Antarctic Ice Imperiled | Hurricane Hunters | Rogue Player in Alzheimer's

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JUNE 2, 2012

If words could kill

Bird flu, biosecurity & scientific censorship

Black Hole Gobbles Red Giant

Painkilling Enzyme Mimics Acupuncture

Crickets Not One-Hit Wonders

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It wasn't more than ten years ago that we met with former U.S. Mint Director Donna Pope. She spoke with pride about what she considered to be her greatest achievement as Director under President Reagan: Creation of the American Eagle silver and gold bullion coin programs, the first of their kind in our nation's history.

The purpose of these coins was to give people the opportunity to own physical silver and gold in a form certified for weight and purity by the U.S. Mint. While the bullion coin program was a signal success, nobody took into account the profound effect it would have on the collector market.

Silver Eagles = Today's Morgan Dollars

In the 1800s and early 1900s, the U.S. Morgan Silver Dollar was struck year upon year at various mints and circulated at face value. Their core value was in their precious metal content. However, in top grades, Morgan Silver Dollars can sell today for tens and even hundreds of thousands of dollars each!

For the same reason, many collectors today see the Silver Eagle series as a literal "ground floor" opportunity to acquire the top-grade coins as they are released. They started submitting Silver Eagles to the leading independent coin grading services, such as Numismatic Guaranty Corporation (NGC), praying that the coins would come back with the highest possible grade: MS70 (all Uncirculated coins are graded on a point system from a low of 60 to a high of 70, with 70 representing flawless perfection). Of all the Silver Eagles produced by the U.S. Mint in 2011, less than one out of every 788 earned the NGC MS70 grade!

MS70 = $$$$$!

In the rarified atmosphere of MS70, Silver Eagles have soared to market prices that I can only characterize as surreal. Consider this: MS70 Silver Eagles have been selling for truly stratospheric prices. Here are just a few eye-popping examples:

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Actual size is 40.6 mm

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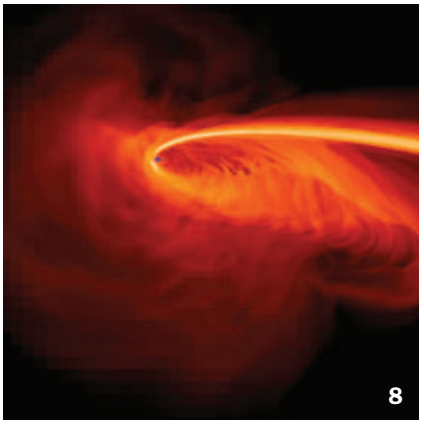

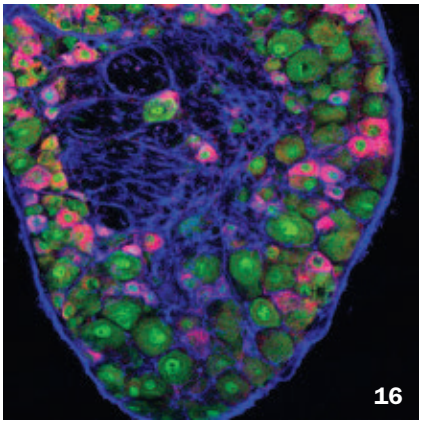

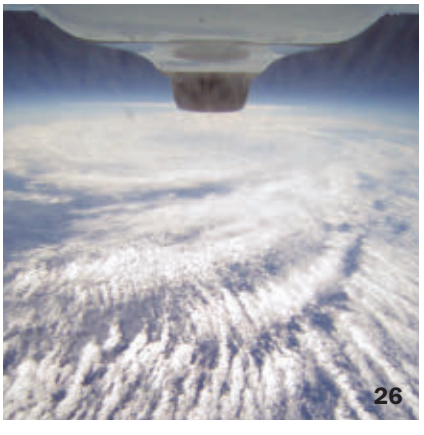

ScienceNews

In The News

Features

Departments

COVER A U.S. biosecurity advisory board initially recommended against publication of two bird flu papers (text of one in illustration). The board later reversed its decision. *Dan Page*

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FROM THE EDITOR

It's not easy, or wise, to suppress nature's secrets

In recent weeks, the world has learned details about how scientists have modified the notorious bird flu virus, H5N1, into forms that can be transmitted via the air rather than only by direct contact.

Some people, even some scientists, are aghast. Such knowledge could be exploited by terrorists to engineer a flu pandemic killing millions, or so the scare scenario goes.

Flu pandemics of any sort are serious, for sure. But the new H5N1 variants are not cause for immediate panic, as Tina Hesman Saey reports (Page 20). Experiments with ferrets show that the modified viruses can be transmitted by sneezes, but not very efficiently. The mutant H5N1 forms don't spread as rapidly as other pandemic-causing flu viruses. And though injecting virus into the lungs will kill a ferret, ferrets infected less directly survived with just a typical case of ferret flu.

Such considerations have now persuaded advisory groups to recommend publishing the results of this research. Such knowledge is valuable to public health workers fighting the flu and to other researchers seeking better flu countermeasures. And keeping these results secret would have stifled the very science needed to better cope with future terrorist attacks.

For that matter, attempting to keep such findings secret would have been pointless, anyway. Once you know something is possible, the science behind it is vulnerable to discovery by anybody. During World War II, Hitler's scientists couldn't figure out how to make an atomic bomb. But when the Germans (by then confined in England) learned about the U.S. bomb, it took them only days to deduce the physics needed to build it.

Shortly after the war, American physicists at the University of Pennsylvania — none involved in the Manhattan Project — prepared a book that described ways to make atomic bombs just the ways the Manhattan scientists had. Nobody had leaked any information — the physicists just figured it out from public documents and scientific papers, as historian Alex Wellerstein recounts in the May issue of *Physics Today*.

Of course, there should be allowances for some exceptional circumstances when sensitive science warrants at least temporary secrecy. But for science to succeed, the guiding principle should always be less secrecy rather than more, sharing knowledge rather than suppressing it. After all, unlike ordinary human secrets, nature's secrets cannot be suppressed by fiat. Nature's book is open for anyone to read, for purposes noble or evil. —*Tom Siegfried, Editor in Chief*

JIM WEBB

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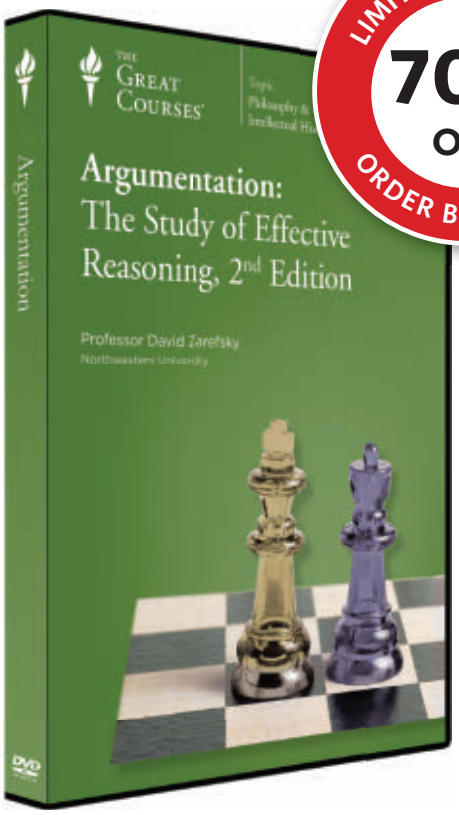

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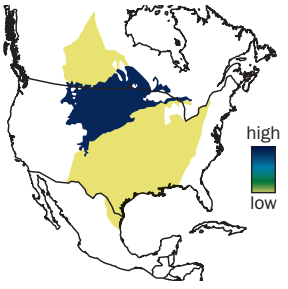

Isoscape ***EYE-soh-skeyp***\ ***n.*** A map of how ratios of isotopes, different forms of a chemical element, vary across space or time. Scientists in Canada used an isoscape to pinpoint where double-crested cormorants (*Phalacrocorax auritus*) picked up mercury. Breeding along Lake Winnipeg in summer, the birds migrate to the Lower Mississippi River Valley in winter, continuously growing new feathers throughout the year. Because hydrogen isotope ratios in precipitation vary by latitude, the team could measure hydrogen in cormorant plumage to estimate where along the migration route a feather developed. Feathers that sprouted in Lake Winnipeg (map for one feather shown) had significantly more mercury than feathers that grew in southern wintering grounds, the team reports in the March 20 *Environmental Science & Technology*. —*Erin Wayman*

Science Past | FROM THE ISSUE OF JUNE 2, 1962

SECOND U.S. ASTRONAUT — Lt. Comdr. M. Scott Carpenter was rocketed into space at 8:45 a.m., EST, on May 24 to become the second U. S. astronaut.... As one of his experiments, Astronaut Carpenter released a small, 30-inch balloon.... The idea of the experiment was to determine whether a man undergoing the rigors of weightlessness could maintain his depth perception. Astronaut Carpenter found that he could.... Another experiment was to eat solid food. Astronaut Carpenter reported he had no difficulty with the bite-sized snacks he carried into orbit in a plastic bag — they went down all right despite his weightless condition. He noted that they were a little crumbly, however.

Science Future

June 9
Researchers hold car washes and bake sales nationwide to raise money and bring attention to budget cuts for planetary science programs. Find out more at bit.ly/SFcarwash

June 26
Learn about the science of local food at the New York Academy of Sciences in New York City. A panel discusses whether eating locally is more nutritious, tastier or better for the environment than nonlocal fare. For more information, go to bit.ly/SFlocalfood

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HUMANS
Learn what confidence means for group decision-making strategies in "Two heads sometimes better than one."

MATTER & ENERGY
A structural change in spider silk (below) makes it strong enough to string a violin. Read "Scientist fiddles with spider silk."

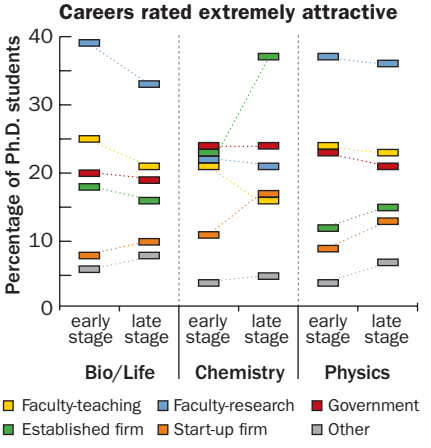
BODY & BRAIN
A physician describes controversial anatomical evidence for a fabled female erogenous zone. See "Pinpointing the G-spot, or not."

New drugs tone down production of an immune protein to fight a skin disease. Read "Psoriasis drugs show promise."

How Bizarre | SOPHISTICATED SAND CASTLES

Researchers at MIT's Computer Science and Artificial Intelligence Laboratory are building sand that can sculpt itself. For now, the "grains" are cubes, each about 10 millimeters wide, that hold a tiny computer capable of sensing an object placed in their midst. This information is passed to other cubes, which produce a duplicate of the object by latching on to each other with magnets. Any cube that's not part of the reproduction switches its magnet off. The team hopes to put this algorithm to use in computers that are even smaller still, creating a true "smart sand." —*Allison Bohac*

Science Stats | SCIENCE GRADS FOR HIRE



A survey of graduate students pursuing a Ph.D. in science finds that career paths can veer during grad school. Despite encouragement from advisers to go into academia, interest in traditional research and teaching careers wanes before graduation, while the draw of working at a start-up firm ramps up.

SOURCE: H. SAUERMANN AND M. ROACH/*PLOS ONE* 2012

CLOCKWISE FROM TOP LEFT: ADAPTED FROM A. OFUKANY *ET AL/ENVIRON. SCI. TECHNOL.* 2012; S. OSAKI/*PHYS. REV. LETT.* 2012; M. SCOTT BRAUER/MIT

“A molecule like Zoloft should be completely innocuous to a yeast cell, in the way that an antibiotic would be innocuous to a viral infection.” —ETHAN PERLSTEIN, PAGE 14

In the News

STORY ONE

Antarctic ice shelf threatened by warming

Collapse could trigger major melting and sea level rise

By Devin Powell

A massive slab of floating ice that juts from Antarctica’s west coast could be in hot water soon. Warm ocean currents threaten to sneak up from below and torpedo the ice in coming decades, researchers report in the May 10 *Nature*.

The degradation of the historically stable Filchner-Ronne Ice Shelf would upset ice on land, triggering melting of the vast West Antarctic Ice Sheet and accelerating global sea level rise.

“The loss of this ice shelf would be catastrophic,” says Ian Joughin, a glaciologist at the University of Washington in Seattle. “We could be looking at tens of centimeters or even meters of sea level rise.” The Antarctica finding balances more optimistic news of recent research showing that sea level rise due to the melting of glaciers in Greenland may fall short of worst-case scenarios (Page 10).

“We need to start paying attention to this area of the West Antarctic Ice Sheet, which has so far been ignored,” says Laurence Padman, a physical oceanographer with Earth & Space Research in Corvallis, Ore.

Antarctica’s Filchner-Ronne Ice Shelf, located just east of the giant peninsula that extends toward South America, hasn’t caused much worry to date in terms of sea level rise. Anchored to the seafloor, the shelf extends outward over the Weddell Sea and covers an area the size of Sweden. The ice is hundreds of meters thick in places and shows signs of growth in recent years.

RALPH TIMMERMANN/ALFRED WEGENER INSTITUTE

An iceberg floats in Antarctica’s Weddell Sea off the Filchner-Ronne Ice Shelf. The shelf may melt completely by the end of the century, triggering the release of more ice from the continent itself, a new analysis suggests.

But climate change may soon reverse that trend, the new study suggests. Global air temperatures are projected to rise 4 degrees Celsius as the amount of carbon dioxide and other warming gases in the atmosphere increases over the next century. New simulations show the warmer air could thin and break up sea ice floating in the Weddell Sea. Winds in the area would then transfer less energy to the ice and more directly into the ocean, churning up the water.

In the researchers’ projected scenario, changing ocean currents would push in warm waters that now circle Antarctica at a distance. By 2036, deep pulses of warm water could reach up into shallow waters just offshore. And by 2070, the warmer currents would move into the

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water that now fills the space between the ice shelf and the seafloor, raising sea temperatures by 2 degrees in the 2090s.

Heated in this way, the bottom of the shelf would disintegrate dramatically. Melting would jump roughly 20-fold from today's 82 billion metric tons per year to 1.6 trillion metric tons per year by the end of the 21st century — or sooner.

"Having in mind that the presently observed CO_2 emissions are larger than projected ... the event can start even earlier," says Hartmut Hellmer, a physical oceanographer at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany.

Warm water has already eaten away at other ice chunks in West Antarctica. Parts of the gigantic Pine Island Glacier lost four times as much ice in 2006 as in 1995. Air above the ice didn't warm fast enough to explain this acceleration in melting, but in 2009 an autonomous submersible discovered a stream of warm water at the base of the glacier that could have done the job.

West of the Antarctic Peninsula, ocean-driven melting might already be widespread. Satellite observations show that several ice shelves on the Amundsen and Bellingshausen seas thinned between 2003 and 2008. Hot spots with the most melting were near seafloor troughs suitable for channeling warm waters blown in by the wind, researchers report in the April 26 *Nature*.

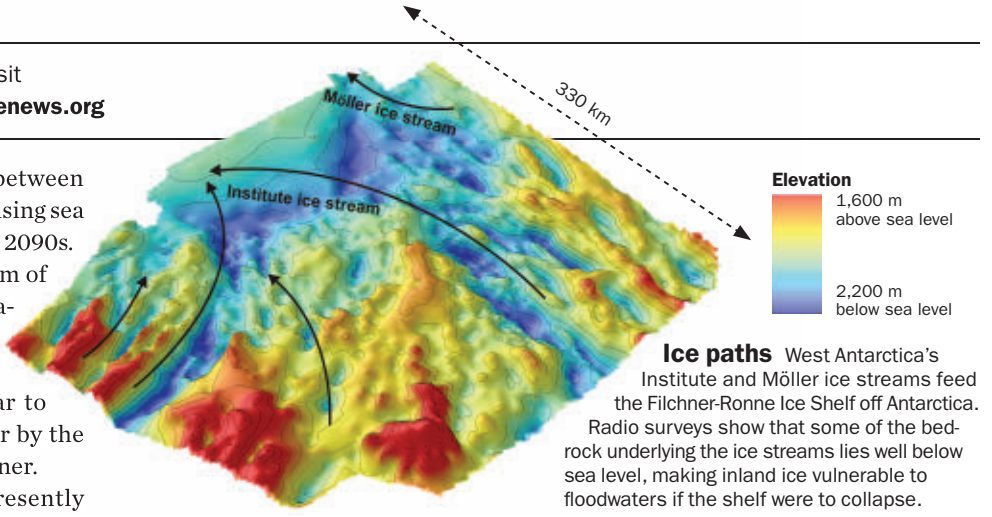
"People once thought that ice shelves change slowly over thousands of years," says Hamish Pritchard, a glaciologist at the British Antarctic Survey in Cambridge. "We're saying there's a sensitivity to the oceans and to the climate that's much greater than we previously realized."

If the Filchner-Ronne shelf started shrinking, things could quickly go from bad to worse. Radio waves beamed from an airplane show that the bedrock on which the ice is anchored slopes downward as it goes inland, scientists report online May 9 in *Nature Geoscience*. Retreating ice would allow water to flood inland, where it would speed erosion of the remaining ice.

"We believe this region is on the threshold of change," says Martin Siegert, a glaciologist at the University of Edinburgh who took part in the bedrock mapping. "It needs some push to get over that [threshold], but we don't believe that push has to be very hard to deliver a lot of deglaciation."

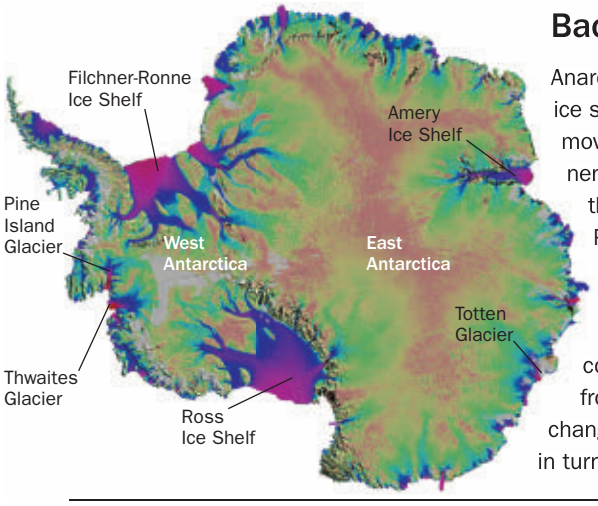
Siegert and colleagues have also discovered that the shelf once shrank dramatically. A layer of sediments beneath ice farther inland must have been deposited during a time when the ice pulled back a couple hundred kilometers, leaving the bedrock exposed to water.

If history repeats itself, the stakes would be high. With the thinning or disappearance of the shelf, ice that now covers West Antarctica would flow faster out toward the sea. An extraordinary amount of water could be dumped into the world's oceans. ■



Ice paths West Antarctica's Institute and Möller ice streams feed the Filchner-Ronne Ice Shelf off Antarctica. Radio surveys show that some of the bedrock underlying the ice streams lies well below sea level, making inland ice vulnerable to floodwaters if the shelf were to collapse.

FROM TOP: NEIL ROSS/UNIV. OF EDINBURGH; ERIC RIGNOT, NASA, JPL-CALTECH, UC IRVINE, E. RIGNOT *ET AL*/*SCIENCE* 2011



Back Story | ICE CONTINENT

Anarctica's vast ice sheets are always on the go. Like giant conveyor belts, the ice sheets can move up to a few kilometers a year (red and purple show faster-moving ice as revealed by satellite measurements), carrying ice from the continent's interior to the oceans. West Antarctica is losing ice, as frozen water on the move melts faster than it can be replaced. That's especially obvious at Pine Island Glacier, which has been wasting away faster than any other glacier on the continent. In contrast, East Antarctica's much larger ice sheet has mostly grown in recent years, fed by accumulating snowfall. But a few fast-moving spots, such as the Totten Glacier, have shrunk. Along the western coast, the giant Filchner-Ronne Ice Shelf helps to hold back the flow of ice from land to sea. If the shelf were to disappear, it would bring widespread changes in the flow of ice in the west as well as the east. Such changes could, in turn, trigger further ice loss in the Antarctic. —*Devin Powell*

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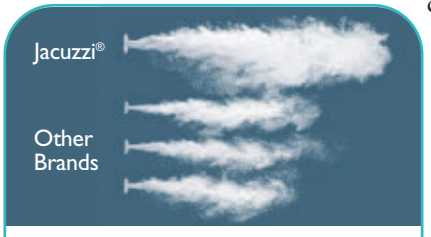

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Earth's beating lasted longer

Bombardment persisted over 2 billion years, analysis finds

By Nadia Drake

It's no secret that the early Earth took a beating from above, but now it seems the planet sustained a longer bombardment than initially thought.

Scientists thought this pummeling — a spike of violent impacts during a period known as the Late Heavy Bombardment — lasted several hundred million years at most. But new simulations suggest that Earth's pummeling persisted for more than 2 billion years, two teams report in the May 3 *Nature*.

"It seems highly likely that these impacts affected the Earth's biosphere in profound ways," says study coauthor William Bottke of the Southwest Research Institute in Boulder, Colo.

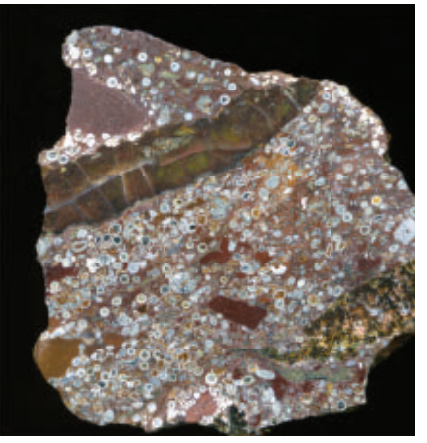
Reconstructions of the early solar system peg the bombardment as beginning about 4.1 billion years ago, triggered by a cataclysmic rearrangement of the outer planets. At that time, changes in Jupiter and Saturn's orbits unleashed a gravitational tidal wave that sent their ice giant brethren farther out while flinging smaller asteroids and comets inward.

Earlier theories suggest the turbulence ended by about 3.7 billion years ago. Yet there's evidence for enormous impacts as recently as 1.8 billion years ago. "Where are these impactors coming from? We must be missing a source," Bottke says.

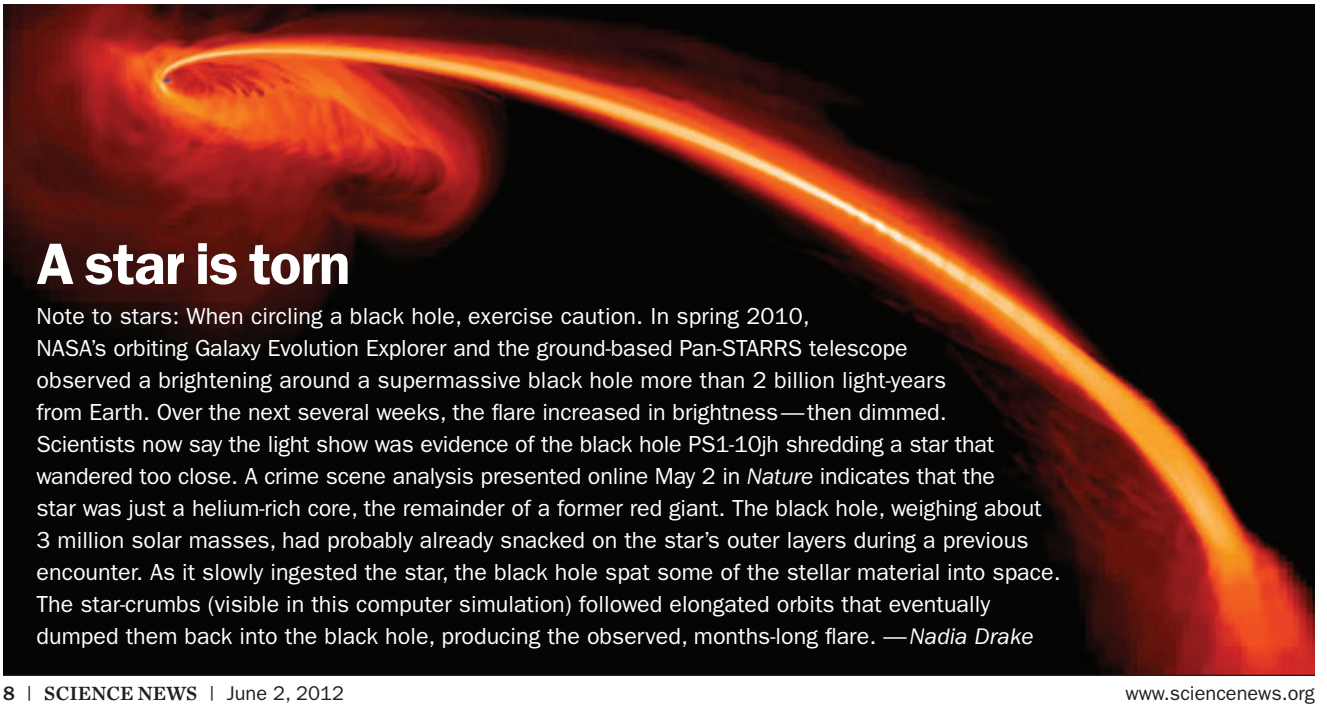
In his new version of events, the asteroid belt's inner boundary was closer to where Mars now resides, rather than out at 2.1 times the Earth-sun distance, where it is now. Simulations show that as the outer solar system spasmed, it perturbed this expanded reservoir, hurling asteroids toward the inner solar system. These asteroids — hotter and more cooked kinds than most of those around today — can explain the fresher impacts.

The longer bombardment matches the story told by tiny "impact spherules" embedded in Earth's sediments. These glassy spheres formed after giant impacts ejected plumes of vaporized rock, which coated the globe and condensed into part-extraterrestrial BBs. The age of the spherules suggests a gradual decline in Earth's pummeling. "This is a good marriage of geology in the field and models and calculations done in the lab," says Donald Lowe, a geologist at Stanford University.

The spherules form layers that linger after craters have been erased by tectonic activity. "If you find one of these spherule layers, you can estimate the thickness of it, and you can estimate the size of the asteroid that created that layer," says Brandon Johnson of Purdue University, a coauthor of the second study.



Tiny beads formed by enormous impacts during Earth's early period of bombardment help scientists estimate the size of the impacting asteroids.



A star is torn

Note to stars: When circling a black hole, exercise caution. In spring 2010, NASA's orbiting Galaxy Evolution Explorer and the ground-based Pan-STARRS telescope observed a brightening around a supermassive black hole more than 2 billion light-years from Earth. Over the next several weeks, the flare increased in brightness — then dimmed. Scientists now say the light show was evidence of the black hole PS1-10jh shredding a star that wandered too close. A crime scene analysis presented online May 2 in *Nature* indicates that the star was just a helium-rich core, the remainder of a former red giant. The black hole, weighing about 3 million solar masses, had probably already snacked on the star's outer layers during a previous encounter. As it slowly ingested the star, the black hole spat some of the stellar material into space. The star-crumbs (visible in this computer simulation) followed elongated orbits that eventually dumped them back into the black hole, producing the observed, months-long flare. — *Nadia Drake*

FROM TOP: BRUCE M. SIMONSON; NASA, S. GEZARI/JOHNS HOPKINS UNIV. AND J. GUILLOCHON/UC SANTA CRUZ

Environment

"This could explain why insecticides are more effective some times than other times." —NANCY MORAN

Bugs join forces against pesticide

Gut bacteria allow insects to survive exposure to chemical

By Devin Powell

Insects and microbes have teamed up against a pesticide commonly sprayed on crops. In lab tests, swallowing a bellyful of certain bacteria protected bugs from the toxic chemical.

This detoxifying diet is the first example of a symbiotic relationship that provides insecticide resistance, scientists report online April 23 in the *Proceedings of the National Academy of Sciences*.

"Mechanisms of insecticide resistance have been thought to be encoded by the insect genomes themselves," says Yoshitomo Kikuchi, a microbiologist at the National Institute of Advanced Industrial Science and Technology in Hokkaido, Japan. "Our findings overturn the common sense."

Kikuchi and his colleagues treated pots of soil with fenitrothion, a cheap insecticide used worldwide. *Burkholderia* bacteria, which can disarm the pesticide and break it down for its carbon, flourished in the dirt.

The insecticide-munching microbes also thrived inside young bean bugs, *Riptortus pedestris*, exposed to seedlings grown in the pots or fed the bacteria by the researchers. A single insect can support an estimated 100 million *Burkholderia* cells in its gut. In return for providing a comfortable living space, infected bean bugs acquired a new tolerance to the pesticide in the lab. Most of the insects survived doses of fenitrothion that killed 80 percent or more of their undefended comrades within five days.

Some scientists worry that this resistance could spread quickly. Insecticide resistance typically evolves slowly, as genetic changes arise and spread in successive insect generations. Snatching up soil bacteria, which reproduce quickly and thus evolve much faster, seems an easy shortcut. Insects flying from place to place could also spread their microbial allies.

The bean bug *Riptortus pedestris*, a soybean pest, can acquire resistance to the common insecticide fenitrothion by nurturing protective bacteria in its gut.

Y. KIKUCHI

"This could explain why insecticides are more effective some times than other times," says Nancy Moran, an evolutionary biologist at Yale University.

Searching for resistant insects outside the lab, Kikuchi's team visited agricultural sites scattered across Japan. At a sugarcane field on Minami-Daito Island, 8 percent of the adult stinkbugs captured by the researchers harbored *Burkholderia* that could break down the insecticide.

That's not many bugs, says Bruce Tabashnik, an entomologist at the University of Arizona in Tucson. He doubts that the bacteria provide much protection in actual fields, where insects are exposed to larger doses of fenitrothion than they received in the new experiment.

"The increased ability to survive exposure to insecticide conferred by the symbionts is relatively small," says Tabashnik. "It might not be enough to be relevant in most places." ■

Puffs of methane found over Arctic

Bacteria may be source of unexplained gas emissions

By Janet Raloff

Atmospheric scientist Eric Kort was flying over the Arctic Ocean three years ago, monitoring readouts as onboard sensors sniffed the air. Suddenly, as the plane dipped low over some breaks in the sea's ice cover, those instruments detected the unmistakable whiff of methane, the second most important climate-warming gas associated with human activities.

"This was unexpected," says Kort, of NASA's Jet Propulsion Laboratory in Pasadena, Calif. On four more excursions north of the Beaufort and Chukchi seas through 2010 — all from November to April — the plane's sensors detected the same taint of methane in low-altitude air over broken patches of ice, Kort and collaborators report in the May *Nature Geoscience*.

Methane-spewing bacteria that live in Arctic surface waters are the prime suspects. But the new data call into question understanding of these microbes, says oceanographer David Karl of the University of Hawaii at Manoa. Normally, these bacteria — in the guts of animals and elsewhere — thrive with no oxygen. But the ocean surface is usually saturated with oxygen. "This exciting study reminds us how little we know about microbial processes in the sea," Karl says.

Kort and colleagues calculate the Arctic's daily methane emissions during the flybys at about 2 milligrams per square meter. "That's a pretty significant flux to come out of the ocean," Kort says.

The big question for climate scientists is how pervasive this seawater methane is. If the measurements reflect the Arctic's marine emissions for much of the year, Kort says, "this could be a pretty substantial methane source."

The winter methane spikes could be explained by seasonal nutrient shifts that favor methane-producing bacteria.

Earth

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Glaciers like Greenland's Jakobshavn Isbrae (shown) are now expected to add less to sea level rise this century than worst-case scenarios predict.

Greenland ice flow stop-and-go

Motion suggests worst-case sea level predictions unlikely

By Devin Powell

Time-lapse snapshots showing Greenland's glaciers racing toward the sea in recent years have turned up some good news and some bad news.

As the island's glaciers disintegrate over coming decades, they won't raise the world's oceans as much as the most pessimistic forecasts had shown possible, researchers report in the May 4 *Science*.

"We're certainly looking at significant rises in sea level, but some of the worst-case scenarios that people have imagined don't seem likely," says glaciologist Twila Moon of the University of Washington in Seattle.

That's in contrast to the situation in some parts of Antarctica, where recent work suggests that researchers' worst fears may be realized (Page 5).

Moon's team used satellite measurements from 2000 to 2011 to clock the speeds of more than 200 of Greenland's outlet glaciers — flowing tongues of frozen water that carry ice away from the vast ice sheet that blankets most of the country. Where the glaciers extend offshore, they tend to fall apart and dump ice into the ocean.

Some of these icy conveyor belts have already been spotted moving — and thus melting — faster in recent years. The giant glacier Jakobshavn Isbrae, for instance, accelerated from 9.4 kilometers per year in 2000 to 12.6 kilometers per year in 2003. A 2008 study in *Science* estimated how much such acceleration might contribute to rising sea level. If every glacier could suddenly increase its speed tenfold, sea level would rise about half a meter by 2100, researchers found. A more realistic doubling of speed between 2000 and 2010, followed by leveling off, would contribute a smaller rise of about nine centimeters.

"We were trying to set some really firm upper limits on sea level rise using values that seemed within the realm of possibility," says glaciologist Tad Pfeffer of the University of Colorado Boulder, a coauthor of the 2008 study.

The new data show that glaciers as a whole haven't accelerated that much, or that uniformly, from winter to winter. On average, they moved about 30 percent faster at the end of the first decade of the 21st century than they did at the beginning.

Sea salinity has shifted since '50s

Warmer atmosphere may be cause of water cycle changes

By Devin Powell

More water moved into and out of the atmosphere in 2000 than in 1950, making saltier parts of the world's oceans saltier and fresher waters less salty, researchers report in the April 27 *Science*.

A warming planet may be to blame. Simulations in the new study suggest evaporation and rainfall got a 4 percent boost as surface temperatures rose half a degree Celsius. That boost is a bigger change than previous studies had suggested, but fits with the idea that a warmer atmosphere can hold more moisture.

"We see big broad patterns of change," says Paul Durack, an oceanographer at Lawrence Livermore National Laboratory in California.

Measuring such global changes in Earth's evaporation and rain cycle has never been easy. Rain gauges on land or at sea tend to be sparsely distributed, and the exact positions of such instruments decades ago isn't always known.

Ocean salinity provides a fairly stable, reliable way to measure how much water goes up and comes down, says William Ingram, an atmospheric physicist at the Met Office Hadley Centre in Exeter and the University of Oxford in England. Small fluctuations in evaporation and rainfall tend to get smoothed out over time, helping scientists to tease out long-term trends.

Durack's team analyzed 1.7 million salinity measurements made by ships during the second half of the 20th century. Other researchers had already seen patterns of change in these data, but Durack and his colleagues sharpened the picture. A network of autonomous buoys deployed in the 21st century helped to fill in gaps in the record, particularly at high latitudes where winter storms keep ships away.

"A sporadic record of subduction is not the same as sporadic subduction." —HUGH ROLLINSON

Plate tectonics got a bumpy start

Crustal motions may have started sporadically on early Earth

By Alexandra Witze

Plate tectonics might have gotten a fitful start on the early Earth.

Two researchers propose that plate tectonics started and stopped over and over billions of years ago, before running continuously. The work, published in the May *Geology*, could explain how plate tectonics evolved into the style geologists see today.

Plate tectonics sometimes pushes one plate beneath another in a process known as subduction. When that diving plate gets deep enough, high pressure and temperature chemically changes the plate's rocks. If those rocks are later uplifted to the surface, geologists can recognize the chemical alteration and show that plate tectonics has occurred.

Scientists have spotted this signature in rocks from the Archean eon, which stretched from about 3.8 billion to 2.5 billion years ago, and so have argued that plate tectonics must have started by then. But the Earth's mantle, beneath the crust, was substantially hotter then thanks to residual heat from the planet's birth. A hotter mantle makes subduction tough, because the diving plate weakens and breaks before it can get too deep.

So Jeroen van Hunen of Durham University in England and Jean-François Moyen of Jean Monnet University in Saint-Etienne, France, decided to look for evidence of short-term plate tectonics. Archean outcrops in western Australia and in Zimbabwe show altered rocks interleaved with more pristine rocks. These repetitions may represent subduction turning on and off over time.

Next the researchers simulated how plates might subduct at various mantle temperatures. At 200 degrees Celsius hotter than today, the calculations showed, the plates make it only partway down before breaking and foundering.

Plates would then have to cool at the surface and become dense enough to sink back into the mantle, starting the process over. Only when the mantle cooled sufficiently — perhaps by around 2.7 billion years ago — could permanent, modern-style subduction take hold.

"A sporadic record of subduction is not the same as sporadic subduction," says Hugh Rollinson, a geologist at the University of Derby in England who has studied Zimbabwe's Archean rocks. But he says the basic concept is "a good idea, and one to test."

Life

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Birds forage with fractal-like flight

Mathematical pattern seen in albatross hunting behavior

By Devin Powell

Flight plans reminiscent of fractals could help hungry birds find food. Albatross sometimes hunt by following a mathematical pattern that repeats itself at smaller and smaller scales, researchers report in the May 8 *Proceedings of the National Academy of Sciences*.

Called Lévy flight, this type of movement includes clusters of small movements every which way, punctuated by the occasional long trip in one direction. It's thought to be a particularly efficient way to locate scarce prey.

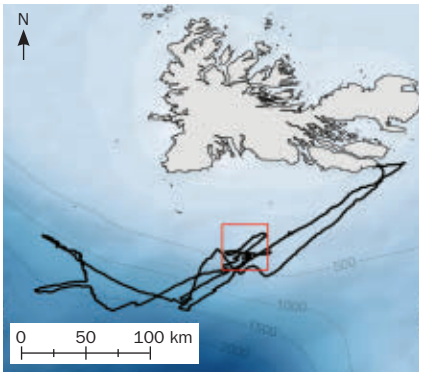
"Think about searching for your car keys," says David Sims, a behavioral ecologist at the Marine Biological Association of the United Kingdom in Plymouth. "You intensively search in one area, but if you don't find them there, you jump to someplace else and search there."

Sims isn't the first to claim to have seen this pattern in albatross flights. In 1996, physicists found Lévy flights in data collected by the British Antarctic Survey that showed when the birds were dry (flying) and wet (landing on the ocean).

But as the ancient mariner learned, albatross can bring both good and bad fortune. A reanalysis of the data, reported in 2007 in *Nature*, showed that some dry periods thought to correspond to long flights were actually just times when the birds sat on their nests. Once those still periods were accounted for, the Lévy flight patterns disappeared.

The latest study gives new wings to the idea, thanks to GPS devices on 88 albatross that relayed the birds' positions either every one or 10 seconds. Sometimes the animals moved in small random steps, a Brownian pattern suitable when food is abundant. But when hunting sparse, unpredictable patches of squid, individual birds often used a truncated version of Lévy flight — a modified pattern that, unlike its pure mathematical counterpart, breaks down at very small and very large scales.

Finding this pattern "overturns the 2007 study," says Gandhi Viswanathan, a coauthor on the 1996 paper and a theoretical physicist at the Federal University of Rio Grande do Norte in Natal, Brazil.



The path of an albatross over the far southern Indian Ocean contains small movements in many directions punctuated by long trips, a pattern repeated at smaller scales within the red square.

For the new study, sensors measuring the belly temperatures of wandering albatross allowed researchers to estimate how much food was caught and eaten. A typical bird in Lévy flight swallowed roughly four times its daily energy needs, about 1.5 kilograms of squid and fish every day.

Simon Benhamou of the National Center for Scientific Research in Montpellier, France, says he applauds the statistical rigor of the new study but questions its biological relevance.

Egg wars

Eggs of cuckoo finches and tawny-flanked prinias have grown more colorful in the last 40 years — a sign that the neighbors are locked in an evolutionary arms race. African cuckoo finches (*Anomalospiza imberbis*) dump their eggs (inner circle shown at left) into the nests of tawny-flanked prinias (*Prinia subflava*). By laying eggs that mimic prinia clutches (outer circle), cuckoo finches trick the prinia into caring for the finch young. Over the last decades, both birds have evolved a greater diversity of egg colors: As prinias developed new hues to defend against invaders, cuckoo finches retaliated with new fakes, researchers from the University of Cambridge in England report in the May *American Naturalist*. The team found a greater color variety in eggs from both species collected in Zambia in 2007–2009 compared with eggs collected in 1969–2002. And recent cuckoo finch eggs better match recent prinia eggs than do older cuckoo finch eggs, indicating the cuckoo finches evolved in response to the prinias, the team says. — *Erin Wayman*

FROM TOP: N. HUMPHRIES *ET AL*/*PNAS* 2012; C. SPOTTISWOODE AND M. STEVENS/*AMERICAN NATURALIST* 2012

"There is an entire population maintained by larval reproduction." —CORNELIA JASPERS

Comb jelly starts reproduction early

Marine species thrives despite never reaching adulthood

By Rebecca Cheung

Comb jellies living in the central Baltic Sea are a bunch of babies. In this part of the world, members of the species *Mertensia ovum* don't appear to reach adulthood but instead sustain the population by reproducing while still larvae, researchers report online April 25 in *Biology Letters*.

It's well known that many comb jellies — gelatinous marine animals that live at various depths of the ocean and use sticky tentacles to capture meals — can become parents before reaching adulthood. This new work is "actual proof from nature that there is an entire population maintained by larval reproduction," says study coauthor Cornelia Jaspers of the Technical University of Denmark in Charlottenlund.

Jaspers and her colleagues suspect that pressure from predators might be driving these comb jellies to start producing a few eggs early in life.

The findings also highlight unexpected ways that species may adapt to external pressures. "I think this is a really nice indication that evolution, depending on the ecological factors involved, can drive things in different directions for simplification and for becoming smaller," says Mark Martindale, director of the Kewalo Marine Laboratory at the University of Hawaii at Manoa. "Generally people have this a priori notion that evolution sort of goes forward. Everything gets bigger and more complicated and smarter."

During 13 monthly expeditions, Jaspers and colleagues collected zooplankton samples from four different regions of the central Baltic Sea. The team found many *Mertensia* eggs and larvae, but never any adults.

Although this species of comb jelly can grow nearly 10 centimeters long in Arctic waters, the researchers collected animals that were no more than 1.6 millimeters long — equivalent to the diameter of a strand of spaghetti. The team found that *Mertensia* larvae as small as 0.75 millimeters could produce eggs in the lab. And the larger the animal, the more eggs were made.

"Their data show that these larvae are reproducing sufficiently to maintain the population," says Claudia Mills of the University of Washington's Friday Harbor Laboratories. This early reproduction might be more widespread in comb jellies than previously thought, Mills adds, but additional field studies will have to confirm this conclusion.

Martindale notes that further studies may offer insights into whether larval reproduction could be turned off in the absence of predators.

Cricket sings highs and lows

Insect uses segmented wings for range of pitches

By Rebecca Cheung

Unique wings allow one type of male tree cricket to hum a different sort of tune — one that encompasses a wide range of pitches. The discovery could mean that these males are saying a lot more than previously thought, and that potential mates might be listening for these notes.

"The frequencies might be carrying some information about the condition of the male," says Natasha Mhatre of the University of Bristol in England and coauthor of the new study, published online April 30 in the *Proceedings of the National Academy of Sciences*. "An insect that is able to sing faster, and hence at a higher frequency, might actually be quite well fed, or he's in a nice warm place you might want to be in."

Crickets produce sound by rubbing their wings together. For most — including field and bush crickets — each male can produce only one musical note. Generally, the pitch of the male's song is directly related to his size. It's believed that when females scout for a potential mate, they tend to be drawn to songs of lower frequency or pitch, which are produced by larger crickets.

But certain tree crickets can vary their tune. A species from southern India called *Oecanthus henryi*, for example, produces high-pitched sounds at warmer temperatures. The trick is possible thanks to five individual segments in each wing. The long, partitioned wings accommodate different types of bending, which enables the insects to make sounds that range from 2.3 to 3.7 kilohertz. At higher temperatures, the crickets tend to move their wings faster, making higher-frequency sounds.

This male tree cricket's individual wing sections vibrate in concert to produce songs with varying frequencies.

N. MHATRE/UNIV. OF BRISTOL

Because the pitch of the male's song is not tied to body size in this species, the findings raise questions about exactly what information females are gleaning when they hear these songs, says Rex Cocroft, an entomologist at the University of Missouri in Columbia. "It's going to change the dynamics of mate choice," he says.

Genes & Cells

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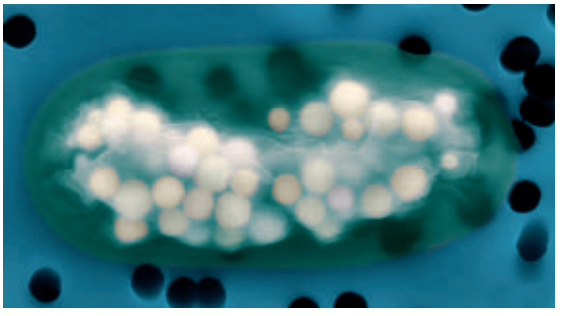
Aquatic microbes have bony insides

Lake-dwellers build stony lumps in their one-celled bodies

By Rachel Ehrenberg



Scientists have found cyanobacteria (one shown) that accumulate tiny calcified structures inside their cells. The lumps are made of minerals that the microbes absorb from the lake where they live.

Scientists have discovered skeletons in the bacterial closet. A never-before-seen species of cyanobacteria loads its cells with little bonelike lumps that may act as ballast, helping anchor the beastie to surfaces in the Mexican lake where it lives. The find, described in the April 27 *Science*, is the first report of bacteria creating calcified structures inside their cells.

"It's interesting and opens up possibilities we hadn't thought about before," says Robert Riding of the University of Tennessee, Knoxville, who wrote a commentary on the research in the same issue of *Science*. Related cyanobacteria play a major role in the planet's geochemical cycles.

Geobiologist Karim Benzerara and his colleagues came across the new species, *Candidatus Gloeomargarita lithophora*, while investigating Lake Alchichica's stromatolites, knobby pillars of sediment and microbes that can form in shallow waters. The researchers cultivated slimy films of the microbes in a lab aquarium. Looking at the slime under a microscope, the team saw that some cells looked like they were filled with little pearllike granules. "That's when we figured out that there was something special," says Benzerara, of the CNRS Institute of Mineralogy and Physics of Condensed Matter in Paris.

The granules are an unusual combination of calcium, strontium, barium, magnesium and carbonate. Because the ratios of these ingredients aren't the same in the granules as in the surrounding water, the researchers suspect that the cyanobacteria have some control over formation of the lumps and are actively transporting some of the ingredients into their cells. While the lumps occupy only about 6 percent of a cell, they increase the microbe's density by 12 percent. This might help the microbes move from the water column to the surface of an underwater rock or stromatolite, the researchers speculate.

Even more intriguing is what the microbes might have been doing during Earth's history, says geomicrobiologist Clara Chan of the University of Delaware in Newark. Cyanobacteria (also known as blue-green algae) are known for making early Earth's atmosphere more breathable. "Cyanobacteria are really the movers and shakers of the Earth," says Chan. "They were a major source of oxygen."

Yeast reacts to antidepressant

Zoloft builds up and triggers cell destruction process

By Laura Sanders

Brewer's yeast cells don't even have brains, but that doesn't stop the single-celled fungi from responding to an antidepressant. A new study finds that the drug sertraline, sold as Zoloft, piles up in yeast cells, distorting normally curved membranes and triggering the cells to start eating themselves.

Sertraline and similar drugs are thought to boost mood by increasing levels of the neurochemical serotonin between nerve cells. Sertraline latches on to a molecule called the serotonin transporter, part of which sits on nerve cells and slurps up serotonin. By gumming up the serotonin transporter, sertraline leaves more free serotonin.

Yeast have none of these molecular bits. "A molecule like Zoloft should be completely innocuous to a yeast cell, in the way that an antibiotic would be innocuous to a viral infection," says pharmacologist Ethan Perlstein of Princeton.

But when Perlstein and his team gave the cells a low dose of sertraline labeled with a radioactive tracer, the drug accumulated inside membranes that surround the yeast cells and their organelles. The drug's buildup distorted the normal curvature of the membranes and seemed to trigger a quality-control check in which the cell starts breaking itself down, a process called autophagy, the team reports April 18 in *PLoS ONE*.

It's unknown whether a similar process happens in human cells, nor is it clear whether the process would be helpful or harmful. Autophagy could trigger some beneficial changes, Perlstein says. If also true for human cells, the results might help enhance understanding of how some antidepressants work.

But neuroscientist Randy Blakely of Vanderbilt University in Nashville urges caution in applying the results to humans. "I don't know of data that would indicate that similar events occur in the brain," he says.

K. BENZERARA AND STEPHAN BORENSZTAJN

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Body & Brain

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Weight loss may cut cancer risk

Shedding pounds reduced inflammation in women

By Nathan Seppa

Losing weight can knock down levels of inflammatory cells and proteins in the body. Since chronic inflammation is a risk factor for many cancers, the finding suggests weight loss might reduce cancer risk.

The inflammation reduction came only with weight loss from dieting. People who embarked on an exercise-only program failed to lower their inflammatory load substantially, despite losing several pounds in many cases. The report appears in the May 1 *Cancer Research*.

A connection between inflammation, obesity and cancer risk has been previously established, says study coauthor Anne McTiernan, an internist and epidemiologist at the Fred Hutchinson Cancer Research Center in Seattle. For instance, obesity has been linked to increased blood levels of a protein called C-reactive protein; those increased levels are associated with risk of breast, colon and lung cancers.

The new findings indicate that the obesity-inflammation segment is modifiable, McTiernan says, but don't address the cancer risk.

McTiernan and her colleagues randomly assigned 399 overweight and obese postmenopausal women to one of four groups — dieting plus exercise, dieting only, exercise only or a control group not required to do either.

Blood tests before and after the 12-month trial showed that dieting women who lost at least 5 percent of their body weight, with or without exercise, had substantially greater decreases in levels of inflammatory proteins and cells than the control group. That group showed no change in the inflammatory markers.

"Anything you can do to decrease your inflammatory status is probably a good thing overall," says Russell Tracy, a biochemist at the University of Vermont, because the association between obesity and inflammation plays out in many conditions, including atherosclerosis and type 2 diabetes.

Enzyme shot may top acupuncture

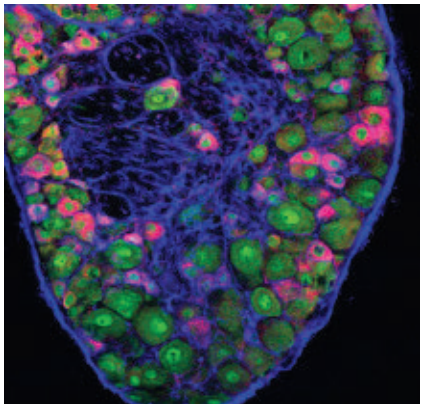
Mouse study finds injection provides days of pain relief

By Tina Hesman Saey

A new treatment mimics the pain-blocking mechanism of acupuncture and offers longer-lasting relief, at least in mice.

Injecting an enzyme called PAP into an acupuncture point behind the knees of mice relieved pain caused by inflammation for up to six days, Julie Hurt and Mark Zylka of the University of North Carolina at Chapel Hill report online April 23 in *Molecular Pain*. That's almost 100 times as long as pain relief from acupuncture, which typically lasts about 1½ hours.

"The beauty of Mark's study is that it takes advantage of the molecular mechanism of acupuncture and improves upon it," says Maiken Nedergaard, a neuroscientist at the University of Rochester in New York. She and colleagues have demonstrated that inserting and manipulating acupuncture needles causes the body to release a chemical called adenosine. Adenosine acts as a local anesthetic to slow pain messages to the brain, she says.



An enzyme called PAP, shown here in pink on the membranes of pain-sensing neurons, suppressed inflammatory and nerve pain in mice for up to six days.

ZYLKA LAB/UNC-CHAPEL HILL

Zylka had already been studying PAP, which stands for prostatic acid phosphatase, when Nedergaard's research on the release of adenosine during acupuncture was published. The study gave him the idea that boosting adenosine at acupuncture points, which are located where nerves contact muscle, could be a localized way to treat pain.

Adenosine lasts only minutes in the human body, so injections of the chemical itself were not an option. But PAP, which produces adenosine by breaking down adenosine monophosphate, or AMP, lasts a long time and can continue churning out adenosine as long as it has a supply of AMP. Muscles are a ready source of AMP, itself a breakdown product of the molecule ATP, which cells use for energy.

PAP injections in mice with inflamed paws made the limbs less sensitive to heat and poking but didn't cause muscle weakness or other discernible side effects, the researchers found.

Other scientists have postulated that acupuncture releases feel-good chemicals called endorphins, which work all over the body. But the new study helps cement the idea that acupuncture really works locally, Nedergaard says.

Not only does PAP relieve inflammatory pain longer than acupuncture does, it also relieves nerve pain in mice, testing showed. Clinical studies in people have found that some patients with nerve pain get worse after acupuncture, says physician-scientist Jon Levine of the University of California, San Francisco.

1.5 hours Average duration of acupuncture pain relief in mice

6 days Average duration of pain relief from PAP shot

Neighborhood linked to obesity

Children lacking nearby parks, supermarkets at higher risk

By Nathan Seppa

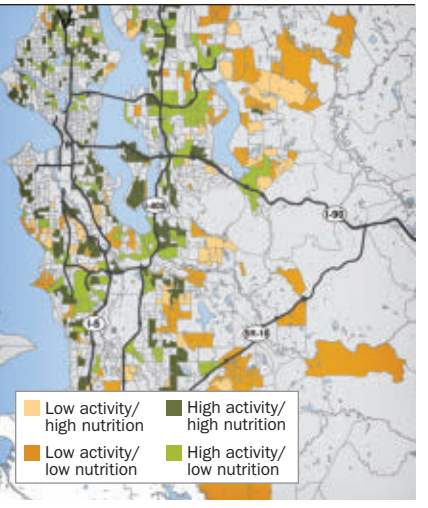
Neighborhood amenities such as green space and a nearby grocery store may offer residents more than just curb appeal. Children who live in such neighborhoods are roughly half as likely to be obese as kids living in areas lacking these features, researchers report in two studies in the May *American Journal of Preventive Medicine*.

Lawrence Frank, an urban planner and public health researcher at the University of British Columbia in Vancouver, and his colleagues considered the "built environment" in hundreds of neighborhoods in San Diego County, Calif., and King County, Wash., which includes Seattle. Researchers rated the number and quality of parks and a neighborhood's "walkability" — whether it had a low level of sprawl, few cul-de-sacs and easy access to retail outlets.

The scientists gauged the nutrition component of the built environment by noting the presence or absence, within a half mile, of a store that sold fresh fruits and vegetables. The number of fast food outlets in that range counted as a negative.

The researchers also collected health information on 681 children randomly identified in the two counties and scored each child's neighborhood amenities.

In neighborhoods with high physical activity and nutrition scores, less than 8 percent of children ages 6 to 11 were obese, compared with nearly 16 percent in places scoring poorly on both measures. Even after accounting for sex, race, ethnicity, parents' income, parents' body mass index, parents' employment status and other factors, children in high-scoring neighborhoods were 59 percent less likely to be obese than those in poorly rated areas.



Neighborhoods in Seattle (shown) and San Diego that ranked high for features promoting physical activity and good nutrition had lower childhood obesity than neighborhoods with lower scores.

"This is a very promising area of research that will inform the way we think about cities and how to design neighborhoods," says Jennifer Black, a nutritionist at the University of British Columbia who wasn't involved in these studies.

Autism drug has effects in mice

Compound curbs repetitive behavior, boosts sociability

By Laura Sanders

An experimental drug eases two of the core behavioral symptoms of autism spectrum disorders in adult mice, a new study shows. A single injection curbed repetitive behaviors and improved sociability, researchers report in the April 25 *Science Translational Medicine*.

Although it's too soon to say whether the drug will work in people with autism, similar medicines are already being tested in humans for a related neurological condition known as fragile X syndrome. "This may be a case where you have a mouse finding that can actually lead to human studies in a fairly short amount of time," says psychiatrist and molecular neuroscientist Jeremy Veenstra-VanderWeele of Vanderbilt University in Nashville.

No currently available drugs treat the core features of autism spectrum disorders — impaired social interactions, communication problems and repetitive behaviors, says study coauthor Jill Silverman of the National Institute of Mental Health in Bethesda, Md. She and her colleagues focused on two kinds of inbred mice with unusual behaviors. One repetitively grooms, doesn't interact with other mice normally and squeaks less than others. The second jumps up to 50 times a minute.

In a test of sociability, mice receiving an experimental drug sniffed around a strange new mouse (in cage) more than untreated animals.

About half an hour after receiving a dose of the compound, known as GRN-529, the animals' pathological grooming and jumping lessened, the team found. Some signs of abnormal social behavior improved, too. Coauthors at Pfizer saw similar results in tests at their Groton, Conn., lab. "For the repetitive behaviors, it was a really strong finding," Silverman says.

The drug works by interfering with a protein in nerve cells called mGluR5, which detects the brain chemical glutamate. Researchers are growing increasingly interested in drugs targeting mGluR5.

FROM TOP: L.D. FRANK *ET AL/AM J PREV MED* 2012; MU YANG, JACQUELINE CRAWLEY/NIMH LABORATORY OF BEHAVIORAL NEUROSCIENCE

Body & Brain

"This opens up a whole new view of the disease." —RUDY TANZI

Odd protein may spur Alzheimer's

Unusual amyloid-beta sows destruction in mouse brains

By Laura Sanders

Scientists have caught tiny amounts of a strangely shaped protein — a relative of a well-known suspect in Alzheimer's disease — spreading destruction throughout the brains of mice. If a similar process happens in the human brain, it could help explain how Alzheimer's starts and even suggest new ways to stop the disease's spread.

Many researchers believe the abundance of a molecule called amyloid-beta in the brain is a key factor in Alzheimer's disease. A-beta commonly takes the form of a chain of 42 protein building blocks called amino acids.

The new study chronicles the dangers of a modified A-beta that lacks the first two amino acids in the chain. Capping this stub is a rare, circular amino acid called pyroglutamate. Until recently, this form "has been largely ignored as some minor, mysterious form of amyloid-beta," says study coauthor George Bloom of the University of Virginia. Yet even trace amounts of this version, called pyroglutamylated A-beta, or pE A-beta, are devastating to mouse nerve cells, he and colleagues report online May 2 in *Nature*.

"This opens up a whole new view of the disease," says neurogeneticist Rudy Tanzi of Harvard Medical School. Instead of focusing just on the amount of A-beta in the brain, scientists need to pay attention to modifications of the molecule, too, he says.

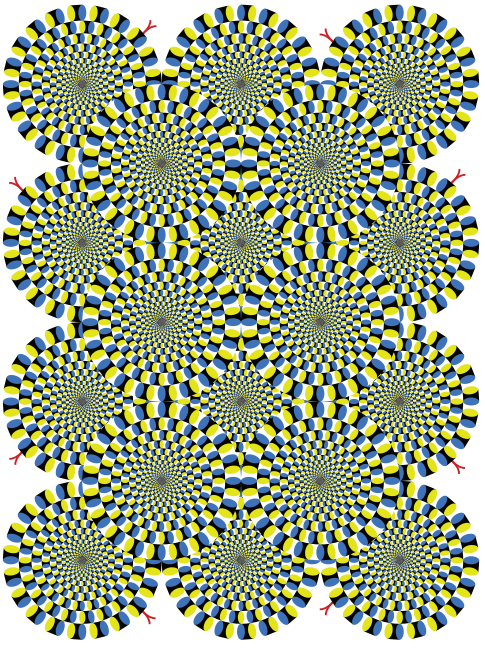
Minuscule amounts of pE A-beta can pair up with more commonplace types and trigger them to misfold, the team reports. These misfolded molecules are then much more deadly to nerve cells, killing about half of mice nerve cells tested in a dish within 24 hours. Experiments with pE A-beta in the brains of mice revealed signs of massive damage, too. "Even at vanishingly small quantities, the mixture is still toxic," Bloom says.

But this toxicity required a co-conspirator — a protein called tau that tangles up inside nerve cells. Mice genetically designed to lack tau were largely immune to the ill effects of pE A-beta, the team reports. Scientists don't yet understand exactly how tau and A-beta interact.

It's not clear whether the results in mice will apply to people. Bloom and his colleagues detected pE A-beta in three out of three postmortem brains of people diagnosed with Alzheimer's, and one out of three from people without the disease.

The study may have uncovered one of the first steps in a long disease process, says Tanzi. "This puts even more emphasis on early detection of the disease before symptoms appear," he says. "We really need to hit this disease early."

The research also points out one potential new way to do that. Some of the *Nature* paper's authors are involved with a Germany-based company called Probiodrug that is developing a medicine designed to curb pE A-beta production in the brain. In 2011, the company announced positive results from preliminary safety tests of the drug in healthy volunteers. ■



AKIYOSHI KITAOKA

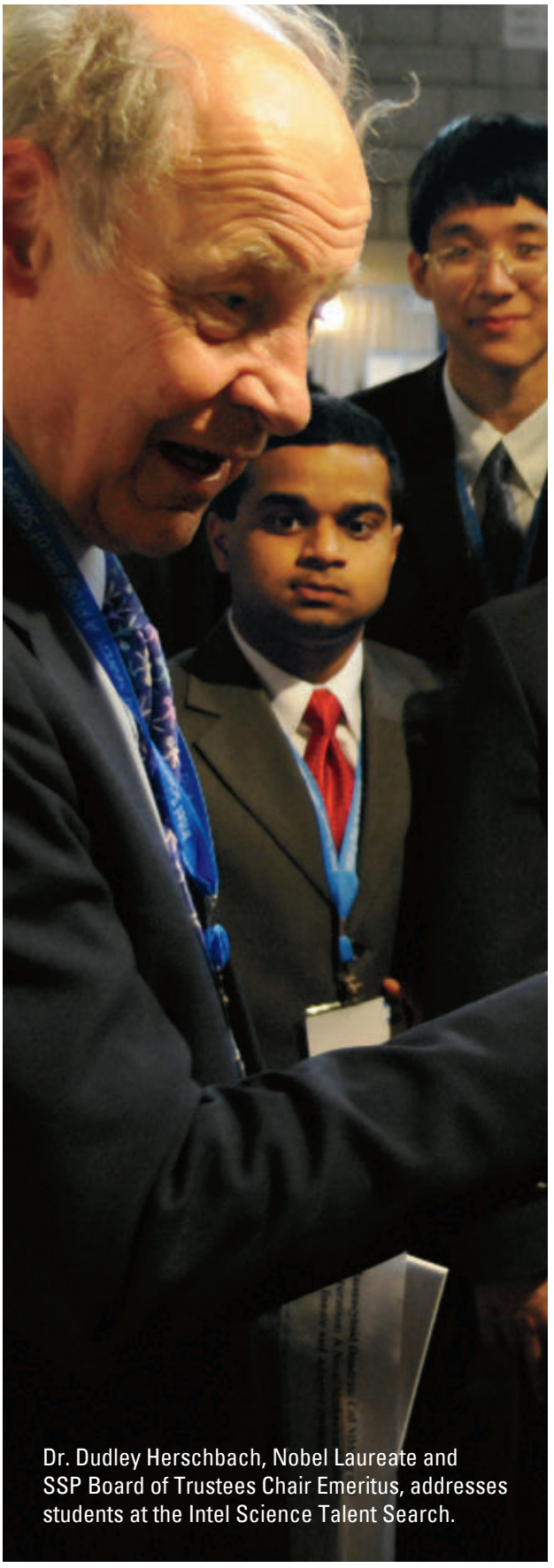
Snakes swirl when eyes jump

Tiny eye movements and blinking can make perfectly frozen snakes appear to dance, a new study shows. The results help explain the mystery of how the "rotating snakes" illusion tricks the brain.

Earlier studies have suggested that the perception of motion is triggered when the eyes drift slowly away from a central target when viewing the illusion. But by tracking eye movements in eight volunteers, vision neuroscientists at the Barrow Neurological Institute in Phoenix found a different explanation.

Participants held down a button when the snakes seemed to swirl and lifted the button when the snakes appeared still. Right before the snakes started to move, participants began blinking more and making short jumpy eye movements called microsaccades, Jorge Otero-Millan, Stephen Macknik and Susana Martinez-Conde report in the April 25 *Journal of Neuroscience*. When volunteers' rates of microsaccades slowed down, the visual illusion faded and the snakes were more likely to stop moving.

The results join a growing number of studies that use magic tricks and illusions to reveal people's perceptual mistakes, such as seeing motion where there is none. Studying the mismatch between perception and reality may lead to a deeper understanding of the mind. —*Laura Sanders*



Dr. Dudley Herschbach, Nobel Laureate and SSP Board of Trustees Chair Emeritus, addresses students at the Intel Science Talent Search.

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★★★★ CHARITY NAVIGATOR
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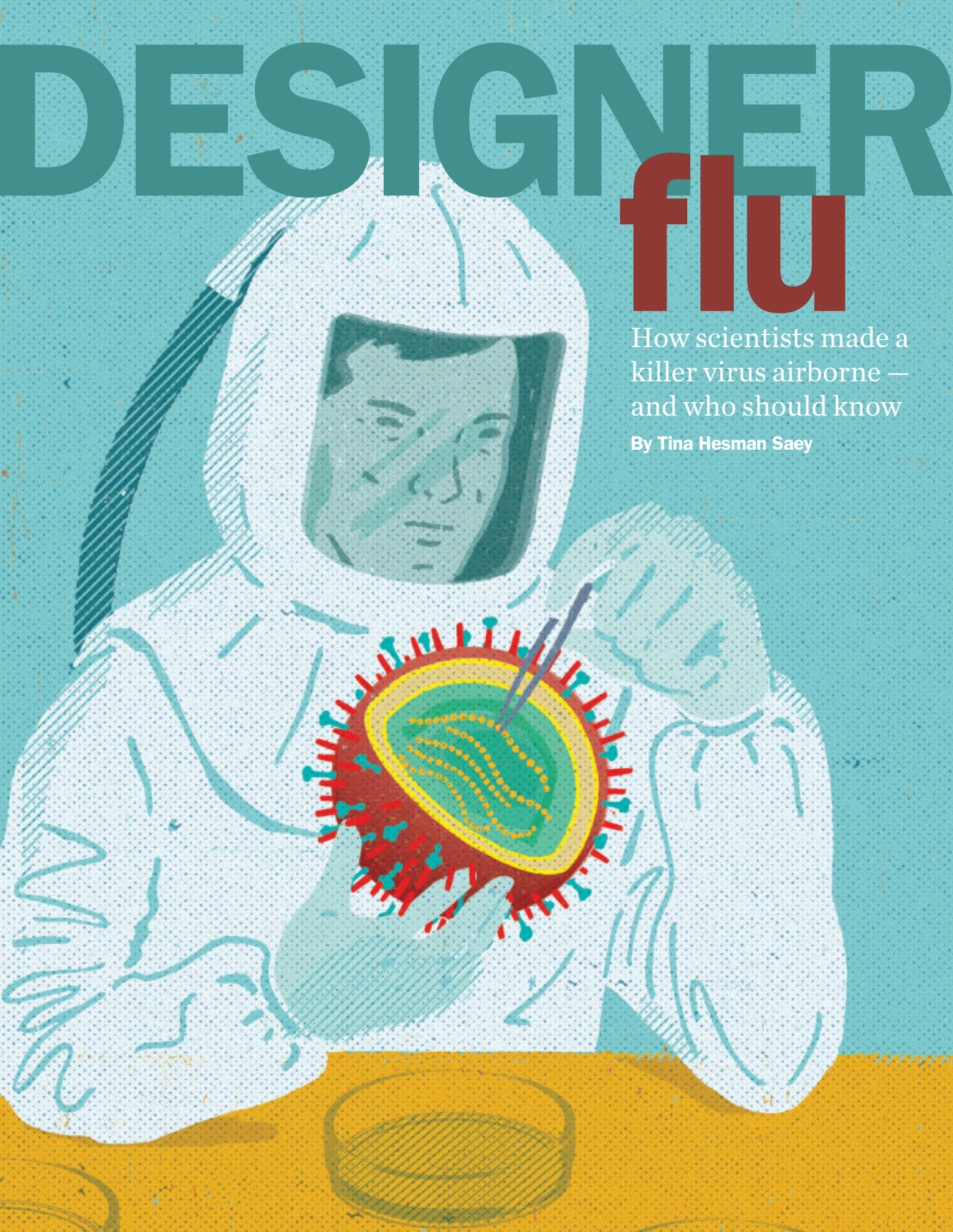
DESIGNER flu

How scientists made a killer virus airborne — and who should know

By Tina Hesman Saey



Last summer, scientists performed an experiment that could have been ripped from the script of a Hollywood thriller. Sealed off in high-tech laboratories in the Netherlands and Wisconsin, researchers transformed one of the world's most deadly viruses, transmissible by direct contact, into versions capable of spreading through the air.

Unlike in the movies, news of the lab-made viruses was not delivered as a threat, and the scientists doing the work weren't henchmen of an evil dictator or members of a shadowy terrorist organization. Instead, the researchers were on the good-guy team — respected academics investigating how a type of flu virus that typically targets birds might become contagious in people.

Though the avian flu virus known as H5N1 infects and kills mostly birds — including chickens, turkeys and waterfowl — it has sickened more than 600 people worldwide since an outbreak in Hong Kong in 1997, killing about half of them. The virus doesn't pass easily from person to person even with close contact, let alone through the air. Most victims contracted it after handling infected birds or from contaminated environments.

But the Netherlands and Wisconsin research teams created their airborne versions of the virus in attempts to determine whether the virus *could* become easily transmissible among people. Knowing more about the virus's potential to make such a change might help public health workers spot a budding pandemic, and even point to ways to head off such a global catastrophe.

Yet even though the researchers undertook the work for noble reasons, they soon found themselves as embroiled in intrigue and worldwide controversy as any fictional villains. Since the Dutch researchers announced the work at a scientific meeting in Malta in September, their saga has featured closed-door meetings, security reviews, publishing restrictions, a voluntary halt on the research, a media frenzy that included a flurry of opinion pieces by other scientists and even threats of imprisonment. The Wisconsin team's story has played out similarly, only with slightly less drama. At issue is the danger posed by the lab-made versions of air-transmissible H5N1 and who should know how they were created.

Each team submitted a paper to a major scientific journal — one to *Nature* and one to *Science* — containing step-by-step instructions for turning H5N1 into an airborne virus, including information about the changes in the genetic instruction book important for the transformation. Initially, a U.S. government advisory board charged with determining whether the research was fit to print decided that open publication posed too great a risk of misuse, recommending the publication of severely redacted versions. Critics siding with the board warned that terrorists or rogue nations could use the information to re-create the viruses and unleash them on the world.

Critics warned that terrorists or rogue nations could use the information to re-create the viruses and unleash them on the world.

Proponents of publishing argued that public health workers need to know which mutations spell trouble in case those mutations are spotted in the wild. At the end of March, the board reversed its decision, ruling — after some clarifications — that the benefits of information sharing outweighed the risks.

One paper has now been published in a full-length version in *Nature* (*SN Online: 5/2/12*); as of mid-May, the second was still in the peer review and editing process. But the controversy the papers ignited has made flu virus research, and the issues of national security and data sharing that come along with it, topics of debate over lab benches and dinner tables.

Before it was clear that the papers would ever see print, they were called "the two most famous unpublished manuscripts in modern life science history" by Michael Osterholm, director of the Minnesota Center of Excellence for Influenza Research and Surveillance in Minneapolis.

Flu-id rulings

Osterholm serves on the 23-member National Science Advisory Board for Biosecurity, NSABB for short, charged with assessing whether the H5N1 papers should be published. Established in 2004, the board evaluates biological research that could be used for nefarious purposes. Such "dual-use" research is generally performed to uncover the basic biology of disease-causing organisms for medical or public health purposes, but could be twisted by people with evil intentions into biological weapons.

In its history, the board has reviewed six other scientific papers, in all cases recommending publication with no changes or only minor modifications, says Paul Keim, an anthrax researcher at Northern Arizona University in Flagstaff who chairs the advisory board.

But in the case of the two H5N1 flu papers, "The full board recommended that neither manuscript be published with complete results," Keim said April 3 in London at a meeting organized by the Royal Society and other groups. "The board found that these results had an unusually high magnitude of risk."

Knowing all the details of the research could allow someone to skip years of work and quickly make a transmissible version of the virus, the advisers concluded after first reviewing the papers in November.

What made some board members so uncomfortable — and what the media quickly picked up on — was the nature of the virus. To call H5N1 deadly is putting it mildly. The virus kills an estimated 59 percent of the people it infects. Though some studies say the actual kill rate is far lower, "Even if it is 20 times lower, it would still have a mortality rate that far exceeds that of the 1918 flu," says Osterholm. That pandemic racked up a body count of tens of millions of people worldwide.

"People like myself have almost been

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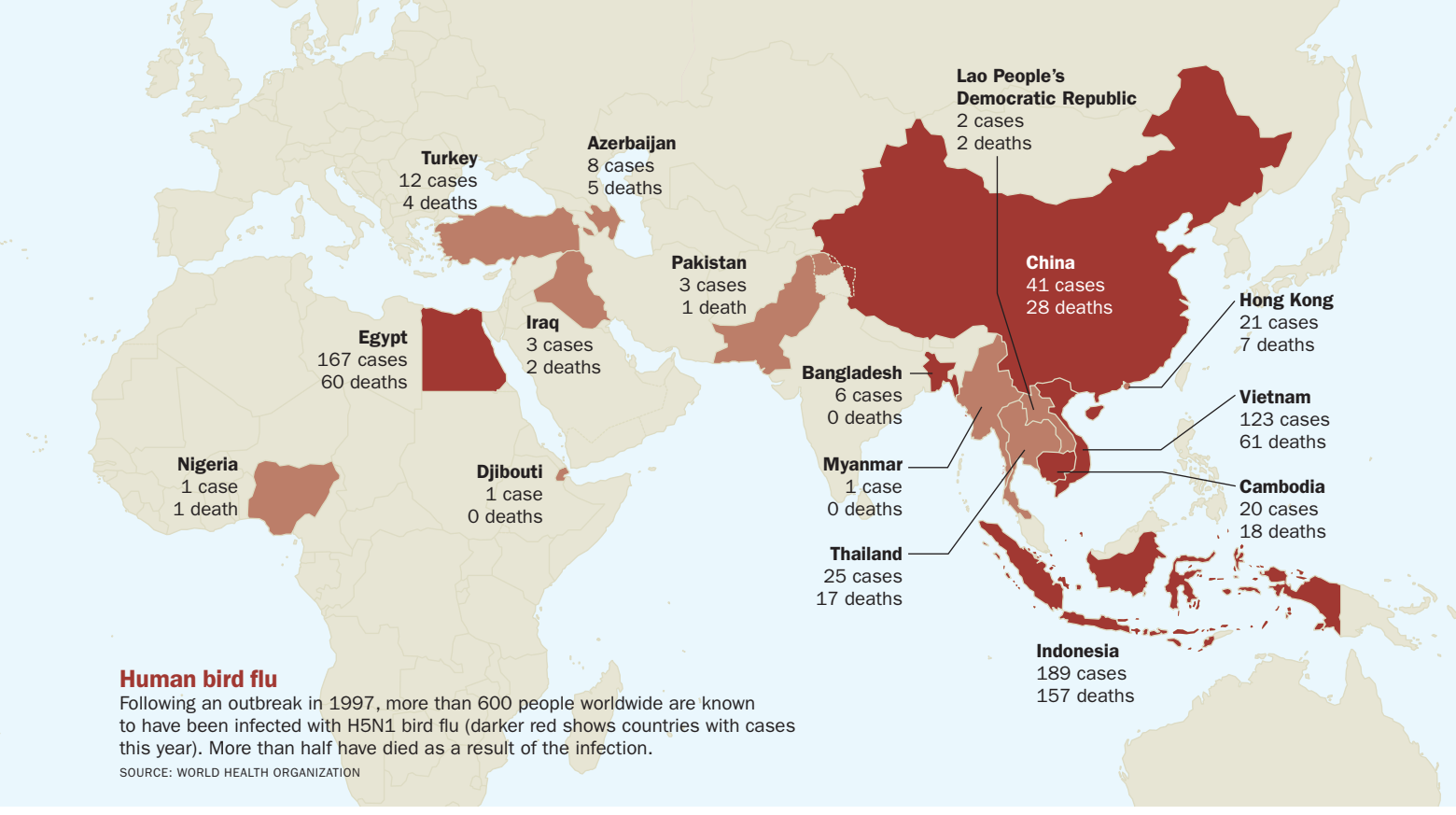


Human bird flu

Following an outbreak in 1997, more than 600 people worldwide are known to have been infected with H5N1 bird flu (darker red shows countries with cases this year). More than half have died as a result of the infection.

SOURCE: WORLD HEALTH ORGANIZATION

ridiculed for our position on the risks of the influenza virus," Osterholm says. If smallpox or SARS were ever to escape from a lab and start infecting people, it would be bad but could easily be brought under control, he says. "Influenza is very different. Influenza is like having one screen door on your submarine. It will sink you."

So telling the general public, including potential terrorists, how to make an airborne version of highly lethal H5N1 was, at least at first, deemed a risk that outweighed the public health benefit of publication.

But other scientists were outraged by the decision, which they saw as holding back essential information. The papers show that although H5N1 has been around for 15 years and has not yet developed the ability to spread easily from person to person, it could be just a few mutations away from becoming a human-transmissible virus. Full disclosure about the steps required for that transformation could be key to finding viruses already heading down that path in the wild.

The Netherlands group, headed by Ron Fouchier of Erasmus Medical Center in Rotterdam, found that five mutations are enough to make the virus infectious through airborne particles in ferrets, which are often used as stand-ins for humans in infectious disease experiments. At the Royal Society meeting, Fouchier was unable to discuss details about the type of mutations that his group found because of Dutch restrictions on the export of dual-use research. (Fouchier's team has since been granted an export license.)

But the United States had already lifted a similar ban, giving Yoshihiro Kawaoka of the University of Wisconsin–Madison the go-ahead to present his team's results in full. Kawaoka's team also reported its findings online May 2 in *Nature*.

Strictly speaking, the Wisconsin group's transmissible virus is not H5N1 bird flu virus. Instead it is a composite of H5N1 and the H1N1 "swine flu" virus that caused a pandemic in 2009. To create the combination virus, the researchers replaced a sugar-spiked protein called hemagglutinin (the H in H5N1) found in the 2009 virus with one from the bird flu virus. Hemagglutinin studs the flu virus's outer envelope and helps the virus grab and invade cells. Although the researchers genetically engineered the bird/swine combination virus in the lab, the experiment mimicked the sort of parts-swapping that influenza viruses often go through in nature.

Merely swapping hemagglutinins wasn't enough to make the composite virus into an airborne infectious flu in ferrets, though. The original combination virus didn't pass between ferrets in neighboring cages. Researchers helped the virus along by transferring it directly from one ferret to another. In ensuing rounds of researcher-assisted ferret infections, mutations cropped up in the hemagglutinin protein.

At least four changes to the molecule were needed to make the virus readily transmit via airborne droplets, the researchers found. Three of the mutations, all located in a part of the protein needed to attach to cells, switched the virus from one that could latch onto cells in the digestive tract of birds and the lungs of mammals to one that also could hang on in mammalian upper respiratory tracts. Grabbing on in that region is necessary for virus particles to spread via coughing and sneezing.

A fourth change in hemagglutinin may affect how well the virus can fuse with cells in ferret — and presumably

GEOATLAS/GRAPHI-OGRE, ADAPTED BY T. DUBÉ

human — hosts. That mutation makes the hemagglutinin more stable and allows the virus to replicate better in mammalian cells, Kawaoka said.

A group of influenza researchers and public health officials convened by the World Health Organization, after hearing the results presented in February, concluded that this information would be valuable for public health workers. A full accounting of the data would aid surveillance teams in identifying naturally occurring mutations that indicate H5N1 is becoming less of a bird virus and more of a human virus, proponents of publishing said. Besides, the WHO panel concluded, there is no currently feasible way to withhold the data from most of the world while still quickly disseminating the information to those who really need to know it.

One of the mutations Kawaoka found in the hemagglutinin molecule may already be helping the virus adapt to humans. In Egypt, 219 H5N1 viruses taken from birds had the mutation, called N158D, while 87 H5N1 viruses isolated from birds did not. All 46 H5N1 viruses isolated from humans carried the mutation, suggesting that the genetic change is important for the virus to infect humans.

And during the Royal Society meeting, Fouchier said that when his data are put alongside Kawaoka's, a pattern emerges that begins to reveal which biological traits an influenza virus needs to become a pandemic strain. It's the ability to spot the trends in virus evolution that makes publishing this kind of information so important, the researchers argued. Even if surveillance measures aren't enough to catch the virus before it becomes a pandemic, Fouchier said, knowing how it is likely to happen will allow researchers to design vaccines and antiviral medications to combat a future pandemic.

Deadly or not

One reason that the cons of publishing may have initially appeared to outweigh the pros is that the findings were hyped. Part of that hype came from the researchers themselves. Fouchier was quoted on *Science*'s website as saying that the virus created in his lab is "probably one of the most dangerous viruses you can make." Scientists as well as members of the media and public interpreted that statement and other remarks Fouchier made to mean that the team's lab-made virus retained its killing capacity as it gained the ability to pass from ferret to ferret. The research done by Kawaoka's team was painted with the same scary brush, even though no ferrets died in those experiments.

But it turns out that the lab-made viruses are neither as deadly nor as transmissible as many people had initially believed.

"What the world thought isn't exactly what happened," says Anthony Fauci, director of the U.S. National Institute of Allergy and Infectious Diseases in Bethesda, Md.

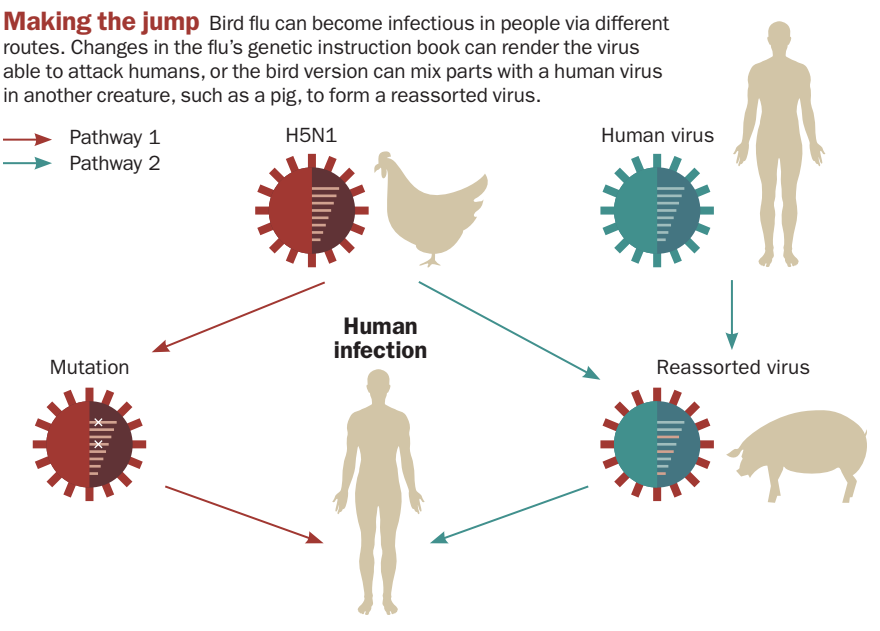
Since the advisory board's original decision was handed down, Kawaoka and Fouchier have been trying to set the record straight, giving detailed presentations to the World Health Organization and at the advisory board meeting at the end of March. The teams rewrote their papers giving more details about the viruses' transmissibility and lethality (thanks to journal editors at *Nature* and *Science* who relaxed word-count restrictions). The additional information, rewritten papers, face-to-face meetings with the researchers and a new comprehensive U.S. government policy on how to handle dual-use research tipped the board's risk-benefit balance and the board reversed its initial decision. On March 30 the board voted to allow the details of the papers to be published in full.

Keim said that the data in the first versions of the papers have not been changed, but that the presentations and interpretations have. The original version of Fouchier's paper, for instance, highlighted the virus's lethality when it was put directly into ferrets' tracheae.

The mutant, transmissible form of the virus killed one of eight animals and only when delivered in high doses into the trachea, Fouchier explained following the board's initial decision.

"It's absolutely clear that H5N1 is a highly pathogenic virus for chickens," Fouchier said. "You inoculate a chicken, the chicken will drop dead." And high doses of the virus put directly into the lungs will kill a ferret in three days. But inoculating the viruses into ferrets' tracheae is another story. Most develop the common symptoms of ferret flu — ruffled fur, loss of appetite and lethargy. "They might get a little bit of flu," he said, "but they certainly do not drop dead."

Ferrets that contracted the virus from



Making the jump Bird flu can become infectious in people via different routes. Changes in the flu's genetic instruction book can render the virus able to attack humans, or the bird version can mix parts with a human virus in another creature, such as a pig, to form a reassorted virus.

CHICKEN AND PIG ICONS: MIKIR/SHUTTERSTOCK; HUMAN ICON: MATTHEW COLE/SHUTTERSTOCK; VIRUS ICONS: T. DUBÉ

other ferrets' sneezes also didn't die. "It's certainly not highly lethal if ferrets start coughing and sneezing at one another," Fouchier said.

A second misconception centered on how well the virus spread. Media reports said that "the virus would spread like wildfire if it came out of our facility," Fouchier said. "But we do not think this is the case."

His team's transmissible, quintuple mutant version of H5N1 appears to spread less efficiently than the 2009 pandemic swine flu strain. "This is a lousy transmitter at this stage still," he said. He cited several pieces of evidence indicating that the virus doesn't spread well, including that fact that animals infected with the mutant H5N1 made few infectious particles. The quantity of such particles is important because the dose of a virus people are exposed to can influence how sick they get.

What's more, ferrets previously exposed to seasonal flu were completely protected from severe disease when given the team's airborne H5N1. A group of researchers in Belgium reported in 2009 in *Vaccine* that being infected with an H1N1 virus gives pigs partial protection against H5N1. Extending those findings to humans, Fouchier said people who have caught seasonal flu would have some protection against H5N1. "Very few individuals would actually develop severe disease, but would actually be protected by cross-protective immunity."

Osterholm disputes the claim that immunity to other flu viruses will protect people from H5N1. "There is no data in the human experience to support that," he says. Contracting one year's seasonal flu strain doesn't protect people from next year's version of the virus, so there's no reason to think that getting other flu strains or flu vaccines will protect people from H5N1, he said.

The argument that the Fouchier team's virus isn't so deadly doesn't convince Osterholm that proceeding with publication is a good idea, either. Osterholm, who was one of the minority of members that voted at the advisory board's March meeting to withhold data from the Dutch group's paper, says he is more worried about the virus's ability to spread. Even low transmissibility is bad: If a terrorist were to let such a virus loose, it may start recombining with seasonal flu strains to produce yet more nasty, pandemic strains.

Information revelation

Some scientists, Adolfo García-Sastre included, think concerns over terrorists making a lab-made replica are overblown. García-Sastre, a microbiologist at Mount Sinai School of Medicine in New York City who specializes in influenza biology, was part of a team that resurrected the 1918 flu virus in the lab and reported the feat in *Science* in 2005. "One could argue that the same thing could have happened when we re-created 1918, but nobody has done it," he says.

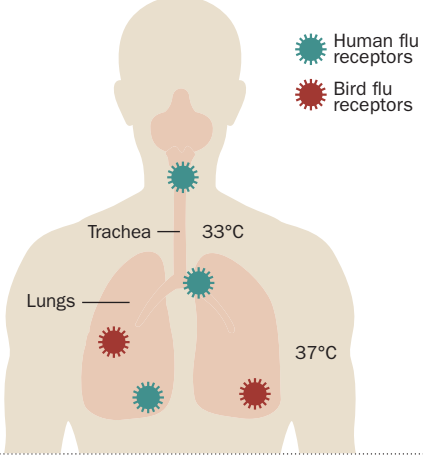
That paper is the only one of the six the advisory board has reviewed that Osterholm now regrets not holding back from publication. The thought at the time was that people would already have immunity to H1N1 viruses, such as the 1918 virus, because many seasonal flu strains are similar. It was only when the 2009 H1N1 pandemic hit that he and others realized they had been wrong, he says. He doesn't want to repeat the mistake with H5N1, and making the Dutch team's paper fully available could be just such a mistake.

But others say even if it is a mistake, it's been made before — information about creating a more dangerous H5N1 virus is already out there. Researchers from the U.S. Centers for Disease Control and Prevention in Atlanta and the Scripps Research Institute in La Jolla, Calif., reported in the Jan. 5 *Virology* that they had made a more transmissible form of the virus. The researchers

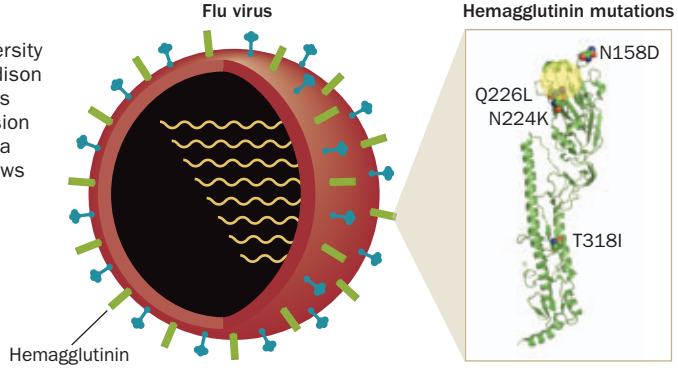
Infectious changes Biological barriers — several of which are related to the human upper respiratory tract — stand in the way of a bird flu strain becoming highly transmissible among humans, scientists say. Late last year, though, two teams reported making a lab-made virus capable of overcoming some of these obstacles.

Barriers to human infection

1. Bird flu would have to latch onto receptor molecules in a person's throat and upper respiratory system. Receptors targeted by bird flu are found only deep in the lungs.
2. The virus would have to survive at cooler temperatures, corresponding to the 33° Celsius environment found in the human upper airways.
3. To replicate, the virus would need to marshal the cells' reproductive machinery for its own purposes.
4. The virus would have to get around human immune defenses.



Genetic tweaks An airborne virus made at the University of Wisconsin–Madison had four mutations in the bird flu version of hemagglutinin, a molecule that allows the virus to hook onto cells.



FROM TOP: RESPIRATORY SYSTEM: MATTHEW COLE/SHUTTERSTOCK, ADAPTED BY T. DUBÉ; VIRUS: T. DUBÉ; RIBBON STRUCTURE: H.-L. YEN AND J.S.M. PEIRIS/*NATURE* 2012

mutated the hemagglutinin from H5N1 and found that three mutations, including one known as Q226L that was also found in the Wisconsin study, were enough to make the virus able to pass via direct contact from ferret to ferret. But those researchers did not make a fully airborne version of the virus.

Many more changes would be required to achieve a version of H5N1 that could transmit easily between people, the CDC and Scripps team speculated. But the researchers may have been closer than they thought. This paper was not reviewed by the biosecurity advisory board.

"That was startling because we did not know it was in the works until it appeared," Keim said.

Both Kawaoka's and Fouchier's groups have also previously published papers describing mutations found in H5N1 in the wild that allowed the virus to bind to cells in the upper respiratory tract, including mutations in some viruses isolated from infected people.

Almost anybody who has training in virology and molecular biology and the specialized skills to grow influenza viruses in the laboratory could, with instructions, replicate the viruses that these two teams created, García-Sastre admits. "But the same people who have this training can make this happen without knowing this information."

The techniques the two groups used are common, and other researchers could use similar methods to develop their own version of an airborne H5N1. So withholding data about the mutations doesn't make people any safer, García-Sastre argues. "I don't want to say that everything should be published," he says. "If someone stumbles upon something that no one could have predicted, or used techniques no one would have thought would result in a very dangerous virus, I think that should not be published."

Most everyone agrees that eventually there will be a dual-use research paper that may be far too dangerous to publish. But for now, the power of public health information sharing has trumped biosecurity concerns.

After both famous manuscripts have had their day in print, the debate over dual-use research in general may be set aside. That's exactly what many people don't want to happen. Researchers, journal publishers and government officials have all urged that a mechanism for dealing with potentially dangerous information needs to be put in place before the next scary paper comes along.

That may happen sooner rather than later: Some reports suggest Fouchier's ferret research uncovered yet another mutation in H5N1, one that may make the virus even more transmissible.

Screenwriters are already penning a sequel. ■

Biosecurity blowback

When two papers reporting lab-made infectious bird flu entered the limelight last year, they stirred up policy issues that went far beyond the question of to be or not to be published.

If the details of the studies were redacted, for example, then who should get to see the information? Currently there is no plan in place for identifying who deserves access to data of this type for public health purposes or for delivering the content in confidence. It is not even clear who has the authority to oversee such a data-distribution system. In the case of both flu papers, government agencies in the United States and the Netherlands decided—to the surprise of the researchers—that export restrictions applied to the scientific data.

Concerns also surfaced about what a precedent of redaction would mean for the future of public health science. Currently, countries share their viruses with the research world under the assumption that they will have access to any findings. Without access, those countries might not be so generous. And then there is the importance of publication to a scientific career: A precedent of redaction might dissuade scientists from tackling topics that mingle with biosecurity. An independent evaluation of one of the flu papers, commissioned by *Nature*, concluded that "pushing the best scientists towards blander areas in which they can more easily publish must increase our vulnerability" to diseases for which no countermeasures exist.

Other questions stemmed from the nature of the research itself. Canada has passed a regulation requiring that transmissible H5N1 human research be conducted at a Biosafety Level 4 lab, the highest designation, which requires scientists to work in space suits inside fully sealed facilities in which nothing gets in or out without sterilization (Level 4 lab shown). Such precautions are hard to come by in many countries where H5N1 is a problem.

Some people have even questioned whether this type of research should be done at all, or have suggested that policy concerns be addressed before studies move forward. In response, on March 29, the U.S. government issued a new, comprehensive policy for overseeing research on avian influenza and 14 other pathogens. This "cradle to grave" policy, as biologist Paul Keim calls it, would require scientists, institutions and funding agencies to take early steps to minimize risks to people, animals or plants. If risks can't be mitigated, the government could classify the research or pull funding. —*Tina Hesman Saey*

Explore more

- To hear the researchers' talks at the April Royal Society meeting, visit www.voiceprompt.co.uk/royalsociety/030412/

STORM FRONT

Hurricane experts push to improve intensity forecasts

By Alexandra Witze

Anyone waiting for Hurricane Irene on North Carolina's coast last August might have been a little disappointed. As the storm barreled toward the Outer Banks, parka-clad TV meteorologists lined the beaches in anticipation. But instead of grinding ashore as powerfully as expected, Irene wimped out, hitting land with wind speeds about 10 percent weaker than predicted.

Just as easily, hurricanes can do the opposite, strengthening when they're not expected to. Take Charley, which jumped two categories on the hurricane scale in five hours before slamming into Florida in 2004. Or 2007's Felix, which intensified quickly into a Category 5 storm, the highest possible, before devastating much of Nicaragua.

Why some storms spin up with deadly force and others putter along, or even weaken, remains something of a scientific mystery. And so hurricane forecasters have made this problem a top priority for the next decade.

Their effort got a big shot of science in 2010, when three research groups flew planes into a series of Atlantic storms as they grew from tropical depressions to tropical storms and on to full-fledged hurricanes. Findings from the flights, just now being analyzed and reported at scientific conferences, suggest new ways that forecasters might finally conquer the challenge of understanding what makes hurricanes rev up.

After looking at the embryonic beginnings of tropical depressions, one team thinks that hurricanes may get their start from pouches of moist air whose ability to stay intact allows them to intensify into stronger storms. Another group has found, at least in the case of 2010's Hurricane Karl, that a strange warm spot at a hurricane's center may help it strengthen. Meanwhile, hurricane hunters have begun comparing storms that intensify quickly with others that don't, finding that the way winds and rainbands move may account for some of the difference.

Soon, scientists hope, the research will help them more accurately predict

A camera mounted on the underbelly of an unmanned Global Hawk aircraft captured this view of the remnants of Hurricane Frank over the eastern Pacific during the summer of 2010.

NASA'S DRYDEN FLIGHT RESEARCH CENTER

what coastal residents should expect. During this year's Atlantic hurricane season, beginning June 1, forecasters will be testing a new approach fine-tuned by the last few years of discovery.

"This is a huge deal," says Frank Marks, head of the National Oceanic and Atmospheric Administration's hurricane research division in Miami. "In the next couple of years we're going to see rapid increases in our ability to forecast peak wind. That's the way we're going."

Just in time, some say, to better understand how hurricane risks may change as rising global temperatures heat the oceans and the atmosphere.

PREDICTions

The basic physics of how hurricanes form is deceptively simple. Thunderstorms over the tropical ocean begin to organize themselves, with water vapor condensing to form rain. Warm air begins to rise, creating more condensation and a feedback loop in which the storm's center warms and an area of low pressure develops. Eventually the hurricane becomes a monstrous swirling storm with rainbands stretching hundreds of kilometers across. But exactly what happens during that early heating and condensation can vary dramatically from storm to storm — with very different consequences for what comes next.

Knowing which storms will strengthen dramatically requires understanding processes on many scales, from individual clouds to mammoth thunderstorm complexes. It's a lot harder than predicting where a particular storm will head, which is driven mainly by steering currents in the atmosphere such as the jet stream.

Imagine trying to figure out how a rubber ducky will move across a bathtub when pushed, says Edward Zipser, a meteorologist at the University of Utah in Salt Lake City. "If you know which way you're pushing and how hard you're pushing, you have a pretty good idea of where that duck will be in another three to five seconds," he says. But imagine trying to figure out how the duck is spinning throughout the journey, especially if the duck also has an internal motor whirling it around like a top. "Events on different scales of motions and dimensions affect the intensity in very complex ways," Zipser says.

100 million
Number of Americans living within 50 miles of a coastline

With nearly 100 million Americans living within 50 miles of a coastline, NOAA wants to solve the riddle of hurricane intensification sooner rather than later. The agency has set specific goals to reduce errors in its seven-day forecasts (by 20 percent by 2014, and 50 percent by 2019) of both where a storm goes and how intense it will be at any given point along that path. Intensity is what drives the category rating, and it's determined based on the highest wind speed sustained for one minute anywhere within a storm at a height of 10 meters above the water. To reach Category 1 status, the sustained speed has to be 119 kilometers per hour, and Category 5 winds exceed 252 kilometers per hour.

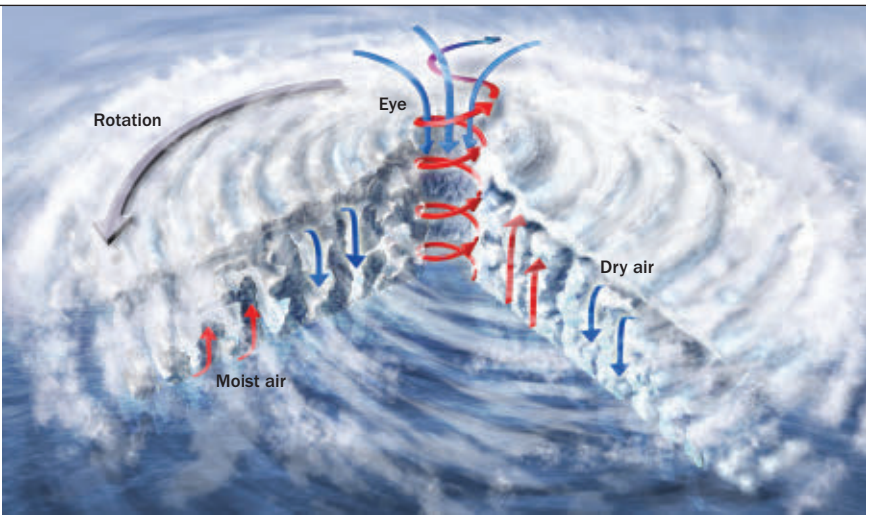
There is, of course, no average hurricane, and forecasters at Miami's National Hurricane Center do well with some storms and poorly with others. "Maybe the better way to state the goal is to reduce the times that we get caught with our pants down," says Zipser.

One way to keep their pants up as often as possible is to gather data on individual storms to see how each develops within specific environmental conditions. Hurricane hunters with the U.S. Air Force have been flying into Atlantic storms since the 1940s, on planes laden with instruments to measure factors such as wind speed, temperature and humidity. NOAA started flying a decade later. As technologies improved over the decades, scientists began tackling such questions as hurricane intensification (*SN: 6/23/07, p. 392*).

But flying the occasional reconnaissance into a single hurricane provides only a snapshot of its evolution in time, rather than a high-definition movie of its birth, life and death. Thus the unprecedented 2010 push, in which three research agencies conquered the logistics of flying multiple planes from

A spinning start Though hurricanes still hold many puzzles, scientists have a general idea of how these storms get started.

- Warm, moist air over the tropical ocean rises upward, generating thunderstorms.
- As the storms grow and merge, an area of low pressure is created below. Air from surrounding high-pressure zones flows in, picking up energy from the warm sea surface and rotating due to circulation patterns linked to Earth's rotation.
- The air that pushed into the low-pressure zone becomes warm and moist, causing it to rise. The air dries as it reaches high altitudes, falling back down toward the sea. As the storm grows and rotation picks up, an eye forms.
- Hurricane status is reached when sustained wind speeds hit 119 kilometers per hour.



NICOLLE RAGER FULLER

Danger scale
The Saffir-Simpson scale ranks hurricanes based on their sustained wind speed and also provides an estimate of the type of damage expected from the storm.

Category	Wind speed (km/h)	Damage at landfall
1	119–153	Some damage to roofs and trees
2	154–177	Major home damage, uprooted trees
3	178–208	Major damage, weeklong power outages
4	209–251	Severe damage, monthlong isolation
5	252+	Total roof failure and wall collapse

SOURCE: NATIONAL HURRICANE CENTER/NATIONAL WEATHER SERVICE

multiple locations into multiple storms.

One experiment run by the National Science Foundation, called PREDICT, targeted storms in their earliest stages. By flying out of St. Croix in the Virgin Islands, the PREDICT team could travel across much of the Atlantic and capture tropical disturbances forming off Africa's coast.

The idea was to test the charmingly named "marsupial paradigm" about how hurricanes are born. This theory holds that tropical disturbances sometimes form a small pouch where the air is more or less stationary. Like a kangaroo pouch that protects a baby from the elements, this pouch isolates and protects moisture on its journey westward across the Atlantic. "Conditions in here are favorable for thunderstorms to keep firing day after day," says Christopher Davis, a team member at the National Center for Atmospheric Research in Boulder, Colo. "This isn't sufficient to get a tropical storm, but it makes it a lot more likely."

What exactly happens to the pouch can also drive what happens to storms later. PREDICT scientists, for instance, watched a vigorous tropical depression with all the hallmarks of a storm that would intensify. It did make it to tropical storm status (with winds of 63 kilometers per hour or greater), receiving the name Gaston. It looked like it would keep getting stronger.

But then Gaston fizzled. "You could see it unraveling," says Davis. Part of the reason may be that Gaston's central vortex became misaligned, shearing sideways at higher elevations instead of maintaining a straight columnar center. Dry air could then penetrate the vortex, interrupting the flow of moist air needed to fuel the storm further, Davis and colleague David Ahijevych wrote in April in the *Journal of the Atmospheric Sciences*. So one prerequisite for intensification may be a storm's ability to hold its center together.

Hawk's-eye view

As 2010's hurricanes got closer to the Atlantic coast, a second group organized by NASA joined the fray. This team, named GRIP for Genesis and Rapid Intensification Processes, flew the typical hurricane-hunter airplanes as well as unmanned Global Hawk aircraft, the first time drones had been used for hurricane science.

The biggest success: tracking Hurricane Karl for more than a week, with more than 20 flights capturing its evolution. Karl took many days to develop from a strong low-pressure system, and scientists don't understand why it took so long. Then Karl weakened while crossing the Yucatán Peninsula, and intensified to Category 3 in the Gulf of Mexico before making its second landfall.

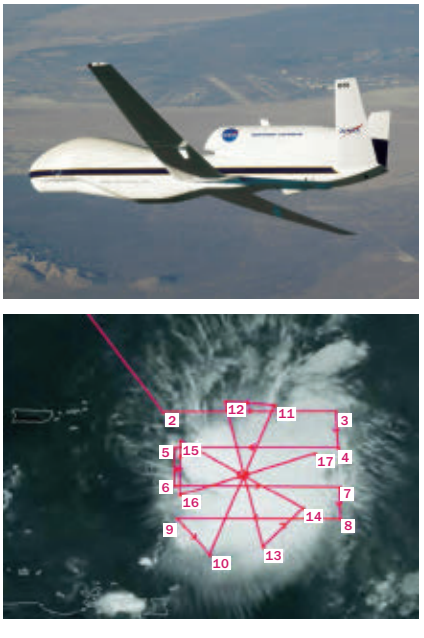
Using a radiation-measuring device on board a Global Hawk, GRIP researchers got data every half-hour for 10 hours directly over Karl's eye. The data showed details unlike any seen before of a warm spot in the upper atmosphere inside Karl. Similar warm spots have been detected in other storms right as they intensify, and may signal that a hurricane is about to get more powerful.

For Karl, the spot started out around 3 degrees Celsius warmer than the surrounding environment, then warmed about another 3 degrees as the storm spun up over the Gulf of Mexico, says meteorologist Shannon Brown of the Jet Propulsion Laboratory in Pasadena, Calif. As temperatures increased, broad swaths of clouds began to develop a sharply defined center, creating the eye. After flooding many parts of Veracruz, Karl eventually died out over the mountains of central Mexico.

Sometimes a storm's speed-up happens very quickly, like gaining several categories in less than 24 hours. If it's close to landfall at that point, forecasters can be caught off guard. "That's kind of the nightmare scenario," says Robert Rogers, a hurricane researcher at the Miami center.

Rogers is involved in the third and usually annual project, NOAA's Intensity Forecasting Experiment, which since 2005 has been flying P-3 turboprops and occasionally a Gulfstream-IV jet into hurricanes approaching the U.S. coast. The jet flies in a pattern around the outside of the storm, to gather data on the environment surrounding a hurricane. The turboprops fly through the eye of the storm. Among many other instruments, they carry Doppler radar in their tails. The radar is the sort that monitors thunderstorms on your local television station, allowing scientists

For the first time in 2010, an unmanned Global Hawk was used for hurricane science. The Hawks fly far above a storm (sample path shown) to collect information on storm intensity and evolution.



FROM TOP: NASA; S. BRAUN/NASA GODDARD SPACE FLIGHT CENTER

to build a three-dimensional picture of how winds and rain are moving in the storm.

In 2010, Hurricane Earl revved up quickly to Category 4 off the U.S. East Coast. "We had an aircraft in there almost continuously," Rogers says. The storm was a classic case of "rapid intensification," in which maximum winds increase by at least 46 kilometers per hour over 24 hours. Rapid intensification is fairly rare, but nearly every storm that gets to Category 4 or 5 goes through this phase at some point in its history. "You don't just get something building up slow and steadily," says Rogers.

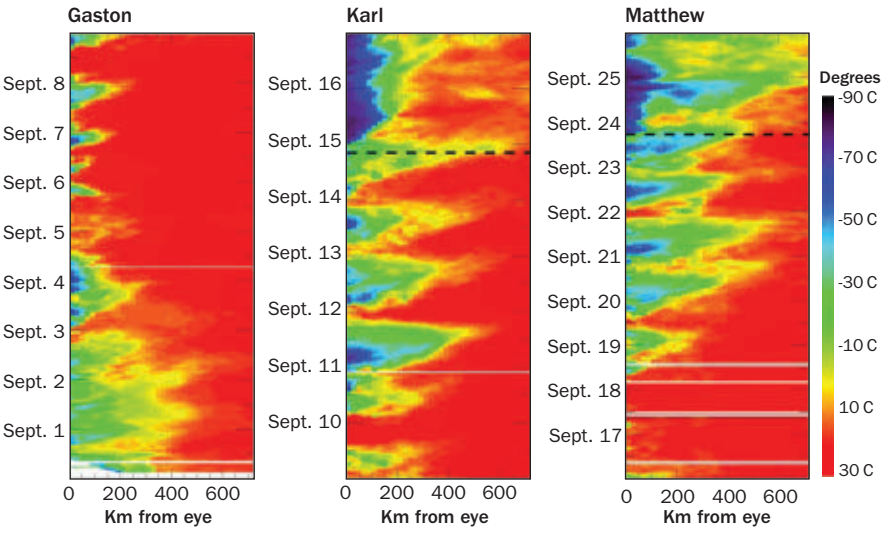
With some 15 years of detailed radar observations in hand, Rogers is now trying to draw broader conclusions about storm behavior from how individual hurricanes act. For instance, he is comparing 14 flights into storms that went through rapid intensification, including Earl, with 14 flights into storms that didn't. So far, he's seeing differences in factors such as the range of winds around the storm, how those winds flow into the center at different heights above the sea surface and how the strongest thunderstorm activity is arranged around the hurricane.

Exactly how these differences translate into being able to forecast intensity better isn't clear yet, but "now we're starting to get some good information out of the data," says Rogers. He reported his findings in April at a tropical meteorology conference in Ponte Vedra Beach, Fla.

Real-time results

After all the excitement of 2010, the following year saw more Atlantic storms than usual, but Irene was the only one to cause major damage. Now scientists are preparing for what 2012 might bring.

Along with NOAA's usual flights this summer, NASA will also be busy testing its Global Hawks to see if they are a useful — if expensive — tool to add to the hurricane-hunting repertoire. The agency will have two drones based at its Wallops Flight Facility in eastern Virginia. One will fly over a hurricane's surrounding environment, while the other will fly over the storm's inner region.



Different strokes Three 2010 storms show different patterns of cloud-top temperatures over time. Studying such measures may reveal why storms intensify as Karl did or unexpectedly unravel like Gaston. Others such as Matthew, which made landfall in Central America, cause serious damage despite remaining tropical storms. (Dotted lines show timing of tropical storm formation.)

Unlike the manned NOAA P-3 flights, which enter hurricanes at altitudes of up to 8 kilometers, the more fragile Global Hawks fly far overhead, some 19 kilometers above the sea's surface.

Global Hawks offer a key advantage in that they can stay in the air for up to 28 hours, says project leader Scott Braun of NASA's Goddard Space Flight Center in Greenbelt, Md. A typical manned hurricane-hunter flight can spend only around six to eight hours flying in a storm before it has to return for refueling and to change out crews. The drone's extra hours allow more continuous monitoring. "To really try to understand what's happening in a storm, you can't just go look at it intensely for six hours and then leave it alone for 20," Braun says. "It might change significantly in the meantime."

All these data have been helping Marks and his colleagues develop a better approach that hurricane forecasters plan to use in real time this summer. The new method for predicting hurricane path and intensity builds on years of tweaking computer codes to better simulate how hurricanes progress. This year, for the first time, NOAA forecasters will be running this experimental approach alongside their old one, to see which might give them more accurate information about a storm.

The technique will embed a detailed computer simulation, at a resolution of just 3 kilometers, inside the coarser-resolution one used until now. Marks' team recently did a three-year retrospective run, plugging in data on how and when Atlantic hurricanes started and seeing how well the simulation reproduced their tracks and intensity. "In our vernacular, it kicked butt," Marks says.

In the long term, forecasters need to better understand intensification to better prepare for the outcomes of climate change. In theory, warmer sea surface temperatures provide more fuel for hurricanes to start and feed off of.

Scientists say it's too early to know whether rising temperatures of the last few decades have already affected hurricane activity in the Atlantic. But if the climate warms as much as expected by the end of this century, hurricanes could increase globally in strength by 2 to 11 percent, according to one middle-of-the-road projection from the Intergovernmental Panel on Climate Change.

Forecasters can expect an intense time ahead. ■

Explore more

- Visit the National Hurricane Center at www.nhc.noaa.gov

C. DAVIS AND D. AHIJEVYCH/J. OF THE ATMOSPHERIC SCIENCES 2012/AMS

Darwin's Devices

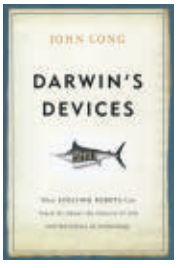
John Long

Years ago, Long realized there was something fishy about robots — that is, robots could be made to be fishlike.

Director of the Interdisciplinary Robotics Research Laboratory at Vassar College in Poughkeepsie, N.Y., Long reflects on his career as a biologist who uses robots to study fish evolution. Up front, he tackles the social hazards that come with his occupation, fielding questions like, "What do robots have to do with biology?"

Though it might be true that the best model for any organism is the organism itself, Long argues that robotic devices can offer answers to difficult questions. For one thing, scientists can construct replicas of extinct animals. As Long illustrates with his early experiments tracking tail stiffness and feeding behaviors in man-made generations of robotic fish, these devices can provide clues to how real animals may have evolved.

The chapters recount Long's quest to build better devices, starting from the early days of tinkering with a seemingly simple robotic fish called Tadros to Madeleine, a robot that can walk on land and swim. (Notably, she also holds the title for the first robot to be named after a French pastry.) Along the way there have been bumps, including



struggles to build a backbone that mimics that of a real fish and finding graduate students who can withstand hours of watching video footage of robotic fish swimming.

Clearly, it's been a labor of love for the author and his scientific collaborators. And through Long's humor and clever descriptions, readers get a sense of how the design concepts underlying these devices — and other robotic animals — have evolved. — *Rebecca Cheung*

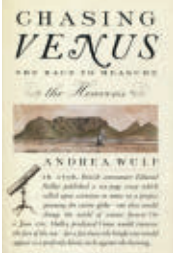
Basic Books, 2012, 273 p., $26.99

Chasing Venus

Andrea Wulf

Next time you're having a bad day at work, consider the travails of Guillaume Le Gentil, an 18th century French astronomer. He spent more than a decade toiling over measuring the transits of Venus in 1761 and 1769. By precisely timing the planet's passage across the face of the sun, Le Gentil hoped to contribute to a global scientific effort to determine the size of the solar system.

Le Gentil made his way to India in



time for the 1761 transit, but the presence of English troops forced the captain to turn back to sea. Disappointed, he stuck around the region until 1769, when (spoiler alert) a "fatal cloud" obscured the entire transit. By the time Le Gentil made it back to France, his heirs had declared him dead.

Le Gentil is just one of many quirky astronomers profiled by Wulf in this overview of the 18th century Venus transits. Wulf forgoes much of the background science in favor of the personalities of those sent to observe from remote corners of the planet. Swedish astronomers battle boredom in the long northern nights, and a French expedition battles typhus in Baja California. Captain James Cook and his *Endeavour* expedition make their way to the South Pacific, where curious natives steal and dismantle Cook's quadrant.

Wulf's stories come together in a portrait of the first truly global scientific endeavor. Countries sent astronomers to observe the transit in hopes of national glory, but science also benefited. And on June 5 this year, astronomers will follow in Le Gentil's footsteps, hopefully with a little more success. That day will see another transit of Venus, the last until the year 2117. — *Alexandra Witze*

Knopf, 2012, 302 p., $26.95

Tutankhamen

Joyce Tyldesley

An archaeologist explores myths surrounding the boy king and updates Tut fans on what experts have learned about his life and times.

Basic Books, 2012, 316 p., $29.99

In Pursuit of the Unknown

Ian Stewart

The author tells the stories of 17 equations, from Maxwell's equations that led to modern TV and radio to algorithms that rattled the stock market.

Basic Books, 2012, 342 p., $26.99

EarthFlight

John Downer

Cameras carried by hand, by gliders and by the creatures themselves give readers a literal bird's-eye view of the world.

Firefly Books, 2012, 240 p., $49.95

A World of Insects

Ring T. Cardé and Vincent H. Resh, eds.

Two entomologists present insect essays that explore everything from insect sex to crime scene investigation.

Harvard Univ., 2012, 404 p., $19.95

The Practical Einstein

József Illy

Einstein's papers reveal a down-to-earth side. Learn about his inventions and ideas, including waterproof breathable clothes and an explanation for rivers' meanderings.

Johns Hopkins Univ., 2012, 202 p., $60

How to Order To order these books or others, visit www.sciencenews.org/bookshelf. A click on a book's title will transfer you to Amazon.com.

Information as substrate

In a recent article ("Enriched with information," *SN: 3/10/12, p. 22*), you point out that some researchers consider consciousness to be a form of information. In another ("Bits of reality," *SN: 4/7/12, p. 26*), you mention that increasing numbers of physicists are coming to regard information as the basic "stuff" from which our universe is made. Information as the substrate of consciousness, information as the substrate of the material universe. An interesting connection, to say the least.
Ed Subitzky, New York, N.Y.

Still learning from *Science News*

Although it took me (as usual) three hours to digest your complete array of articles in the April 21 issue, I wouldn't miss that brain stimulation for anything in the world. It's a little like a mini–college course. You certainly know how to get a 75-year-old to pay attention, stay mentally alert and feel 40 years old again. Congratulations and thanks for another superb job done. Keep it up.
Pete Grumbach, Clearlake Oaks, Calif.

One cough cured

I read your April 21 issue with special interest in Laura Beil's "Throat therapy" article (*SN: 4/21/12, p. 22*). However, one "cough cause" was left out that most doctors miss. A very important one. I had a chronic cough that steadily worsened to the point that I was unable to sleep without medicine. I casually mentioned the problem to my cardiologist and he immediately said, "You take Altace, an ACE inhibitor, I'll bet that is the problem." My general practitioner agreed that it's a common problem. I promptly stopped my Altace (generic ramipril) and in three days my problem was totally gone. I now take another high blood pressure medicine that works well in its place.
Don Todd, via e-mail

Dark side of statins

While I can respect statins for the miracles they seem to produce in the health of others, I didn't see the dark side of these drugs mentioned in the article ("Another side to statins," *SN: 5/5/12, p. 30*). Six weeks into statin therapy I was awakened multiple times every night with intensely sharp cramps in my thighs, calves and feet. Another statin was tried, with worse results. True, few patients suffer such extreme and painful effects from statins, but for those of us who do, they are anything but miracle drugs. It seems as though statins can cure, or at least treat, a host of horrible maladies, but I would like to see an article examining the other side of this wonderful two-edged sword.
P.J. Neuschwanger, Platteville, Colo.

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

The Science Life

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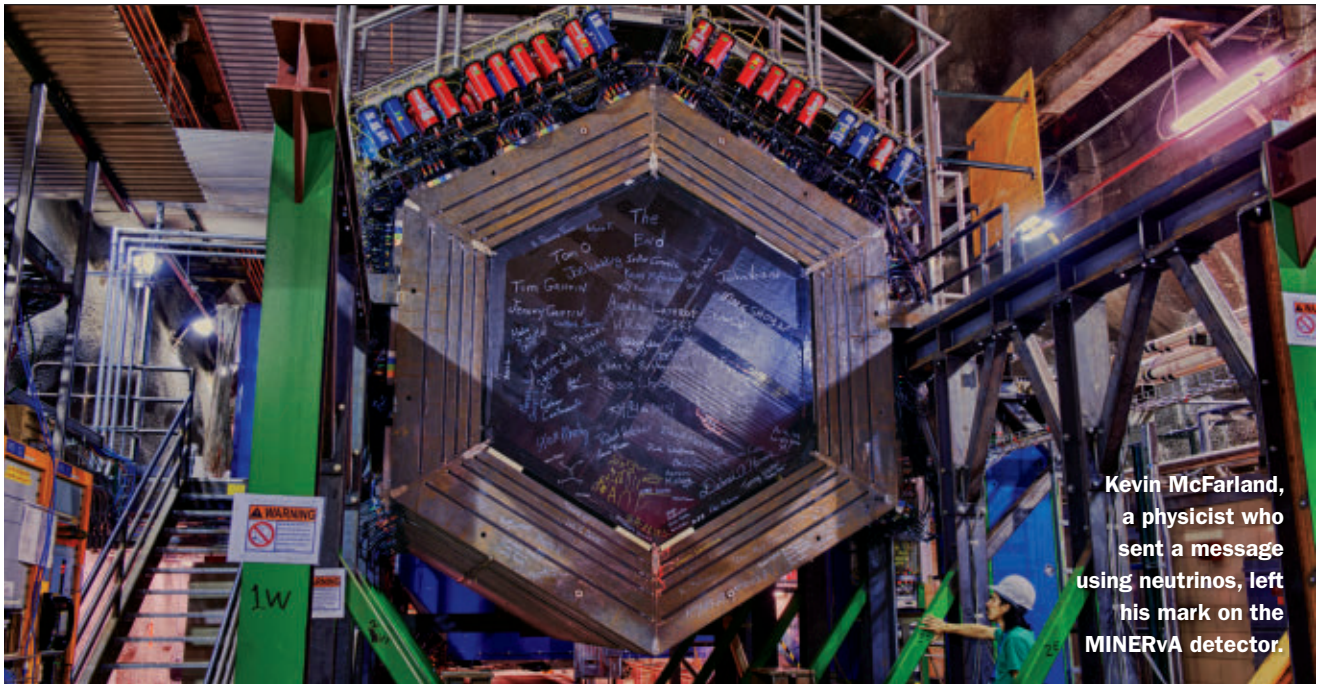


Kevin McFarland, a physicist who sent a message using neutrinos, left his mark on the MINERvA detector.

The neutrino messengers

In 1844 Samuel Morse sent a telegram from Washington, D.C., to Baltimore using pulses of electrons to encode "What hath God wrought." Now that message has gotten a reply, courtesy of physicist Kevin McFarland and a team of his colleagues.

"Neutrino" was the team's tongue-in-cheek response, broadcast in the first-ever message carried by these ghostly particles. It was supposed to be "neutrinos," but someone goofed and cut off the "s."

This offbeat project started with Daniel Stancil, an electrical engineer at North Carolina State University in Raleigh. He's been thinking about how to use all sorts of particles — including neutrinos and hypothetical entities called axions — to communicate over long distances.

"I chose neutrinos because they have a pretty significant advantage over axions," says Stancil. "They're known to exist."

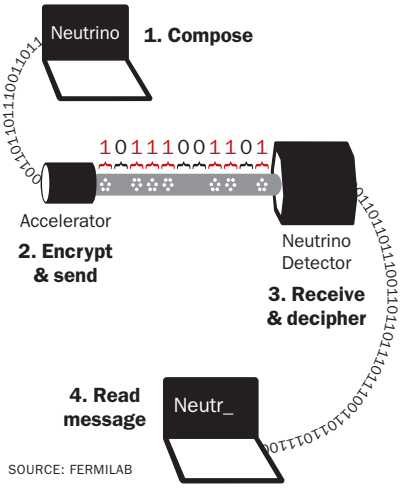
Stancil asked McFarland whether it would be possible to send such a message using the neutrino experiment MINERvA at the Fermi National Accelerator Laboratory just outside of Batavia, Ill. McFarland liked the idea but worried that it would distract from the experiment's primary goal.

"When you're doing something that's very pie in the sky like this, something that's so far off the main science mission, you have to think about whether it's worth it," says McFarland, of the University of Rochester in New York.

After deciding that a proof-of-principle trial run wouldn't take long, the physicists created bursts of neutrinos, each with 100 million particles. These pulses traveled to a 170-metric-ton detector a kilometer away that translated them, like Morse code, into the letters of the message.

Neutrinos aren't exactly the most efficient way to send a message. Just making the particles required 100 gigawatts of power. But neutrinos can zip through Earth's interior unmolested, potentially delivering messages from one side of the planet to the other — or to places difficult to reach with conventional communications, such as submarines deep underwater. — *Devin Powell*

Communicating through neutrinos



SOURCE: FERMILAB

The beam goes on

The neutrino beam used by Fermilab scientists to send a message (above) is a key part of larger physics experiments. Most neutrinos pass right through the detector that picked up the message, called MINERvA, but the few that are caught provide information about what happens when a neutrino strikes an atom's nucleus. That information helps physicists understand what happens later, when the particles arrive at a mine deep underground in Minnesota 735 kilometers away. There, a detector called MINOS looks for signs of neutrinos shape-shifting from one to another of their three flavors during flight.

FROM TOP: FERMILAB; ADAPTED BY STEPHEN EGTS

EXPERTS AGREE:

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Coin shown larger than actual size of 40 mm.

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Designed by **Impact Research Technologies**, the VersoShock™ Reverse Trampoline Sole is exclusive to Gravity Defyer shoes. It's the special combination of space age polymers and lightweight, durable "Smart Springs" that form the foundation of the first biomechanical shoe. Within your first 10 days it will adjust to your activities—improving your overall comfort by taking the "hard" out of standing on hard surfaces like concrete and tile. You'll feel like you are walking on clouds.

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Every decision in their design and execution has been focused on comfort—from their wide toe boxes and lush padded insoles to their internal cooling system. That's right, a cooling system! With every step, fresh air is exchanged for the old hot air inside your shoes and expelled through a water-tight one-way valve. *Now you can deodorize your footwear and reduce microbial growth effortlessly.*

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