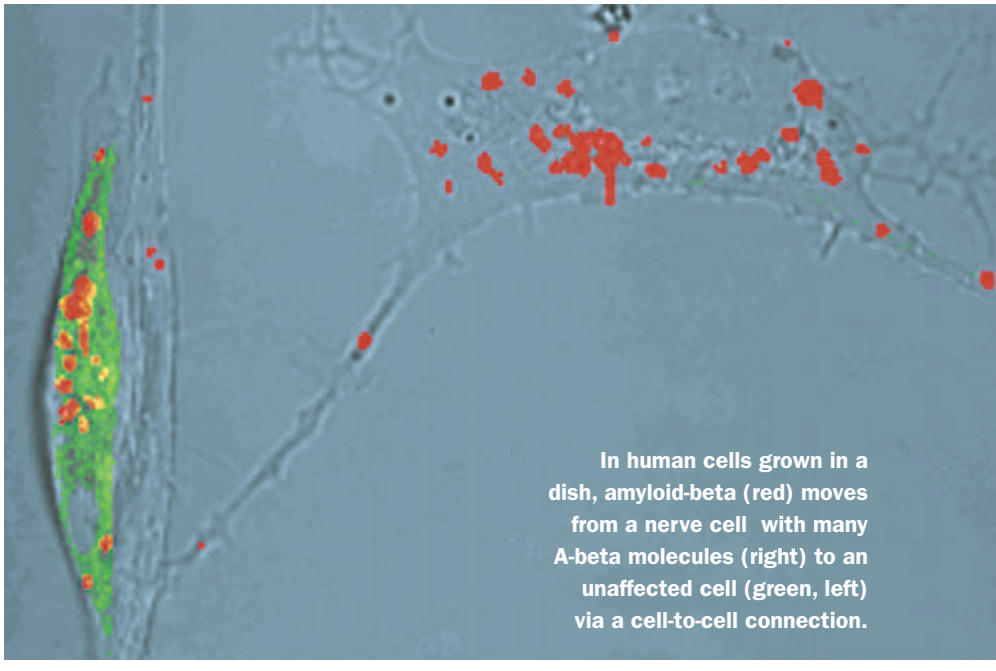
By Laura Sanders

A protein implicated in Alzheimer’s disease travels directly from one brain cell to another, damaging the cells in ways that could lead to dementia, a new study shows. Such spreading may be extra dangerous because the protein, amyloid-beta, seems to have the prionlike ability to convert its harmless form into a toxic version, other new work suggests.

Together, the results cast the cellular events of Alzheimer’s in a new light, offering a view that may ultimately lead to effective ways of interrupting the devastating disease.

The two studies add to the argument that A-beta is a prion like the contagious culprits behind Creutzfeldt-Jakob disease, mad cow disease and scrapie in sheep. A prion’s misfolded, toxic form can induce misfolding in other proteins, leading to disease. There’s no evidence that Alzheimer’s can spread from person to person, but thinking of it as a prion disease could change the way researchers approach treatments and prevention.

In one of the studies, researchers injected purified A-beta protein into one side of mice’s brains and monitored the protein with a fluorescent molecule that became visible as the A-beta accumulated.



In human cells grown in a dish, amyloid-beta (red) moves from a nerve cell with many A-beta molecules (right) to an unaffected cell (green, left) via a cell-to-cell connection.

SANGEETA NATH

After about 300 days, the A-beta had piled up throughout the brain, similar to what happens in Alzheimer’s, the scientists report online June 18 in the *Proceedings of the National Academy of Sciences*. “It really does spread,” says study coauthor Kurt Giles of the University of California, San Francisco. “We inoculate in one part of the brain, but the pathology spreads through the whole brain.”

The most devastating A-beta, the team found, was the kind taken directly from other mice’s brains and purified. But a synthetic kind made in the lab also spread, albeit slower than brain-derived A-beta. Previous studies have hinted that A-beta acts like a prion, but no one had successfully shown that, on its own, synthetic A-beta could seed widespread A-beta deposits. Presumably, that occurs as misfolded forms convert the brain’s native A-beta into harmful versions. By demonstrating that synthetic A-beta can kick off the spread, researchers nailed that A-beta can act as a seeding agent, says neurobiologist Mathias Jucker of the University of Tübingen in Germany. “It’s very, very beautifully shown.”

Neuroscientist George Bloom of the University of Virginia in Charlottesville points out that the study doesn’t rule out an alternative explanation for the effect of the A-beta inoculations. The extra A-beta could be changing the flux of A-beta production or clearance, which would then result in A-beta accumulation. But the data are convincing, he says. “It sure looks and smells a lot like prion disease.”

The UCSF team didn’t have the resolution to see exactly how the A-beta spread through the brain, nor did the team know which form the prionlike A-beta took. But results from another new study, published June 27 in the

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Journal of Neuroscience, help answer both of these questions.

Martin Hallbeck of Linköping University in Sweden and colleagues caught A-beta moving directly from inside one nerve cell to the inside of another in a dish. A-beta flowed from a cell chock-full of A-beta to a healthy cell via long cellular tendrils akin to nerve cells' message-moving axons and dendrites, the team found. Both rat and human cells showed this A-beta transfer, visible because the researchers manipulated A-beta so that it glowed red under the microscope.

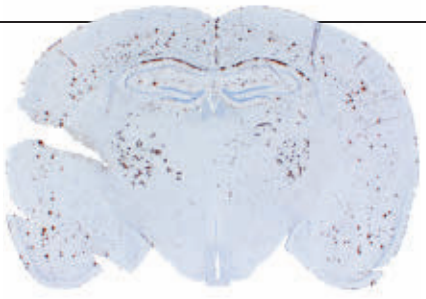
As A-beta began to pile up in previously amyloid-free cells, the researchers saw signs of cellular deterioration, such as ominous shape changes and leaky organelles. "For the first time, we show that A-beta can be spread from one neuron to the next through connections, and the receiving neuron will start to deteriorate," says Hallbeck.

In these experiments, A-beta proteins were arranged in oligomers, a form that's smaller and less sticky than the plaques visible in the brains of people with Alzheimer's. Some scientists have suggested that oligomeric A-beta is the truly dangerous form. And location matters, too. Hallbeck and colleagues' data suggest that in its oligomer form, A-beta causes damage by actually invading the cell, as opposed to triggering harmful changes from outside nerve cells, says Bloom.

"This is the strongest evidence to date that intracellular accumulation of amyloid oligomers may be toxic," Bloom says.

Hallbeck and his team couldn't tell whether their glowing A-beta was able to convert harmless forms of the protein in the cells into toxic species, as would be expected if the protein was behaving as a prion. But the team hopes to develop a way to tell the difference between its tweaked A-beta and cells' natural stores.

More experiments will be needed to reveal the 3-D shapes of the A-beta molecules, and how those conformations may change. But having a deeper understanding of how A-beta moves through the brain will help scientists develop ways to halt that process, Hallbeck says. "The implications are quite large," he says. "With this knowledge, we can start looking for ways to block A-beta transfer between cells. That'll be a way to stop the spread of the disease."

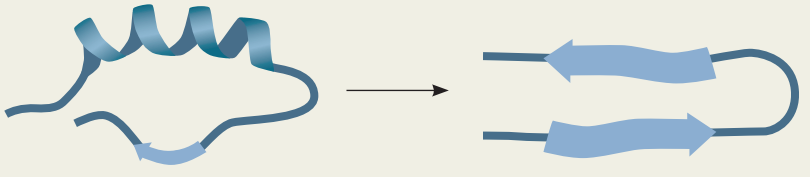


Amyloid-beta taken from the brain of one mouse was injected into a second mouse brain (shown); 300 days later, the protein had spread throughout and formed deposits (dark spots).

In addition to pointing out ways to interfere with the disease, the idea that A-beta is a prion also raises troubling implications for people who participated in a clinical trial in which they received a form of A-beta made in the lab, Giles and colleagues write in their paper.

In a clinical trial halted in 2002, people with mild to moderate Alzheimer's were immunized with synthetic A-beta in an effort to clear their brains of A-beta buildup. If synthetic A-beta behaves like a prion, these people could face a heightened risk for A-beta buildup, the researchers propose. There's currently no evidence of this, says pathologist Eliezer Masliah of the University of California, San Diego. "Even though it's something to be aware of, I think the likelihood of that is very small." ■

Back Story | SHAPE-SHIFTING PROTEINS AND DISEASE



Protein in helical form — Beta-sheet form

Bacteria, viruses and parasites can cause infections, but so can misshapen proteins called prions. Prions' infectivity comes from a self-propagating change in shape. In prions, the innocuous form of a protein often contains helical twists that can be converted to flat beta-sheets (although this can be a normal form for proteins too). For unknown reasons, this flat conformation can incite other proteins of that species to shape-shift too, sometimes forming toxic deposits. For amyloid-beta protein, the suspected culprit in Alzheimer's disease, the exact shape change isn't known. But new work suggests that Alzheimer's can be added to a growing list of brain disorders that share some key features with prion diseases. In the June 22 *Science*, Stanley Prusiner of UCSF argues that a prion-based explanation unites a wide array of neurodegenerative diseases, all of which may stem from misfolded proteins self-propagating through the brain.

Proteins and neurodegenerative diseases

Disease	Deposit-forming protein
Alzheimer's	amyloid-beta and tau
Parkinson's	alpha-synuclein
Amyotrophic lateral sclerosis	superoxide dismutase 1
Huntington's	huntingtin

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Second blocked flu paper released

Research shows modified H5N1 can be passed through air

By Tina Hesman Saey

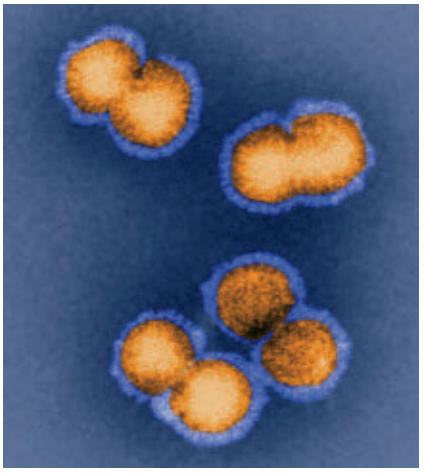
A controversial research paper banned from publication in 2011 because it contained potentially dangerous information is now available for the world to see.

The study, appearing in the June 22 *Science*, details experiments in which researchers in the Netherlands created a version of the H5N1 bird flu virus that can be passed through the air from one ferret to another. The virus currently does not spread between people through coughs or sneezes, but the new work suggests that only a few mutations would be needed to turn H5N1 from a virus that requires close contact into one that could spread through the air.

A U.S. government advisory board originally ruled that the *Science* paper and a similar one published June 21 in *Nature* by researchers from the University of Wisconsin–Madison and Japanese colleagues should not be published in full because terrorists might use information about the flu virus mutations to create a biological weapon (*SN: 6/2/12, p. 20*). The panel reversed the decision in March after seeing revised versions of both papers and speaking with the scientists.

All the hoopla may have come down to one line in the original version of the *Science* paper. The potentially offending statement implied that the airborne version of the virus might be as deadly as the original H5N1 strain, which has killed more than half of the people it has infected, says Vincent Racaniello, a virologist at Columbia University who has read both versions of the paper.

The revised version of the paper clearly states that ferrets that caught the airborne version of the virus from other ferrets did not die. "The data are the same, but the way it is explained is very different," Racaniello says. "Everything is explained and put in context."



Just five genetic changes can render the H5N1 bird flu virus (shown) capable of airborne transmission among mammals, though apparently in a less deadly form. The work raised biosecurity concerns.

In the study, researchers led by Ron Fouchier of Erasmus Medical Center in the Netherlands performed experiments to determine if the H5N1 virus could mutate into an airborne form capable of spreading among mammals, including humans. The researchers genetically engineered into H5N1 three mutations previously found in other flu viruses that had caused pandemics.

Two of the mutations alter a protein called hemagglutinin on the outside of the virus. Flu viruses invade human and animal cells by using hemagglutinin (the H in H5N1) as a grappling hook to snag proteins that stud the surfaces of the cells. H5N1's standard hemagglutinin grasps proteins in the bird intestinal tract and in human lungs. The researchers' changes to hemagglutinin have been shown to help the virus grab proteins found in the nose and throat, where the virus could more easily be coughed or sneezed out.

A third mutation in a protein called PB2 helps the virus copy its genetic material more easily at the relatively cool temperatures in human respiratory tracts.

But those mutations did not allow the virus to spread between ferrets through air. So the researchers put evolution to work by infecting one ferret, then harvesting viruses from that ferret and inoculating another. Each time the virus reproduces in an infected animal, it may pick up new mutations. After three to four cycles, the virus was already reproducing better than it had before in the ferrets' upper respiratory tracts, Fouchier says.

After 10 passages the researchers tested the virus's ability to spread through the air and found that sick ferrets could infect a ferret in a neighboring cage. Fouchier and colleagues discovered many mutations in the virus's genes. "We show that as little as five mutations and less than 10 are sufficient to make H5N1 virus airborne," Fouchier says.

Only two mutations (beyond those the researchers engineered) were found in all of the airborne viruses, both in the gene for hemagglutinin. One mutation, known as H103Y, may make hemagglutinin more stable, Fouchier says. The other mutation, T156A, helps the virus cling to the upper respiratory tract proteins. That mutation is found frequently in nature, including in all human cases of H5N1 infection in Egypt, where the virus is currently active. Egypt has had 168 cases of H5N1 and 60 deaths since 2003, including 10 cases and five deaths so far this year.

Although these changes in hemagglutinin differ from ones found by the Wisconsin group, the mutations may change the protein's function in similar ways. The virus requires few if any other changes in its other genes to become airborne, Fouchier says.

Since several of the mutations needed to make H5N1 airborne are found in nature, it is possible that the virus could mutate in a single human host to become a pandemic strain, Derek Smith and Colin Russell of the University of Cambridge and colleagues say in the June 22 *Science*. ■

DR. KLAUS BOLLER/PHOTO RESEARCHERS, INC.

Life

300 g Top acceleration of mosquito riding a falling raindrop

135 g Acceleration reached by jumping fleas

How a mosquito survives in rain

Insects ride drops downward then depart before the splat

By Susan Milius

A raindrop hitting a mosquito in flight is like a midair collision between a human and a bus. Except the mosquito survives.

New experiments show how the insect's light weight works in its favor, says engineer David Hu of the Georgia Institute of Technology in Atlanta. In essence, the (relatively) huge, fast drop doesn't transfer much of its momentum to a little wisp of an insect. Instead the falling droplet sweeps the insect along on the downward plunge. As Hu puts it, the mosquito "just rides the drop."

The trick is breaking away from that drop before it and the insect splash onto the ground. Mosquitoes that separate themselves in time easily survive a raindrop strike, Hu and his colleagues report June 19 in the *Proceedings of the National Academy of Sciences*.

Such studies help reveal how animals evolved to take advantage of flight, says biologist Tyson Hedrick of the University of North Carolina at Chapel Hill. Mosquito tricks may also inspire engineers designing swarms of tiny flying robots, or be of interest to physicists studying complex fluid dynamics at this scale.

Plenty of lab work has investigated how flying animals recover from disturbances. But there's little work on raindrops, as those collisions are hard to study. To mimic a raindrop speed of about 9 meters per second, Hu and colleagues tried dripping water off the third floor of a building toward ground-level mosquitoes. "It's the worst game of darts you can imagine," he says. "You have no hope of hitting them."

Finally, Hu sprayed streams of water from a pump at caged lab mosquitoes and then refined the process by spraying mosquito-sized beads. His team found that mosquitoes hit with water survived using an insect version of tai chi: Move with the blow instead of resisting it. A raindrop can reach 50 times the mass of a mosquito, and after the collision, "the mosquito becomes a stowaway," Hu says.

The wild ride comes with danger. Mosquitoes hitchhiking on water experience acceleration up to 300 times the force of Earth's gravity, the researchers found. The previous champs for surviving acceleration had been jumping fleas, at a mere 135 times Earth's gravity.

A mosquito survives a collision with a raindrop by riding along during the drop's descent but breaking away before hitting the ground.

Mosquitoes' small mass might allow them to fly through raindrops but leave them more vulnerable to other menaces, such as wind. Larger and heavier horseflies "should have no problem with wind but might be more disturbed by raindrop impacts," Hedrick says.

Scientists who work outdoors know how readily mosquitoes can survive wet weather. "I've worked in the field many rainy nights," says entomologist Nathan Burkett-Cadena of the University of South Florida in Tampa, "and received zero respite from mosquitoes during even heavy rains." ■

Arachnophobic bugs

Chemical remnants of fear in the corpses of grasshoppers slow the decomposition of dead grass and other debris important for fertilizing new plant growth, a new study finds. Spiders that frighten grasshoppers may thus play a role in shaping ecosystems, adding a menace that cows the predators' prey and may suppress local vegetation, researchers report in the June 15 *Science*. A team at Yale spooked *Melanoplus femurrubrum* grasshoppers by raising them in cages with *Pisaurina mira* spiders with mouthparts glued shut so the arachnids could scare but not kill the insects. Stress boosts a grasshopper's appetite for carbon-rich carbohydrates. So compared with insects in predator-free cages, grasshoppers living with spiders were made of more carbon and less nitrogen. That change in composition proved a problem for soil microbes, which need nitrogen to break down plant litter. Adding carcasses of once-fearful grasshoppers to dirt dropped microbial activity by 62 percent in the lab and 19 percent outdoors. —*Devin Powell*

FROM TOP: COURTESY OF TIM NOWACK, ANDREW DICKERSON AND D. HU/GEORGIA TECH; DROR HAWLENA

Atom & Cosmos

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Study finds new exoplanets are often impostors

A third of Kepler's hot giant orbs may be 'false-positives'

By Nadia Drake

When the Kepler spacecraft finds a giant planet closely orbiting a star, it might not really be a planet at all.

A new study testing some of Kepler's thousands of candidate planets against a complementary method for discovering objects in stellar orbits suggests that 35 percent of candidate giants snuggled close to bright stars are impostors, known as false-positives. The result is posted online June 5 on arXiv.org.

"Estimating the Kepler false-positive rate is one of the most burning questions in this field," says astronomer Jean-Michel Désert of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Estimates by Désert and others place the false-positive rate for smaller planets at less than 10 percent. That doesn't necessarily contradict the new results, given the different exoplanet populations in various research efforts.

"We cannot say anything about smaller planets," says graduate student Alexandre Santerne of the University of Aix-Marseille in France and coauthor of the new paper. "It's just for giant planets close-in."

Kepler detects periodic dimming of starlight caused by planets passing between Earth and their home stars. But not everything that darkens a star is a planet; smaller stars, for example, can masquerade as a planet. Instead of monitoring for periodic twinkles, Santerne and colleagues looked for gyrations in stars produced by orbiting planets' gravitational tugs. Since heavy, nearby planets yank more noticeably on their stars, the team focused on giant candidates with orbits of 25 days or less.

Out of more than 2,300 possible planets, only 46 fell into that category. Eleven of these were already known planets. Santerne's team confirmed nine more.

The remaining 26 candidates included 13 unknowns, two failed brown dwarfs and 11 members of binary star systems. "These can mimic clearly a planetary transit event," says Santerne. "That's why it's so important to distinguish these things when you want to study planets and transits from the Kepler mission."

After distributing the unknowns by the observed ratios of objects, the team arrived at the 35 percent false-positive rate. That number might seem high compared with previous estimates, but scientists don't consider it a serious flaw for Kepler. "This false-positive percentage is very low compared to all other transit programs," says study coauthor Claire Moutou, also at Aix-Marseille.

The authors point out a discrepancy between their result and a 2011 study by Timothy Morton and John Johnson at Caltech, who found a false-positive rate closer to 5 percent. But Morton notes that the groups calculated different things. Instead of looking at impostor rates in a specific planet population, Morton and Johnson determined the probability that any candidate — plucked from all twinkling candidates — was real. And they excluded data from obvious impostors.

"Everything here is sort of a game of probabilities," Morton says. "It will be impossible to confirm them all with observations."

NASA, ESA, Z. LEVAY AND R. VAN DER MAREL/STSCI, A. MELLINGER

Milky Way will be hit head-on

The monstrous Andromeda galaxy and the Milky Way are destined for a direct collision, not just a glancing blow, new observations from the Hubble Space Telescope show. By precisely locating the same stars in Andromeda in 2002 and then again in 2010, astronomers at the Space Telescope Science Institute in Baltimore and colleagues have calculated how the galaxy has moved against the background of deep space — confirming that the galaxy's sideways motion is but a fraction of the speed at which it's hurtling toward the Milky Way. Andromeda is 2.5 million light-years away and closing in on the Milky Way at 400,000 kilometers per hour. The cosmic collision will transform the heavens into a hallucinogenic swirl beginning about 4 billion years from now (shown in illustration). Calculations suggest that the sun will be tossed out during this galactic mash-up, to drift erratically in the eventual single, large galaxy that will coalesce from the two. The work will appear in an upcoming *Astrophysical Journal*. —*Alexandra Witze*

"It sort of resets the bar for weird." —THOMAS BEATTY

Giant celestial disk hard to explain

Star's sculpted debris ring challenges planet-formation ideas

By Nadia Drake

About 80 light-years away, an enormous, dusty ring swirls around a sunlike star, with a defined inner edge that is probably sculpted by a planet orbiting at 140 times Earth's distance from the sun.

A planet located so far from a sunlike star presents astronomers with a conundrum.

"How do you get a planet out that far? We don't know how to form something out there," astronomer Karl Stapelfeldt of NASA's Goddard Space Flight Center in Greenbelt, Md., said on June 14.

Stapelfeldt and a team led by John Krist of the Jet Propulsion Laboratory in Pasadena, Calif., used the Hubble Space Telescope to study 10 stars suspected of hosting large debris disks. Hubble saw a ring around only one, HD 202628, which resides near the southern constellations Grus and Microscopium.

Everything about the dusty circle — the biggest ever seen around a solar cousin — is huge. In places, the ring itself is 70 times wider than the 150 million kilometer Earth-sun distance, a length astronomers refer to as an astronomical unit. From end to end, the disk is roughly 400 astronomical units long — larger than the well-known ring surrounding the star Fomalhaut. Like that ring, the newly observed one is also groomed by a celestial gardener — a planet living about 140 astronomical units from HD 202628.

This planet hasn't yet been observed, but Stapelfeldt speculates that it might be several times more massive than Jupiter. "You can't get a structure like this, and have it last for a long period of time, unless something keeps all the particles' orbits lined up," he said.

Such distantly orbiting planets challenge theories describing planet formation, especially around sunlike stars. Debris disks around these stars don't contain enough material to grow a planet so far away. "The formation of wide-orbit planets is particularly not well understood," says astrophysicist Aaron Boley of the University of Florida, who studies the Fomalhaut system and its far-flung ringscaping planets. "To build a complete understanding of planet formation, we must understand the architecture of planetary systems, which includes planets that are at very large stellar separations."

Both Krist's team and Boley suggest that the planet living around HD 202628 may have formed closer to the star, then migrated outward. But, Stapelfeldt says, that process would have had to be unusually gentle. "If you did something violent and you threw the planet out there, its gravity would tear up the ring," he said. "You wouldn't expect to have something like this left over." ■

MEETING NOTES

Sun's short-term memory

Scientists trying to forecast peaks in solar activity have generated vastly variable estimates, ranging from Wimpy to Hulk. Dibyendu Nandi of the Indian Institute of Science Education and Research in Kolkata has an explanation for that problem: "The sun has a very short memory. It forgets its history of past activity," he said on June 11. That's because "turbulent pumping" of the solar magnetic field erases memories of past activity cycles. This mixing makes previous solar cycles bad indicators of future intensity. Nandi suggests that solar maximums, when the sun has its highest number of sunspots, can be reliably predicted only by using the previous minimum — which means the sun remembers its own history for just 5.5 years. — *Nadia Drake*

Small telescope, big planet

Sometimes, a tiny eye turned toward the sky can see big things. The Kilodegree Extremely Little Telescope — basically a digital camera — discovered two enormous stellar companions orbiting faraway stars. One is a Jupiter-sized planet orbiting a star bright enough to allow scientists to study the planet's atmosphere. The other, a big brown dwarf, is "something that has never been seen before," said Thomas Beatty of Ohio State University on June 13. KELT looks for dips in light caused by bodies passing between a star and Earth. KELT-1b, the brown dwarf with a mass of about 30 Jupiters, is one of these bodies. It circles its star in just 29 hours, receiving 6,000 times the amount of sunlight that Earth gets. "It sort of resets the bar for weird," Beatty said. — *Nadia Drake*

Weird and distant planet

The dwarf planet Quaoar (kwa-war) and its satellite Weywot present some unusual features. Quaoar, which orbits the sun at 40 times the Earth-sun distance, is much denser than expected. Weywot takes a more oval-shaped path around Quaoar than it should, if theories describing satellite formation apply to the two Kuiper Belt bodies. Both of these features suggest that the system formed after an unusually violent collision blasted away Quaoar's outer icy sheath, leaving behind a dense chunk of rock. And Weywot, instead of condensing from the resulting debris, was borne of a large fragment — the remainder of an "unusually high-velocity collision," said Wesley Fraser of Canada's Herzberg Institute of Astrophysics on June 13. — *Nadia Drake*

Earth

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Mystery volcano site pinned down

Indonesian crater implicated in mid-13th century eruption

By Alexandra Witze

The Rinjani volcano in Indonesia may be the long-sought site of a mysterious and massive eruption known to have occurred around 1258.

One of the biggest mysteries in volcanology may finally be solved. An eruption long thought to have gone off in the year 1258 happened the year before in Indonesia, scientists report.

Until now, researchers have known a big volcano went off somewhere in the world around that time, spreading cooling sulfur particles around the globe. But they didn't know exactly where or when.

The new report remains something of a mystery. Franck Lavigne, a geoscientist at Panthéon-Sorbonne University's Laboratory of Physical Geography in Meudon, France, showed close-up photographs of the perpetrator volcano on June 14. But he declined to name it, saying he had agreed with his international colleagues not to identify it until the work is published in a peer-reviewed journal.

"We have new and solid evidence for the biggest volcanic eruption in 7,000 years," Lavigne said.

Consensus in the meeting hallways was that he had shown pictures of Indonesia. Volcanologist Erik Klemetti of Denison University in Ohio, who wasn't at the meeting, speculates that the culprit might be Rinjani, a volcano on the island of Lombok. Lavigne would say only that Indonesia has over 130 active volcanoes.

Scientists know that a big eruption happened in the mid-13th century because ice cores from Greenland and Antarctica contain huge amounts of sulfur dating to that time. Historical records and other evidence show that the planet cooled soon thereafter. Big eruptions can spew sulfur dioxide into the upper atmosphere, where the gas generates sulfate aerosols that spread around the globe and reflect sunlight, temporarily chilling the planet.

Candidates for the 1258 eruption have included Mexico's El Chichón and Quilotoa in the Ecuadorean Andes. But the chemical makeup of rocks from those volcanoes doesn't match the 1258 sulfur from ice cores.

At the meeting, Lavigne reported that rocks from his mystery volcano matched the chemistry of the ice-core sulfur almost perfectly.

Newly unearthed historical records and other evidence show that climate changes were already happening in the region by the winter of 1257–1258, Lavigne said. "We think the eruption may have been in the late spring or summer of 1257," he said. That's nearly a year earlier than previously thought.

Volcanic bromine destroyed ozone

Blasts emitted gas that erodes protective atmospheric layer

By Alexandra Witze

Scientists have exposed another assault on Earth's protective ozone layer — not by manufactured chemicals, but by gas ejected in huge volcanic eruptions.

A new study shows that volcanic rocks in Nicaragua contain bromine, an element known for speeding ozone's destruction in the upper atmosphere. When magma erupted to form those rocks, scientists say, it released enough bromine to destroy large parts of the ozone layer for several years.

"We have to be aware of this," says Kirstin Krüger, a meteorologist at the GEOMAR Helmholtz Center for Ocean Research in Kiel, Germany. "Large-scale tropical eruptions have the potential to deplete ozone on a big scale." Krüger presented the work, led by GEOMAR volcanologist Steffen Kutterolf, on June 12.

The scientists studied rocks formed during 13 big Central American eruptions over the last 70,000 years. Volcanoes at such latitudes are good at injecting stuff into the stratosphere, some 16 kilometers up. When elements such as chlorine and bromine reach that high, they help trigger reactions that break down ozone molecules. The new work is the first to pin down in detail the role of bromine, which is 60 times as efficient as chlorine at destroying ozone, Krüger says.

Kutterolf and colleagues analyzed bromine levels in thousands of rock samples both on and offshore, concluding that 4,000 to 600,000 metric tons of bromine came out per eruption.

Enough bromine would have made it to the stratosphere to create at least double the ozone-destroying potential seen with the highest modern-day bromine levels, Krüger says. It would have taken three to six years for the chemicals to clear out so that ozone could begin to recover.

PRZEMYSLAW SKIBINSKI/SHUTTERSTOCK

Matter & Energy

"We found hundreds of volts from just tumbling flour." —TROY SHINBROT

The electric flour voltage test

Just before 'avalanche,' granular materials give off a zap

By Rachel Ehrenberg

Ordinary baking flour isn't the most electrifying substance, but spilling a box of it yields a jolt of voltage, hinting at prospects for sensing early signs of events like earthquakes and industrial accidents.

Scientists have long known that materials such as rock, crystals and adhesive tape can produce an electrical signal as they fracture or crack under a load. It's also known that before a granular material can flow, the space it takes up has to enlarge — think of a traffic jam in which another lane opens up and cars begin to move again. The voltage measured in the flour may be a signal of this "dilation," which indicates flow is about to happen.

"We've known about dilation and that there's an electrical signal when things fail, but nobody has put these two together before," says chemical engineer Joseph McCarthy of the University of Pittsburgh.

Researchers at Rutgers University took a cylindrical tumbler — the sort used to mix powders — and filled it with a blend of ground-up acetaminophen and cellulose. After running a static eliminator over the setup to clear out any built-up charge, the researchers affixed a voltage probe to different locations on the tumbler and slowly spun it. Seconds before the powder dumped from one side of the tumbler to another — essentially right before the avalanche — the researchers detected a zap of electricity, they report online June 11 in the *Proceedings of the National Academy of Sciences*.

They then repeated the experiments using unbleached white flour. "Our expectation was that we weren't going to see anything, but we found hundreds of volts from just tumbling flour," says Troy Shinbrot, a granular materials specialist at Rutgers. "It seemed very strange, like something was wrong with the flour."

Puzzled, the researchers made the setup simpler: They built an acrylic box, filled it with flour and slowly tipped it. A voltage spike was detected in 15 of 18 trials. This spike occurred less than one second before the flour began to slip.

While the spike was often very close in time to the start of the grain cascade, the researchers think the voltage is released from the crack that precedes the event. Such a signal might be harnessed for predicting the failure of granular materials, McCarthy says, perhaps in huge industrial vats, silos or even earthquakes. ■

Body & Brain

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Replacing fatty acids may fight MS

Lipid injections ease disease's hallmark symptoms in mice

By Nathan Seppa

By delving into the components of protective nerve coatings that get damaged in multiple sclerosis, scientists have identified a handful of lipid molecules that appear to be attacked by an immune system run amok.

Bolstering the supply of these lipids might help preserve these nerve coatings and, in the process, knock back the inflammation that contributes to their destruction, researchers report in the June 6 *Science Translational Medicine*.

In MS patients, antibodies assault myelin, the fatty sheath that insulates nerves and facilitates signaling. Inflammation exacerbates the attack on myelin and the cells that make it. But other details of MS, including the roles of myelin lipids, have been less clearly understood.

"I think this is a very good study," says Francisco Quintana, an immunologist at Harvard Medical School. "Overall, there are not many papers on lipids in MS."

The researchers tested spinal fluid from people with MS, healthy people and patients with other neurological disorders. Tests showed that antibodies targeted four lipids more often in MS patients than in the other groups. Autopsied brains from MS patients and people without MS revealed that in MS patients, these four lipids were depleted at the sites where the nerve coatings were damaged.

A nerve needs an intact myelin sheath to conduct signals. "It short-circuits if they are not there," says study coauthor Lawrence Steinman of Stanford University. This nerve damage causes loss of muscle control and other MS symptoms.

Steinman and colleagues found that injections of the lipids into mice with a condition similar to MS could limit severity of the disease and even reverse some symptoms. The four lipids — abbreviated PGPC, azPC, azPC ester and POPS — share a similar phosphate group, to which the rogue antibodies bind.

Other tests in mice showed that side chains of fatty acids, attached to the lipids like fingers on a glove, "keep the myelin-making cells alive and reduce the inflammatory response," Steinman says. The side chains are imbued with protective properties; they repel inflammation and even kill the T cells that trigger it, the researchers found.

No-cal sodas can trick the brain

Sugar-free sweeteners may contribute to obesity risk

By Janet Raloff

By baffling the brain, saccharin and other sugar-free sweeteners — key weapons in the war on obesity — may paradoxically foster overeating.

At some level, the brain can sense a difference between sugar and no-calorie sweeteners, several studies have demonstrated. Using brain imaging, San Diego researchers now show that the brain also processes sweet flavors differently depending on whether a person regularly consumes diet soft drinks.

"This idea that there could be fundamental differences in how people respond to sweet tastes based on their experience with diet sodas is not something that has gotten much attention," says Susan Swithers of Purdue University in West Lafayette, Ind. A key finding, she says: Brains of diet soda drinkers "don't differentiate very well between sucrose and saccharin."

Erin Green and Claire Murphy of the University of California, San Diego and San Diego State University recruited 24 healthy young adults for a battery of brain-imaging tests. Half reported regularly drinking sugar-free beverages, usually at least once a day. The rest seldom if ever consumed such drinks. While the brain scans were under way, researchers pumped small amounts of saccharin- or sugar-sweetened water in random order into each recruit's mouth.

Both the diet soda drinkers and nondrinkers rated each sweetener about equally pleasant and intense, Green and Murphy report in an upcoming *Physiology & Behavior*. But which brain regions lit up while making those judgments differed sharply based on past diet drink consumption.

Some affected brain regions are associated with pleasurable feedback or reward in response to desirable sensations. Compared with nondrinkers, diet soda consumers "demonstrated more widespread activation to both saccharin and sucrose in reward-processing brain regions," the scientists say.

One strong link to higher diet soda consumption was reduced activation of the caudate head, an area associated with the food motivation and reward system. Green and Murphy note that decreased activation of this brain region has also been linked to higher risk of obesity.

The new findings may help explain an association between diet soda use and weight gain. Once fooled, the brain's sweet sensors may no longer be able to reliably gauge energy consumption.

Two years ago, Swithers' group showed that rats that always received a saccharin-sweetened yogurt learned to modulate their food intake to account for the sweetener's failure to deliver calories. But rats that alternately got saccharin- and sugar-sweetened yogurts blimped out.

SCHULTEPRODUCTIONS/ISTOCKPHOTO

2.5 percent | Portion of U.S. population consuming artificially sweetened drinks, 1965

10.8 percent | Portion of U.S. population consuming artificially sweetened drinks, 2003–04

Antipsychotics need to pile up

New insights explain delayed action in schizophrenia drugs

By Laura Sanders

New details about how some drugs for schizophrenia accumulate in the brain may help explain why patients often must wait weeks before the medications work.

Because many commonly used antipsychotics such as haloperidol and clozapine quickly latch onto their targets, it would seem that the drugs should bring fast relief.

"But there's always a side story," says neuroscientist Michael Cousin of the University of Edinburgh. "There's another layer of complexity" that this new work uncovers.

Researchers led by Teja Groemer of Friedrich-Alexander University of Erlangen-Nürnberg in Germany illuminate this complexity in the June 7 *Neuron*. They describe how the buildup of certain drugs in the brain may have underappreciated consequences for their effectiveness.

The idea that drugs accumulate in the brain isn't totally new; other scientists have suggested that antipsychotic drugs can pile up in certain places, Groemer says. But most people have assumed such accumulation is inconsequential.

Not so, Groemer and his team found. Stockpiled drugs may actually squelch nerve cells' behavior in a highly selective way, kicking in only when needed most.

Stockpiled drugs may squelch nerve cells' behavior in a highly selective way.

Using a proxy compound that could be seen with a microscope (because making the drugs themselves visible would have changed their behavior), the researchers watched the chemical build up in small pockets, called synaptic vesicles, inside nerve cells that were growing in a dish. Normally, vesicles carry messenger molecules made by the cell. In an excited nerve cell, vesicles rise to the surface, glob onto the cell's outer membrane and float these messages out and away.

Vesicles chock-full of unnatural cargo — haloperidol, chlorpromazine, clozapine and risperidone — also float their contents into the space between nerve cells when a cell is excited, the team found. This evacuation sends a "calm down" signal back to the cell releasing the drug. In this way, the activity of a nerve cell dictates the drugs' effects. The more active a cell, the more antipsychotic drug it gets. "The brain doses itself," Groemer says.

This accumulation process might help explain why people typically have to take such drugs for several weeks before noticeably improving: The drugs need time to build up in the vesicles before exerting their calming effect. Other drugs with similar chemical makeups, including some antidepressants, may behave similarly.

The experiments were conducted with cells in dishes and with rodents; it's not clear whether the same thing happens in people. If so, the results could have important implications for doctors, Groemer says. "One really needs to wait for a drug to accumulate before deciding whether the drug is effective or not." ■

NEWS BRIEFS

Good touch, bad touch

A leg caress can delight or feel totally skeevy, depending on who's doing the caressing. A touch's emotional baggage can be seen in the brain's initial response to that touch, scientists report in the June 19 *Proceedings of the National Academy of Sciences*. Heterosexual men's somatosensory cortices, brain regions that detect a touch's basic attributes, responded differently when a touch was thought to come from a gorgeous woman in a black evening dress or a masculine man in a black tank top. Emotions are incorporated into touch sensation surprisingly early in the sensory process, the study shows. —*Laura Sanders*

Brain zap helps an aging memory, if you're educated

Brain jolts improve working memory in older adults, but only in those who are highly educated. With age comes a growing number of working memory failures, such as walking into the kitchen and forgetting why. After a session of transcranial direct current stimulation, working memory improved for highly educated participants (schooled for 16.9 years on average). People with lower education levels (13.5 years) saw no benefit or grew worse. The results may reflect people using different strategies to solve problems, Marian Berryhill and Kevin Jones of the University of Nevada, Reno write in an upcoming *Neuroscience Letters*. —*Laura Sanders*

High-risk Alzheimer's gene variant poses greater threat to women

A well-known risk factor for Alzheimer's is particularly dangerous for older women even if they are healthy and sharp, researchers at Stanford University School of Medicine and colleagues report in the June 13 *Journal of Neuroscience*. Women with one copy of the e4 version of the *ApoE* gene had abnormal activity in key brain regions and elevated levels of the Alzheimer's-related tau protein in spinal cord fluid compared with women who lacked that version of the gene. Men with one copy of e4 were less affected in those respects. The results may help explain why women are more susceptible to Alzheimer's. —*Laura Sanders*

CHASING A COSMIC ENGINE

A helium-filled balloon launched from McMurdo Station in Antarctica in 2004 carried the Cosmic Ray Energetics and Mass experiment on a 42-day journey.

After 100 years, energetic space particles continue to pose a perplexing mystery

By Nadia Drake

It was August 7, 1912, and Victor Hess was about to solve a mystery.

The Austrian physicist climbed aboard a highly combustible, hydrogen-filled balloon, carrying three electroscopes — small, brass-enclosed instruments with metal-coated wires that separate when hit by charged particles. At the time, such invisible ions in the atmosphere were already an aging conundrum, having first been detected in 1785.

His balloon lifted off from the Bohemian town of Aussig. It was just after 6 a.m. Six hours later, having soared to a chilly 5,300 meters, the balloon touched down near Berlin.

Along the way Hess made a discovery that would later earn him a Nobel Prize. His electroscopes recorded three times as many charged particles at an altitude of 4,500 meters as they had on the ground, demonstrating that these particles come from the sky.

Previous experiments with electroscopes underground, underwater and atop the Eiffel Tower had been inconclusive. Some suggested that the charged particles came from the Earth instead of raining down from above. But Hess' finding that detections increased with altitude proved that the particles weren't produced in-house. "The results of the present observations seem best explained by assuming that a radiation of great penetrating power enters our atmosphere from above," Hess concluded in *Physikalische Zeitschrift*.

In the 100 years since Hess' flight, scientists have continued to study what became known in the 1920s, somewhat misleadingly, as cosmic rays. They are actually subatomic particles, space travelers slung to Earth from afar. Some come from inside the Milky Way; others, which slam into the Earth with tremendous energies, come from beyond the galaxy. About 90 percent of the rays reaching Earth arrive in the form of energetic protons. Maybe 1 percent are electrons. The rest are heavier atomic nuclei, such as helium or iron.

But that's about all scientists know for sure.

Coaxing cosmic rays to share their stories hasn't been easy. With the exception of some lower-energy particles produced during solar outbursts, the rays are surprisingly secretive. Most take circuitous paths to Earth, erasing any trace of the way back home. The most mysterious, called ultrahigh energy cosmic rays, are remarkably scarce and continue to confound scientists. "Whatever is making these rays must be the biggest cannons, the biggest guns," says astroparticle physicist Peter Gorham of the University of Hawaii at Manoa.

In the effort to find out where exactly cosmic rays come from, powerful detectors now live on land, are submerged in the sea and soar through space. Still, no one knows what astrophysical accelerators hurl these energetic travelers into the void.

"It's a bit sad that it's now a hundred years since Hess' famous balloon flight and we still don't know where these things come from," says cosmic ray physicist Alan Watson of the University of Leeds in England.

But cosmic detectives are muscling through. Recent work has crept up on proving beyond a reasonable doubt that supernovas accelerate cosmic rays from within the galaxy. Scientists also have new clues to the chemical composition of the ultrahigh energy rays that journey from farther afield, though the cosmic engine remains unknown. Borrowing from the escapades of yesteryear, a host of balloonborne experiments in the last decade have converged on the frigid Antarctic ice cap — a natural, all-purpose laboratory whose reflectivity might help unveil the anonymous accelerators behind the curtain.

A century ago, Victor Hess (center) determined that energetic particles in the atmosphere, called cosmic rays, come from outer space. But their astronomical sources still elude scientists.

"Scientists ultimately love a mystery," says James Buckley, an astrophysicist at Washington University in St. Louis. "It's a good thing if you want to keep building newer and bigger instruments. It's not like science is failing."

Pinged from nearby

Cosmic rays arriving from sources within the Milky Way are better understood than their higher-energy brethren. The galactic flavor is common, with about 10 particles passing through a person's thumb every minute. Fifty times that many would bombard a thumb above the Earth's atmosphere, which is one reason why prolonged spaceflight can be a risky proposition.

Galactic cosmic rays arrive with anywhere up to a billion billion electron volts of energy, tens of thousands of times the amount produced in proton collisions in the Large Hadron Collider, at the

OPPOSITE PAGE: NASA; THIS PAGE: SPL/PHOTO RESEARCHERS, INC.

European physics laboratory CERN in Geneva. Most of these rays, though, are somewhat less energetic — between 100 million and 10 billion eV. Since they're charged, rays at these energies are bounced around by magnetic fields.

"A particle wandering across the Milky Way toward Earth would be taking essentially a drunken walk," says particle physicist Jasper Kirkby of CERN. "The final arrival direction has absolutely no relation to where it came from."

That complicates efforts to find the accelerators that send these particles on their way. But scientists think they have a lead on at least one source: supernovas.

"That's a perfect explanation," says physicist Francis Halzen of the University of Wisconsin–Madison. "The only problem is, there's no evidence for that."

No definitive observational link between incoming particles and faraway stellar explosions has yet been seen, but the proposal does make astrophysical sense. Cosmic rays could easily come out of a turbulent accelerator consisting of supernovas and blustery, giant stars — a chaotic cosmic environment that not only produces particles, but also traps them, shoots them around and eventually kicks them out.

Such places are called superbubbles, and NASA's Fermi Gamma-Ray Space Telescope recently came close to observationally implicating superbubbles as galactic cosmic ray accelerators.

A telescope looking for gamma rays, a high-energy form of electromagnetic radiation, is a helpful hound in the hunt because gamma rays are produced when cosmic rays interact with the interstellar medium. And gamma rays have no charge. "They do point back to their source," says Robert Binns, an astrophysicist at Washington University in St. Louis.

A clustering of gamma rays in a suspicious environment might point to a cosmic ray homeland. Such clustering is exactly what the Fermi telescope saw when it peered at the Cygnus superbubble, an enormous star-forming region 4,500 light-years away in the Milky Way.

When imaged, the gamma-ray distribution matched the shape of the bubble's lumps and cavities, formed by billowing stellar winds. The combination of spent supernovas and spasming young stars, plus the gamma-ray match, offers some of the best evidence yet that these regions act as cosmic accelerators, scientists reported late last year in *Science* (*SN Online: 11/29/11*).

Added to this evidence is the fact that heavier elements in galactic cosmic rays are also cooked up in these superbubbles. Like fingerprints, the ratios of different elements — such as iron, nickel and neon — can suggest an origin for cosmic rays. "About 20 percent of the material in the cosmic rays is what I would call superbubble material," Binns says. "The other 80 percent is most likely normal interstellar material, but much of that is probably accelerated by these massive stars anyway."

Binns is working on reading the stories these ratios tell, using detectors including one called TIGER, flown on a balloon more than 30,000 meters above the Antarctic surface.

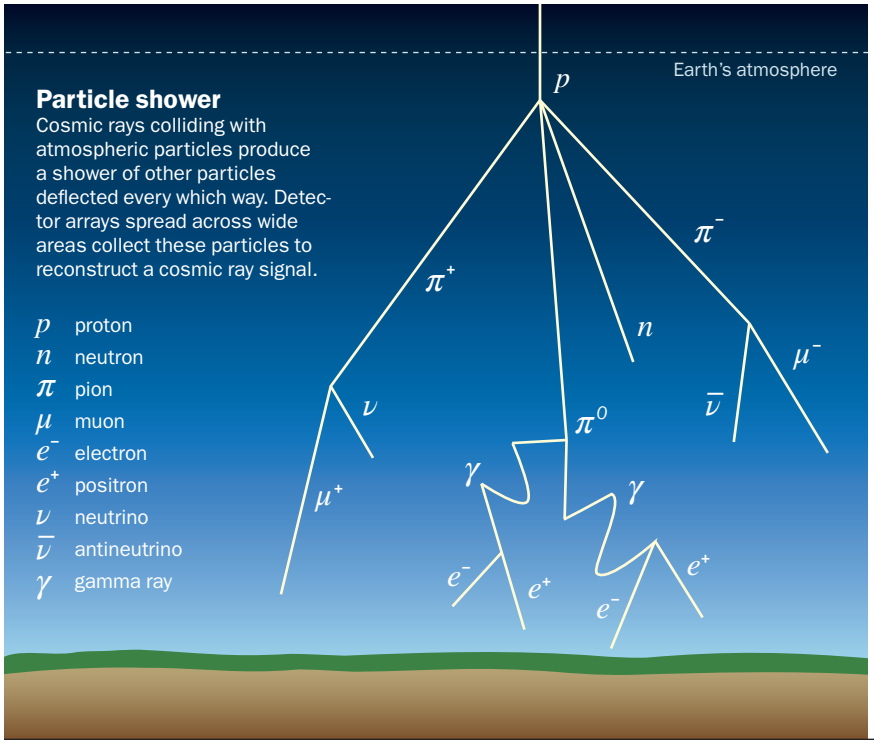
Distant homeland

But supernovas, whether in superbubbles or solo, won't be the answer to a more stubborn mystery: What mammoth astrophysical accelerators create the cosmic rays that, because of their superhigh energies, must come from outside the galaxy?

A half-century after Hess delivered proof that cosmic rays come from above, scientists received an uninvited guest — a particle with an energy of 100 billion billion eV, millions of times the energy generated by the Large Hadron Collider. In 1962, this particle slammed into an array of detectors in Volcano Ranch, N.M. It wasn't long before more of these enigmatic particles arrived, and in 1991, a ray with more than three times the energy of the Volcano Ranch particle struck the University of Utah's Fly's Eye detector. It became known as the "Oh My God particle." Such subatomic particles, traveling with energies that had never before been seen, opened a new mystery — that of the ultrahigh energy cosmic ray. Scientists are still seeking a superslinging culprit.

"There aren't many 50-year-old mysteries in science that have been pounded on as hard as this one and have still not yielded a really solid clue," Gorham says.

The good news is that unlike their less-energetic galactic cousins, these ultrahigh



E. FELICIANO

energy rays aren't deflected en route, so they do point home. The bad news is that the rays are so rare that scientists haven't gotten a good look at them.

Early estimates suggested that one of these particles lands in a square kilometer of space just once a century. Newer estimates place that frequency at around three particles per millennium.

To study such rare particles, scientists need enormous detectors. Currently, the Pierre Auger Observatory holds the title of largest array, consisting of 1,600 tanks each containing 12,000 liters of water — a battalion spread out over 3,000 square kilometers. The particle-catching array is located in the Argentinean desert, nestled near the mountains.

"It's a beautiful place, right up against the Andes, between one and 10 cows per square kilometer," says Watson, who proposed the observatory along with Nobel physics laureate James Cronin in 1992.

When cosmic particles collide with an atmospheric atom — usually a nitrogen nucleus — they fracture into many smaller particles, producing a cascade called an air shower. These showers rain down over as much as 30 square kilometers, which is why the observatory occupies a plot of land roughly the size of Rhode Island. When the particles hit the water, they produce a bit of light visible to detectors inside. Some of the energy also takes the form of something like dim mini-auroras — ultraviolet light that can be seen by an additional array of 24 fluorescence telescopes.

Once, it seemed an ultrahigh energy engine had been found. In 2007 in *Science*, the Auger team reported a tantalizing link between incoming particles and active galactic nuclei, the violently churning, supermassive black hole–fueled centers of distant galaxies (*SN: 11/10/07, p. 291*). Nearly 30 particles neatly lined up with mapped galactic cores — one of two good candidates for the role of accelerator. "I would probably bet on active galaxies," Gorham says. "A monster black hole is nothing to sneeze at."

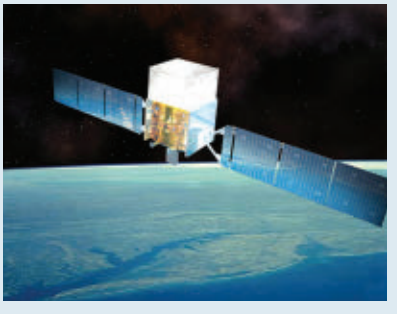
But with more data, the connection

Patchwork of arrays

Cosmic ray detectors now cover the land, sea and sky, a sign of ongoing efforts to try to understand what's accelerating these charged particles.

Land: Size matters for modern-day cosmic ray observatories on the ground and buried beneath. Behemoth detectors maximize the chances of catching a ray. The Pierre Auger Observatory in Argentina searches for the highest-energy particles arriving on Earth, using water tanks (one shown) as detectors spread across 3,000 square kilometers. The IceCube Neutrino Observatory, occupying a cubic kilometer of space beneath the South Pole, and the Askaryan Radio Array, which will cover 200 square kilometers when it moves in next door, look for signs of cosmic rays via neutrinos. In the ultimate size exercise, a company called Image Insight is working on an app that will transform anybody's smartphone into a cosmic ray observatory, allowing an array to spread across the globe.

Sea: Whether liquid or frozen, water is useful for detecting cosmic rays. Energetic particles interacting with water produce a spark of light that can be measured — hence Auger's water tanks. But some scientists have taken that method of detection one step further and submerged entire telescopes. Similar to IceCube in design, the ANTARES neutrino telescope (shown before deployment) lives in the Mediterranean, off the French coast. Not all detectors are so lucky, though. The Baikal Deep Underwater Neutrino Telescope has been submerged for years in the frigid Siberian lake.



Sky: For another group of cosmic ray detectors, a fear of heights is a definite disadvantage. Some detectors soar tens of thousands of meters up on a balloon, like ANITA or the soon-to-be-launched Super-TIGER experiment. Others hitch a ride through the solar system on spacecraft, including the Cosmic Ray Isotope Spectrometer aboard the Advanced Composition Explorer spacecraft. ACE, launched in 1997, hovers about 1.5 million kilometers from Earth. The Fermi Gamma-Ray Space Telescope (illustration shown), launched in 2008, peers into the high-energy gamma-ray universe from 550 kilometers in altitude. Even closer to Earth is another particle detector, the Alpha Magnetic Spectrometer, that has lived aboard the International Space Station since 2011. It will be joined in a few years by a detector called CALET, hunting for energetic electrons, and a fluorescence detector planned for launch in 2016 that is similar to the array found at Auger. — *Nadia Drake*

FROM TOP: PIERRE AUGER OBSERVATORY; L. FABRE/CEA 2006; NASA E/PO, SONOMA STATE UNIV., AURORE SIMONNET

disappeared, leaving scientists stumped. Then the mystery deepened.

Newer data from the Auger team suggest that ultrahigh energy rays aren't mostly protons like their galactic counterparts, but are instead heavier atomic nuclei, such as iron (*SN: 7/18/09, p. 8*). It almost makes sense: Heavier particles carry more charge and could be more easily accelerated to faster speeds. But it is not yet clear how the findings, published in 2010 in *Physical Review Letters*, fit with current theories of high-energy particle physics. "It's the most unexpected result," Watson says. "We see protons at 10^{18} eV, but more ironlike particles at higher energies."

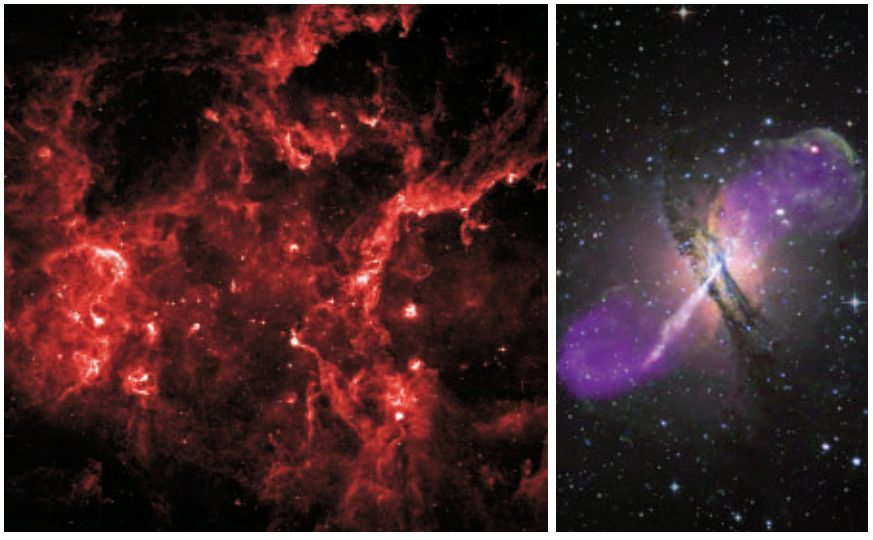
Though perplexing, such a scenario might mesh with another recent puzzling result.

In April, researchers reported in *Nature* that a detector called IceCube at a South Pole laboratory failed to identify any signs of ultrahigh energy cosmic rays coming from gamma-ray bursts — the other front-runner for the title of super-duper accelerator (*SN: 5/19/12, p. 18*). Buried beneath the Antarctic ice, the IceCube detector fills a cubic kilometer of space. Like the Auger water tanks, the detector searches for what's known as Cerenkov radiation — the spark of light produced by particles interacting with water (or ice).

But unlike Auger, IceCube doesn't look for cosmic rays directly. Instead, it focuses on neutrinos: slippery, shape-shifting particles produced as some of the highest-energy cosmic rays travel through space. Neutrinos, like gamma rays, travel in straight lines and point toward home.

"The problem has been that cosmic rays haven't given us the answer on where the cosmic rays are accelerated," Halzen says. "So you try the next thing. Building a [cubic] kilometer neutrino detector is an act of desperation."

After two years of observations, and more than 300 gamma-ray bursts, the team didn't see any neutrinos. The frustrating result calls into question the link between gamma-rays bursts and ultrahigh energy cosmic rays, assuming current astrophysical theories are accurate.



Gamma-ray signals from the Milky Way's Cygnus superbubble (left) suggest that the star-forming region may be a source of cosmic rays. Higher-energy cosmic rays may come from active galactic nuclei, as found in the galaxy Centaurus A (right).

If, however, gamma-ray bursts unexpectedly spit out heavier particles, the Auger and IceCube results would fit together, Watson says. Heavier nuclei, like iron, behave differently than protons and produce fewer neutrinos, which could explain why IceCube isn't seeing a link between gamma-ray bursts and neutrinos. "But we're a long way from sorting out that puzzle," Watson says.

> "Cosmic rays haven't given us the answer on where the cosmic rays are accelerated."
> FRANCIS HALZEN

Soon, a second large neutrino-detecting array will be joining IceCube at the South Pole. Called the Askaryan Radio Array, this collection of radio antennas is being constructed to detect neutrinos produced when extragalactic ultrahigh energy cosmic rays are accelerated to the point that they interact with the thermal radiation left over from the Big Bang.

Using radio waves instead of light to detect neutrinos has its advantages, Halzen says. The paths of the incoming particles are longer, and the ice is more transparent to the radio bursts than it is to light. Scientists are currently constructing the array, which will have 37 detectors all buried 200 meters beneath the ice, covering 200 square kilometers. "These are really kind of little islands that link together because of the extreme clarity of the ice," Gorham says.

Back to balloons

The South Pole has been a point of convergence for teams studying cosmic rays over the last decade, thanks to its built-in icy reflector and seasonal winds. While some detectors are buried beneath the ice, others fly far above the frosty landscape in balloons lofted high into the atmosphere by a polar vortex that begins churning sometime around November. Carried by these winds, the balloons circle the icy pole, easily remaining airborne for weeks at a time, a far cry from Hess' six hours.

"It's really kind of fun because balloons have been the backbone of cosmic ray research ever since Hess' flight," says astrophysicist John Wefel of Louisiana State University in Baton Rouge. "And still today, we're using them."

Beyond the longer flights, today's balloons also fly much higher than Hess' hydrogen-filled balloon, reaching more than 30,000 meters above the Earth. They're much bigger, often large enough that an American football field could fit

FROM LEFT: IPAC AND MSX/NASA; X-RAY: NASA, CXC, R. KRAFT *ET AL*/CFA, RADIO: NSF, VLA, M. HARDCASTLE *ET AL*/U. HERTFORDSHIRE, OPTICAL: ESO, M. REJKUBA *ET AL*/GARCHING

inside. Binns' TIGER experiment and a proposed follow-up are two of these Antarctic balloon-based escapades. ANITA is another. This experiment detects radio waves produced when high-energy particles fragment into pieces, resulting in a radio pulse. "That radio pulse is then reflected off the ice in Antarctica," Binns says. "And our experiment is up in the sky with an array of radio antennas looking down at that."

For eight years, another balloon experiment called ATIC sniffed out levels of high-energy electrons — perhaps an underappreciated galactic cosmic ray species because of their relatively low contribution to the total amount of incoming particles.

But ATIC uncovered something strange: Electrons with 300 billion to 650 billion electron volts pinged the detector too frequently to be explained by conventional astrophysics (*SN: 2/28/09, p. 16*). The 210 captured particles hinted that something lurking nearby must be shoving them toward the Earth. Later, ATIC-4, a follow-up experiment, confirmed the initial anomaly.

That first paper incited a flurry of wild speculation, including the possibility of a dark matter source. But Wefel offers another suspect: "The most plausible explanation in standard astrophysics seems to be pulsars," he says, noting that his answer isn't so simple. While pulsars — rapidly rotating neutron stars — might be able to accelerate particles, there is no easy way for the particles to escape. "How the heck do we get the particles out so they can start floating around?" he says.

Bit by bit, clues for solving this and the larger cosmic ray mysteries are coming in from detectives working in the coldest places on Earth, in desert plains and from data collected by orbiting spacecraft. But questions still swirl around both classes of cosmic rays. Not that scientists are complaining. "It's a plague that we enjoy having," Gorham says.

The ultimate answers may come from detectors even bigger than today's bulked-up cosmic ray hunters. "Auger is 10 times too small," Watson says of the Argentinean array. "You get toward the end of your career, and you realize that you made it too small. It's one of the most frustrating things."

A commitment to building a bigger detector, sending more gadgets into space, perhaps even one day assembling an observatory on the farside of the moon — these are the strategies that scientists hope will push forward the understanding of these most stubborn of astrophysical phenomena.

And for what reason? "Until we find the source, we don't know what we will learn from it," Halzen says. "Most likely, we learn astrophysics that's so extreme we have not seen it anywhere."

Gorham expresses the motivation behind the ongoing search in another way. "If you knew that somebody on your block had the biggest, most powerful stereo in the neighborhood, and you could hear it every once in a while, pounding away, wouldn't you want to know more about what the heck it was and who lived there?" he says. "Maybe it's some famous rock band." ■

Explore more

- For more on the Auger observatory: www.auger.org
- Nobel Prize page for Victor Hess: http://bit.ly/Hif4la

In the clouds

Cosmic rays might be doing more than providing fodder for curious scientists. A controversial theory around since at least the 1970s suggests that these energetic charged particles from outer space could play a role in changing Earth's climate through cloud formation.

The cosmic rays' effect would fluctuate as the sun moves through its 11-year cycle of magnetic activity. A more magnetically active sun would deflect incoming rays. In principle, cosmic rays interact with vapor particles in the atmosphere to form seeds that can grow into clouds. Fewer rays would mean fewer clouds and higher temperatures.

Now, Jasper Kirkby (shown) of the European physics laboratory CERN in Geneva is using a cloud chamber to determine whether cosmic rays can in fact produce clouds. "It's quite remarkable to think that events going on millions of light-years away could affect our everyday life, our weather," Kirkby says. In his cloud chamber, Kirkby carefully assembles an atmosphere from scratch, introducing vapors that live in Earth's upper atmosphere. After that, Kirkby aims a particle beam of synthetic cosmic rays into the cloud chamber.

MAXIMILIEN BRICE/CERN

Last year, Kirkby and his team reported in *Nature* that synthetic cosmic rays interacting with sulfuric acid aerosols did lead to the formation of small particles in the atmosphere, though they weren't big enough to seed clouds. The researchers are currently testing the contributions of additional vapors. Initial results have inevitably added fuel to an already heated debate. "We have no prejudice," Kirkby says. "We may find at the end that there's nothing climatically significant." — *Nadia Drake*

Mosquitoes REMADE

Scientists reinvent agents of illness to become allies in fight against disease

By Susan Milius

It's a bit unnerving that Scott O'Neill bursts out laughing at the basic premise behind the story you are beginning to read.

He is dean of the science faculty at Monash University in Australia and lead scientist for research on developing bacteria-infected mosquitoes as a public health tool. The premise put forth was that scientists suddenly have made visible progress on a daydream that has been around for at least 50 years. Apparently, though, O'Neill thinks the "suddenly" is funny.

To the general insect-bitten public, a mosquito that fights disease instead of spreading it is the flying car of public health. Twentieth century science was supposed to create all kinds of marvels. But it's a new millennium, cars are still grounded and mosquitoes are still dangerous. They pass along maladies, including malaria, yellow fever and dengue, that together kill hundreds of thousands of people each year, and often stump vaccine makers and drug developers. Small, frail-bodied creatures, easily knocked out of the air with the slap of a rolled-up science magazine, rank among the deadliest animals on Earth.

But now, retrofitted *Aedes aegypti* mosquitoes that might interrupt disease transmission are flying around freely in a wave of real-life tests.

In 2010, the British company Oxitec announced results of the first known tests of free-flying transgenic mosquitoes, a milestone for both friends and foes of genetic engineering. The mosquitoes — 3 million of them — were engineered to start a population crash after infiltrating wild, potentially disease-spreading *A. aegypti* swarms in a village on the Caribbean island of Grand Cayman. And last year, O'Neill and his colleagues reported results of field trials using a completely different strategy. His team's mosquitoes, several hundred thousand of which were released into towns in Queensland, are not transgenic and are not intended to reduce the overall number of mosquitoes. Instead, regular mosquitoes infected with a bacterial disease that makes them far less likely to spread dengue were supposed to replace the usual swarms. Both research groups are continuing their tests this year, and both are discussing expansions (Vietnam for O'Neill's group and Key West, among other places, for Oxitec).

Yes, these are just tests. The basic strategies have their pluses and minuses. And who knows what chances the saboteur mosquitoes have for ultimate success in fighting disease. But the big news is that the insects are actually out of the lab. The last widely reported releases for mosquito control that made it this far ended in 1981. Public health at least has a flying tricycle, soaring in from out of the blue.

O'Neill doesn't see it that way. With a note of cheerful teasing, he says: "Well, I'd say you took your eyes off the ball."

From inside the mosquito effort, he wouldn't describe the outdoor tests as a pop-up surprise, but more as a matter of researchers continuing to attack the problems at hand. Presented with the same premise of sudden visible progress, Oxitec's chief scientific officer, Luke Alphey, merely says that progress toward a better mosquito "took longer than we expected."

Listening to their accounts of what happened behind the scenes, however, makes the progress sound more, rather than less, surprising. It's easy to understand why outsiders took their eyes off the ball. The effort stalled for years at a time, careened sideways and rolled backward as much as forward.

200+ million
Worldwide cases of malaria per year

50–100 million
Worldwide cases of dengue per year

200 thousand
Worldwide cases of yellow fever per year

Death by mozzie

The perils of mosquitoes can set anyone dreaming. Female mosquitoes have evolved marvels of stealth hypodermics, drawing out blood in search of proper prenatal nutrition. So living amid the surreptitious blood-seeking moms is the disease-risk equivalent of sharing needles with anybody nearby who has some uncovered skin and a pulse.

These flying syringes spread quite a lot of unpleasantness: Beyond malaria, dengue and yellow fever, there's also West Nile virus; lymphatic filariasis, with its elephant-scale swellings; St. Louis encephalitis; La Crosse encephalitis; eastern and western equine encephalitis; and plenty more.

Malaria is easily one of the biggest killers. Several mosquito species inject malaria parasites into the human bloodstream in the course of sucking up a meal. The World Health Organization estimates that 655,000 people died from the disease in 2010, many were children in Africa, and many more get very sick.

Almost half of humankind now lives in areas at risk for malaria, but decades of medical research have yet to yield an effective vaccine. Malaria parasites have evolved resistance to older drugs designed to treat or prevent the disease and are showing signs of getting around the current drug generation. The mosquitoes carrying the parasite have also evolved resistance to several waves of pesticides deployed against them. Particularly worrying are signs of emerging resistance to the pyrethroids. Bed nets treated with these insecticides have become the mainstay of campaigns proven to reduce malaria risk by keeping night-flying species away from still flesh.

To fight malaria and the pathogens that mosquitoes spread, "you have to be smart — it's a very smart system," says Raymond St. Leger of the University of

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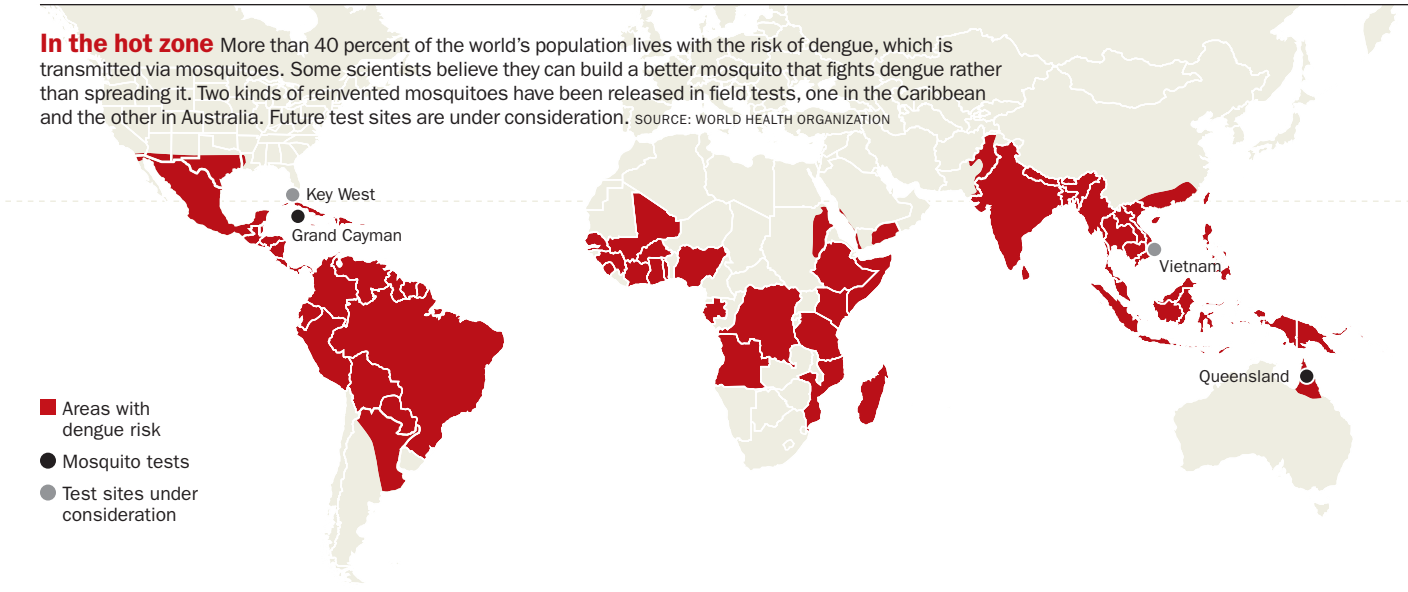


In the hot zone More than 40 percent of the world's population lives with the risk of dengue, which is transmitted via mosquitoes. Some scientists believe they can build a better mosquito that fights dengue rather than spreading it. Two kinds of reinvented mosquitoes have been released in field tests, one in the Caribbean and the other in Australia. Future test sites are under consideration. SOURCE: WORLD HEALTH ORGANIZATION

Maryland in College Park. Research has therefore expanded out of the box, out of mosquito-stopping bed nets and definitely out of the insecticide canister.

St. Leger and his colleagues, for instance, are genetically engineering a fungus that targets the young malaria pathogen growing inside the mosquito. When enhanced with genes for producing the toxin scorpine, as well as some other parasite-unfriendly substances, the *Metarhizium anisopliae* fungus can cut a mosquito's parasite load by 98 percent, the team reported last year in *Science*.

The researchers have applied for regulatory permission to test how well mosquitoes pick up the souped-up fungi in a giant enclosure in a part of Burkina Faso that St. Leger describes as squarely in Malaria Central. During mosquito season, residents there can expect some 200 mosquito bites a day, many from *Anopheles gambiae*, a major malaria spreader.

St. Leger's approach lets each and every mosquito pick up the disease-fighting fungus from the environment, like a living insecticide. But a burst of new field trials for fighting another disease rely on mosquito inheritance.

Within the sweep of ideas for defending humankind, directly monkey-wrenching the mosquito so it no longer spreads a parasite or virus is "conceptually beautiful," St. Leger says. But for malaria, it's not exactly easy. Civilians in the war against insectborne diseases may refer to "the mosquito," but entomologists have named roughly 3,000 species. Twenty are important malaria spreaders, he says, and more species can carry the disease. A safer mosquito for malaria zones would need to be a swarm of simultaneously modified species.

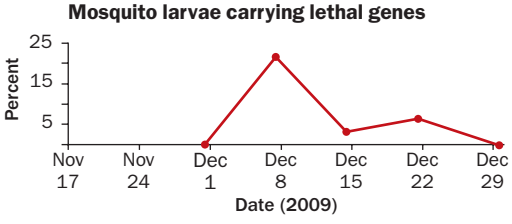
Though not as famous as malaria outside the tropics, dengue makes a worthy target. It's the forgotten pandemic, says Scott Ritchie, a medical entomologist at the James Cook University in Cairns, Australia, who works with O'Neill. A potentially lethal viral disease, dengue has been spreading rapidly since the 1970s. Now more than 40 percent of the world's population lives at risk. A first round of the disease brings such miseries as a fever of around 104° Fahrenheit (40° Celsius), a sharp headache behind the eyes and intense skeletal pain, inspiring the name "breakbone fever."

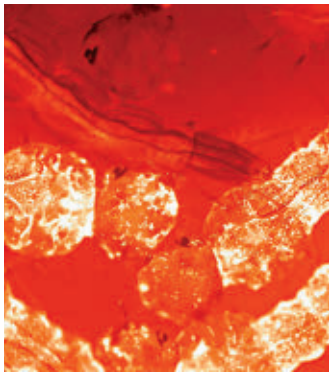
"Most people remember it as one of the most miserable weeks of their lives," says Cameron Simmons. Although he is a University of Oxford professor of medicine, Simmons lives in Ho Chi Minh City, Vietnam, in a zone at high risk for dengue. And yes, he's had the disease once, so he is speaking from experience.

What he explains, with remarkable matter-of-factness, is that enduring one round gives long-lasting immunity to that particular group of dengue viruses — but not to the three others. The first bout actually increases the risk that infection with a second kind will turn into what's appropriately called severe dengue. Symptoms include bleeding gums, plasma leaking out of blood vessels, difficulty breathing and vomiting up blood. In 2010, 49,000 people in the Americas alone developed severe dengue.

No drugs or vaccines for dengue have made it to the market yet, although trials

Genetic takedown A field test in 2009 showed that released mosquitoes carrying lethal genes would mate and pass on the genes to offspring. Following a November release, researchers collected eggs to see how many hatched into larvae with the genes (below), marked by fluorescence (right). SOURCE: A. HARRIS *ET AL*/*NATURE BIOTECH*. 2011





FROM TOP: GEOATLAS/GRAPHI-OGRE; ADAPTED BY STEPHEN EGTS; COURTESY OF OXITEC

are under way. Even if the leading vaccine candidate aces its tests, it requires three doses spaced six months apart, Simmons points out. For many high-risk dengue zones, that's not an easy vaccine to spread around.

But, when it comes to a mosquito-based solution, targeting dengue has an advantage over malaria. One species, *A. aegypti*, is mostly responsible for spreading dengue, making the problem more manageable than malaria for the Oxitec and Australian teams. St. Leger, with ironic undertones, says, "Dengue is the simple one."

Sterile strategy

Even with the aid of the 20th century's scientific advances, not much has been simple about controlling mosquitoes. But in the 1990s, Oxitec's Luke Alphey took a new look at some early failures. One was the sterilization technique.

In the 1950s, U.S. Department of Agriculture researchers developed a way to irradiate the pupal resting stage of screwworms just enough to let them develop into adults that can fly around and mate but can't sire viable young. Releasing clouds of these sterile male adults lured natural females into dead-end relations. By 1966, waves of releases had eliminated the screwworm from the southern United States. Rare among insects as a dedicated eater of the living flesh of warm-blooded mammals, its disappearance was not mourned.

Trying to radiate mosquitoes by just the right amount proved difficult. In spite of the death they deal to humankind, mosquitoes are fragile. Among other problems, too much radiation kept males from competing well for wild females.

Alphey says he heard about the screwworm eradication in the 1990s from a colleague at the University of Oxford. It was hardly a secret among pest specialists, but, he deadpans, "I'm a geneticist."

Even though he came to the concept late, his years of research on fruit fly genetics gave him an unusual take on irradiating mosquitoes. Why bother, he wondered. Considering what geneticists can do as a matter of routine, it might be possible to sterilize male mosquitoes genetically. Alphey says his inspiration was "an idea at the right time."

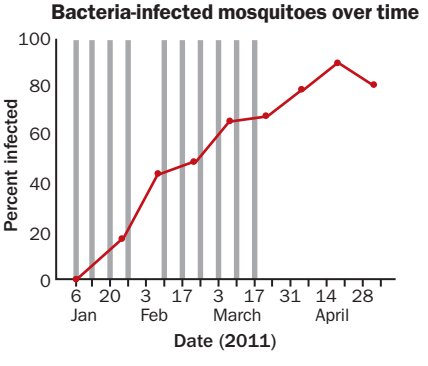
In 1982 geneticists had reported how to insert new genes into the natural complement of DNA in the *Drosophila melanogaster* fruit fly. Hopes rose among entomologists that some kind of genetic redesign of the mosquito would render disease-carrying killers harmless nourishment for birds and bats. This feat proved much harder than expected. The bit of DNA used to insinuate a gene into the fruit fly refused to cooperate in many other insects, mosquitoes included. "A lot of time was wasted and postdocs burned up — though not by me," Alphey says.

Fortunately, he had his inspiration for genetic tinkering after this long, dark period. Sixteen years after the announcement of the genetically engineered fruit fly, researchers reported coaxing a gene into a mosquito's DNA. Thus began an ongoing effort to change insect biology to render a mosquito less likely to pick up, harbor or transmit a pathogen.

When Alphey learned about the screwworms, he realized he just needed to make the mosquito sterile. That's not a small "just," but he and his colleagues did it by refining a genetic system they call RIDL. Pronounced "riddle," it stands for Release of Insects carrying a Dominant Lethal genetic system. The fatal genes can be rendered harmless in the lab. But outdoors, RIDL males pass along the genetic booby trap to their offspring, so the youngsters die. In 2002, Oxitec was formed to commercialize the technique.

A small test on Grand Cayman in 2009 confirmed that RIDL lab mosquitoes could survive the shock of the wild. "They hadn't seen a predator in 100 generations," Alphey says. "They hadn't seen rain. But they did OK." And a bigger test of free-flying mosquitoes on the island in 2010 demonstrated that they could fool the local females into mating, thus reducing the population by 80 percent.

Microbe pump-up Researchers are testing a mosquito intended to fight dengue by passing along the disruptive *Wolbachia* bacteria to other mosquitoes. The bacteria successfully spread through a population after mosquito releases (bars) in a town in Australia last year. SOURCE: A.A. HOFFMANN *ET AL*/*NATURE* 2011



Scott O'Neill and his Australian team have raised hundreds of thousands of bacteria-infected mosquitoes. The mosquitoes may one day help fight dengue.

COLYN HUBER/ELIMINATE DENGUE PROGRAM

Bacterial intervention

O'Neill's reinvention of the mosquito takes a very different approach. He doesn't want to wipe out a population. He wants *A. aegypti* still flying around — just not spreading dengue.

He started thinking about disease-fighting mosquitoes during the 1980s, when he was in grad school working on remarkable bacteria in the group *Wolbachia*. Various species in this group naturally infect thousands upon thousands of different insects, perhaps three out of four of all kinds in existence. The bacteria often don't kill their insect host, instead transforming it into a lean, mean, baby-bacteria machine. *Wolbachia* infections spread from mother to offspring. Fathers aren't much use as far as the bacteria are concerned, and *Wolbachia* do have tricks for this, such

as turning genetic males into bacteria-spreading females.

The trick that intrigued O'Neill gives infected females an unfair advantage in the mating scene. Bacteria-carrying females produce viable bacteria-carrying youngsters regardless of whether their dad is infected or not. But an uninfected female won't have viable young if she mates with an infected male. So that male, who wouldn't have passed on his infection directly, still does his bacteria-spreading part by taking a healthy female out of the gene pool.

Wolbachia infections sweep through populations at great speeds, and O'Neill began to wonder if this spreading power could be harnessed to drive some yet-to-be-invented disease-fighting trait through a mosquito population. Instead of a eureka moment, he says, "It crept up on me."

Even if safer mosquitoes can be made, a further challenge is making them numerous. The best, safest, most cleverly engineered mosquito does nothing for public health if wild females don't mate with it or if helpful traits get swamped by wild genes. *Wolbachia* might give some disease-fighter a chance to spread its genes far and wide.

O'Neill's big problem was that no natural *Wolbachia* infected *A. aegypti*. He had to find a way to coax a mosquito to catch the insect disease. "Everybody said it was a great idea," he says. "But we couldn't get it to work."

For years he and his colleagues tried to persuade *Wolbachia* from fruit flies to colonize the mosquito. "It was a big jump," he says. "They would get it, and then it would fall out of the population."

He did succeed in coaxing the bacteria to grow in lab dishes of cells from mosquitoes, and, although he moved on to other projects and also moved back to his native Australia, he kept those cultures going. When the Bill & Melinda Gates Foundation announced their Grand Challenges funds for edgy science on intractable problems in 2003, O'Neill applied. The foundation also thought the approach was a "great idea," he says.

Receiving Gates money brought on a chest-tightening moment for O'Neill. He was delighted to have another chance to try his *Wolbachia* scheme, but its track record was terrible.

This time, he got his bacteria to infect the mosquitoes and travel from mother to offspring for generations. What made the difference, he speculates, is the four years of growing in mosquito cells.

But the project strategy took a sharp left turn when research showed that *Wolbachia* could do more than accelerate the spread of some other disease-stopping trait. A strain also shortened the life of its mosquito hosts. Because the dengue pathogen takes time to multiply and render mosquito spit truly dangerous, any shortening of life reduces mosquitoes' abilities to pass along the infection to humans. This *Wolbachia* strain alone, then, might have a big effect on disease transmission.

Then came another scientific twist from research on fruit flies. A version of the same *Wolbachia* strain interfered with pathogens multiplying inside the flies. Research confirmed a similar interference in mosquitoes with dengue. So, in the best news for the project yet, a *Wolbachia* strain not only shortens the life of a mosquito, but also reduces the amount of virus it develops. *Wolbachia* infection may have two ways to make mosquitoes less likely to transmit dengue — at least that's how it plays out in the lab. But the idea needed testing in the field.

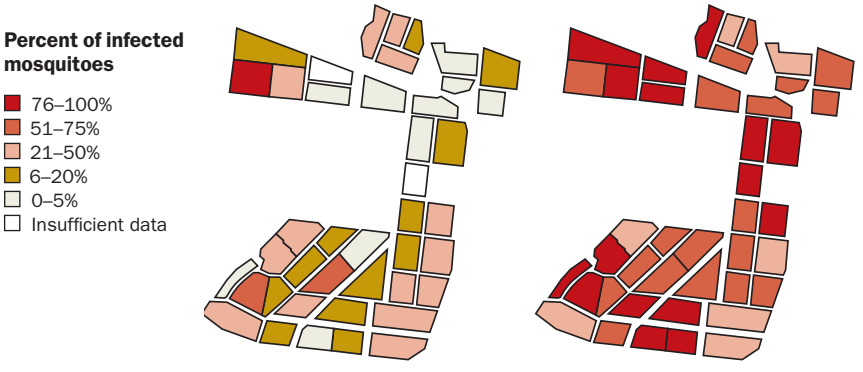
To make sure captive-reared *Wolbachia* carriers have what it takes to go wild, hundreds of thousands of test mosquitoes grow up biting real people. "We need very, very high-quality mosquitoes," says geneticist Ary Hoffmann, a collaborator at the University of Melbourne.

Releases in Queensland last year showed that *Wolbachia* could spread through a wild population. And O'Neill, Hoffmann and their colleagues spent the early months of this year testing the spreading power of a more effective disease-fighting *Wolbachia*.

As exciting as the Australian and the Oxitec tests are for anyone dreaming of a better mosquito, the efforts are far from any real-world disease control. So far no tests have looked at whether the efforts actually whittle away at dengue.

Neither O'Neill nor Alphey sounds particularly dismayed about how far their projects still have to go. Maybe — at the risk of speculating too much — their perseverance comes along with the special point of view it takes to get even this far. Steps forward can't seem too astonishing or too sudden. The way onward can't seem overly twisted or steep. Saying somebody has to be a special kind of crazy sounds too rude, but to keep fiddling with tricycles does take openness to the possibility that, despite half a century on the ground, cars really could fly. ■

Block breakdown After releasing bacteria-infected mosquitoes into an Australian town last year, researchers tested sections of the town to see how prevalent the bacteria became. Most sections (shown below) saw a big jump in the percent of infected mosquitoes during a roughly two-month period. SOURCE: A.A. HOFFMANN *ET AL*/*NATURE* 2011



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- World Health Organization on dengue: www.who.int/topics/dengue/en/

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Dialogues on 2012: Why the World Will Not End

Christopher Keating

If you're waiting for an apocalypse on December 21, 2012, you're in for a big disappointment, says Keating. The physicist's book aims to reassure people that the world is not going to end, educate them about why and entertain along the way. He succeeds on all fronts.

Keating pays homage to Galileo's 1630s best seller *Discourse on Two New Sciences* with another three-way conversation between friends. Galileo's book was a discussion about science between two philosophers and a layman that took place over about four days. Keating updates the format to an e-mail exchange among three friends: Tom, a scientist exasperated with doomsday prophesying; Fred, a regular guy who buys into the hype; and Aileen, a woman with a background in social science who is trying to keep an open mind. Keating's characters seem so real that it may feel as if you've stumbled upon someone's actual correspondence, but this is a made-up conversation that takes place over the course of the year. Spoiler alert: The last entry is in mid-December.

The friends tackle the supposed Mayan prediction of global disaster and theories about how the end could come, including a flood, supervolcano or being fried by the sun on an Earth with a weakened magnetic field. Along the way

Keating furnishes history about how the date of destruction was chosen and who has furthered the idea. Readers get an introduction to the scientific method and learn to identify pseudoscience, but the lesson is more like eavesdropping on a stimulating discussion than listening to a lecture.

It's not giving anything away to say that the friends resolve to meet at a favorite restaurant in New York City on December 22. Don't worry. If the world ends, Tom will buy dinner for his buddies. — *Tina Hesman Saey*

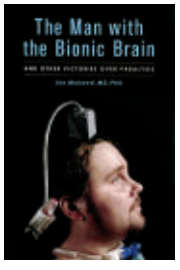
Dog Ear Publishing, 2011, 355 p., $18.50

The Man with the Bionic Brain

Jon Mukand

In 2001, in the melee of a Fourth of July beach brawl, someone plunged a hunting knife deep into Matt Nagle's neck as the former football player tried to pull people off his friends. Nagle survived, but the knife severed his spinal cord, paralyzing him below the neck.

Physician and researcher Mukand recounts Nagle's journey to becoming



the first person with an implanted brain device, called BrainGate, that allowed him to control a computer cursor, open e-mails and change the TV channel with his thoughts alone.

The book reads like a doctor's tell-all, in which Mukand confesses his deepest worries and fiercest hopes for Nagle and other paralyzed people. The climax comes after Nagle's surgery, when researchers realize that the electrical signals coming from the brain are gibberish. Weeks later, tweaks and a tightened connection finally do the trick, and neural data pour in. "We could hear his brain," Mukand writes.

Through interviews with Nagle and his family and friends, Mukand captures Nagle's complexity — undeniably charismatic, prone to deep depressions, intensely driven, sharp-tempered and above all, faithful that he would recover.

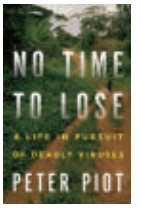
He didn't. Nagle died in 2007 from what doctors think were complications of an infection. But research continues. Next-generation BrainGate systems seem promising (*SN: 6/16/12, p. 5*), as do other approaches (*SN: 6/30/12, p. 5*). Data from Nagle were tremendously valuable, Mukand writes. And in his last heroic move, Nagle donated his organs to those in need. — *Laura Sanders*

Chicago Review, 2012, 353 p., $26.95

Secret Lives of Ants

Jae Choe

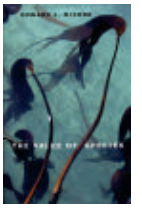
Enter the miniature world of ants and learn about their societies, from massacres and power plays to self-sacrifice and factory-like enterprises. *Johns Hopkins Univ., 2012, 156 p., $34.95*



No Time to Lose

Peter Piot

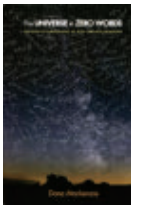
A microbiologist tells tales of his adventures in Africa battling infectious diseases from Ebola to AIDS. *W.W. Norton & Co., 2012, 304 p., $28.95*



The Value of Species

Edward L. McCord

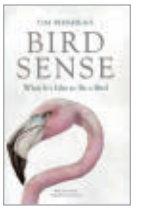
A naturalist explores reasons to care about preserving species that don't have practical use to people. *Yale Univ., 2012, 184 p., $25*



The Universe in Zero Words

Dana Mackenzie

This history of mathematics revels in the logical beauty of 24 equations that describe the workings of the universe. *Princeton Univ., 2012, 224 p., $27.95*



Bird Sense

Tim Birkhead

A look at what it's like to be a bird explores avian senses and traces how scientists have studied birds through time. *Walker & Co., 2012, 288 p., $25*

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Redesigning flu mortality

In "Designer flu" (*SN: 6/2/12, p. 20*), researcher Michael Osterholm is quoted as saying that even if the actual kill rate of H5N1 is 20 times lower than the current estimate of 59 percent, H5N1 would still have a mortality rate that "far exceeds" that of the 1918 flu. Wikipedia gives a 1918 flu infection rate estimate of 27 percent, with 3 percent of the world's population dying. Using the 3 percent mortality rate, "20 times lower" would require an assumption that the H5N1 infection rate is 100 percent, so the phrase "far exceeds" would require an infection rate of over 100 percent [for H5N1 to kill a larger percent of the world population], obviously impossible. Not that any of these numbers aren't terrible and scary, but shouldn't we avoid exaggerating the risk?
Linda Riley, Shawnee, Kan.

Mortality rates can be confusing. Osterholm was quoting the World Health Organization estimate that 59 percent of those infected with H5N1 die, which is different from the percent of the world population that dies. What's more, estimates of the number of people killed by the 1918 flu vary widely, from 20 million to 100 million. If the estimates at the low end of that range are correct, then about 1 percent of the world's population perished in the pandemic. If the H5N1 rate were a twentieth of the 59 percent estimate, or 2.95 percent, then H5N1 infection rates would need to be only about 50 percent to outstrip the total killed by the 1918 virus. Michael Osterholm's larger point is that even if H5N1 is a far less deadly virus than WHO numbers suggest it is, if it were to become a pandemic it could kill millions more people than the 1918 Spanish flu did. — Tina Hesman Saey

Quick-change eggs

Regarding Erin Wayman's article "Egg wars" (*SN: 6/2/12, p. 12*), what is the explanation for egg color changing in two species of birds over a mere 40 years? My understanding is that change, or evolution, occurs as a result of random mutations in DNA over very long periods of time. The environment then determines the fitness of the mutation. So let's say that you are getting random mutations frequently: What are the odds that the right mutation in egg color will happen within 40 years? Wouldn't frequent mutations on this scale threaten the eggs with bad mutations?
Audrey Irvine, via e-mail

New mutations may not be necessary to explain the rapid changes in egg colors. Prinia eggs come in a variety of colors, such as white, blue, red and green. When a particular egg color is common in the prinias — say, blue — selection will favor cuckoo finches that lay blue eggs. But as blue mimic eggs become more common, selection may then favor prinia that lay eggs of rare colors, such as red. So the most common egg colors may change frequently, but the species isn't necessarily evolving new egg colors—just switching back and forth among the colors they already produce. — Erin Wayman

Death of locked-up neutrons

Rebecca Cheung's article "Secret of a lifetime" (*SN: 5/19/12, p. 20*) notes that "The Particle Data Group ... currently puts the neutron lifetime at 881.5 seconds." I assume this refers to free neutrons? Or do the neutrons in, say, an atom of iron disintegrate and get reconstituted about every 15 minutes? When I studied chemistry and physics long, long ago, nobody knew anything about that.
Ernest Nussbaum, Bethesda, Md.

The measurements mentioned in the article all refer to the lifetime of free neutrons. Generally, neutrons bound within atomic nuclei are stable. In some cases, these neutrons can live for billions of years, says Geoffrey Greene, a physicist at the University of Tennessee, Knoxville and Oak Ridge National Laboratory. Still, neutrons stored away in nuclei can die. For example, when carbon-14 radioactively decays into nitrogen-14, a neutron in the carbon atom becomes a proton, just like what happens at the end of a free neutron's life. — Rebecca Cheung

Déjà vu on different scales

After seeing the glass squid on the cover of the June 16 *Science News*, I flipped open the magazine. My eyes first landed on the photo in the lower left of Page 16. It appeared to be a photomicrograph of some reddish bit of pond scum in a lovely, thin blue membrane, surrounded by a few dozen much smaller microorganisms. "What is that?" I thought. I was very surprised when I read what it was: Tycho's supernova remnant. It is not excessively important that two things which differ in size by 20 orders of magnitude or more can look so similar. Nevertheless, that something viewed through a high-powered telescope looks so similar to something viewed through a low-powered microscope is a suggestion that some very different organizing forces in nature can result in similar-looking structures. Speaking unscientifically, this feels to me like some sort of fractal "déjà vu all over again."
Jeff Barry, Acton, Mass.

Naming trends

Have microbiologists adopted a new naming code that I am not aware of? The publication of the name *Candidatus Gloeomargarita lithophora* in "Aquatic microbes have bony insides" (*SN: 6/2/12, p. 14*) makes no sense at all.
Norman Scott, Creston, Calif.

Yes, microbiologists now use the name Candidatus *(for "candidate") as a prefix for a species before an official name is conferred. The proposed name* Gloeomargarita lithophora *is derived from* margarita *(Latin for "pearl"),* litho *(Latin for "stone") and* phora *("bearer"). — Rachel Ehrenberg*

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The Science Life

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Monks in India learn about physics, perception and other science topics through the Science for Monks program.

Bringing science to Buddhist monks

As a senior staff scientist at the Exploratorium museum in San Francisco, Paul Doherty has taught kids, high school teachers and the audience of the *Late Show with David Letterman* about physics. But when he visited India last year, he had a different set of students: monks and nuns.

Doherty is part of Science for Monks, a program run by the Sager Family Foundation in Boston and the Library of Tibetan Works & Archives in Dharamsala, India. The two groups partnered after the Dalai Lama asked them to bring science education to exiled Tibetan monastic communities. In December, Doherty taught 18 monks and nuns who have completed their Tibetan monastic education. And this May, nine monks and nuns visited the Exploratorium to put on an exhibit called "The World of Your Senses" that delves into views of sensory perception.

"They are the best learners on Earth," says Doherty, who has a Ph.D. in physics from MIT. "I was in awe."

Doherty has a long-standing interest in education. In the 1970s, he started studying how computers could help students learn physics. After visiting the Exploratorium in 1982, he was so impressed by the science exhibits that he asked physicist Frank Oppenheimer, the museum's founder, to hire him.

For Science for Monks, Doherty traveled to the College for Higher Tibetan Studies near Dharamsala, where he taught physics concepts such as relativity and the nature of particles. His lessons on perception often overlapped with Buddhist ideas and prompted challenging questions, such as whether the ink inside a red pen — where no one can see it — is still red.

His students also showed a playful side: During an exercise with a "telephone" made of two cups and a string, one monk dropped his iPhone into the cup and sent music to another monk. "When they learned something new, they were not shy about laughing out loud," says Doherty. "For me, that was a joy." — *Roberta Kwok*

Experiments to contemplate

Physicist Paul Doherty uses interactive exercises to teach science to Tibetan monks and nuns.

- **Thermal energy** To learn why thermal energy must be measured with a thermometer, one monk with cold hands and another with warm hands shook hands with an average-temperature monk. When asked if the average person's hand was warm or cold, the two monks gave different answers.
- **Scientific integrity** The students stretched a string outward from their noses (above) and were asked what they saw. Some saw X's, while others saw V's or parallel lines. The lesson: Reporting truthful results is more important than getting the "right" answer.
- **Perception** The students looked at a bright point of light, which seemed to emit rays. But when the light source was blocked, the rays vanished; they are a trick of the eye and brain.

Physicist Paul Doherty teaches Tibetan monks why the sun appears larger at sunset during a 2011 trip to India.

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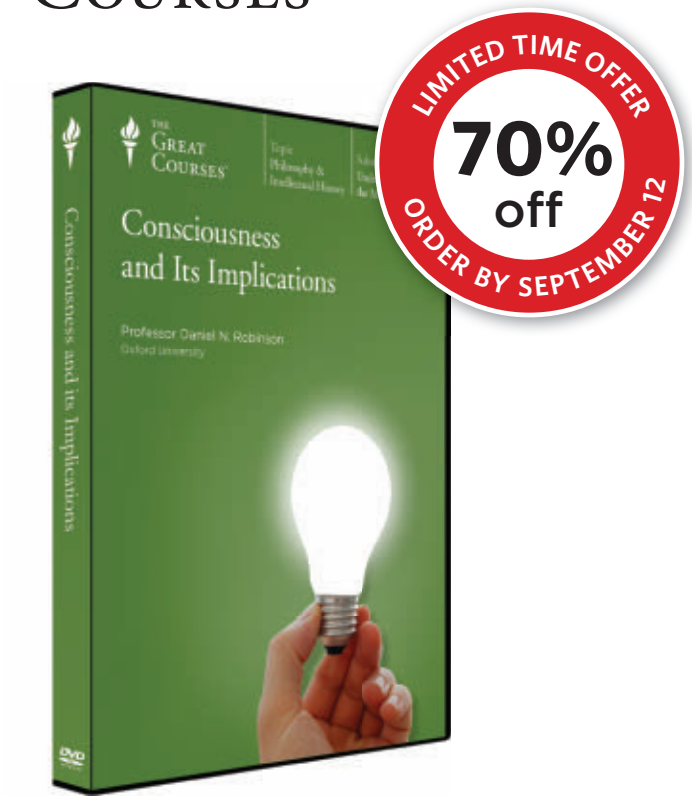

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