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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ APRIL 21, 2012

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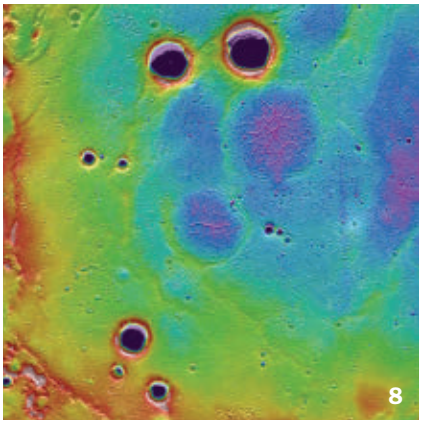

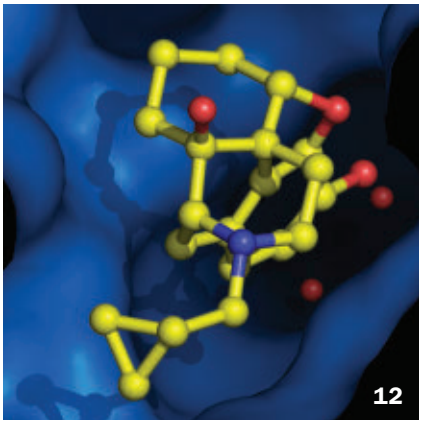

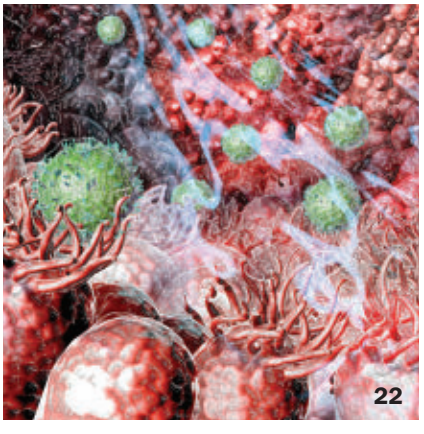

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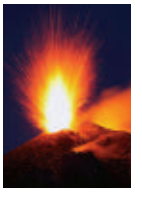

COVER Scientists are using advanced photographic technology to analyze the explosive process of volcanic eruptions at Stromboli in Sicily. *© Martin Rietze/ Westend61/Corbis*

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FROM THE EDITOR

When cooking up planets, ice grains add dash of life

Life's origin on Earth inspires a lot of scientific speculation. How did molecules get together and decide to start self-reproducing? If they had known ahead of time what life would ultimately be doing, would they have changed their minds? Would they be annoyed by someone talking about mindless molecules as if they could make choices to begin with?

Obviously, the first molecules on the newborn Earth didn't possess self-awareness — or the self-replicating survival strategies that got life going. Scientists have ideas about how that might have happened but haven't succeeded in establishing any one scenario as the likely real story. But there may be an answer to another crucial question about life's origin: Where did the raw material molecules come from in the first place?

Life's key molecules — proteins and nucleic acids — are made from the complex organic molecules known as amino acids (the links in the molecular chains composing proteins) and nucleobases (ring-shaped molecules that make up DNA and RNA). Scientists can make those molecules in the lab from simpler molecules including water, carbon dioxide and ammonia. So maybe some alien chemist concocted an organic soup and delivered it to Earth once the planet was safe enough for molecules to start families.

But it's also plausible that the disk of dust and gas in which the sun, Earth and other planets formed cooked up such molecules all by itself, as Nadia Drake reports (Page 5).

In computer simulations, scientists have analyzed what would happen to ice grains in the protoplanetary disk around the infant sun. Bombardment with ultraviolet rays (from the new sun or more distant stars) would have messed with simple molecules on the ice grains, stimulating the construction of the amino acids and nucleobases that served as life's Legos.

This analysis shows that the conditions needed to create such chemicals should be common in the disk from which planets form around any star. And so wherever you find planets (which these days, is all over the place), the prospects of life in the neighborhood would seem to be pretty good, at least on those planets with hospitable conditions.

It seems the science is saying that creating life from scratch is an experiment that has been repeated often. It would be interesting to know if the results always come out the same. But finding that out will require a lot more than computer simulations. *—Tom Siegfried, Editor in Chief*

JIM WEBB

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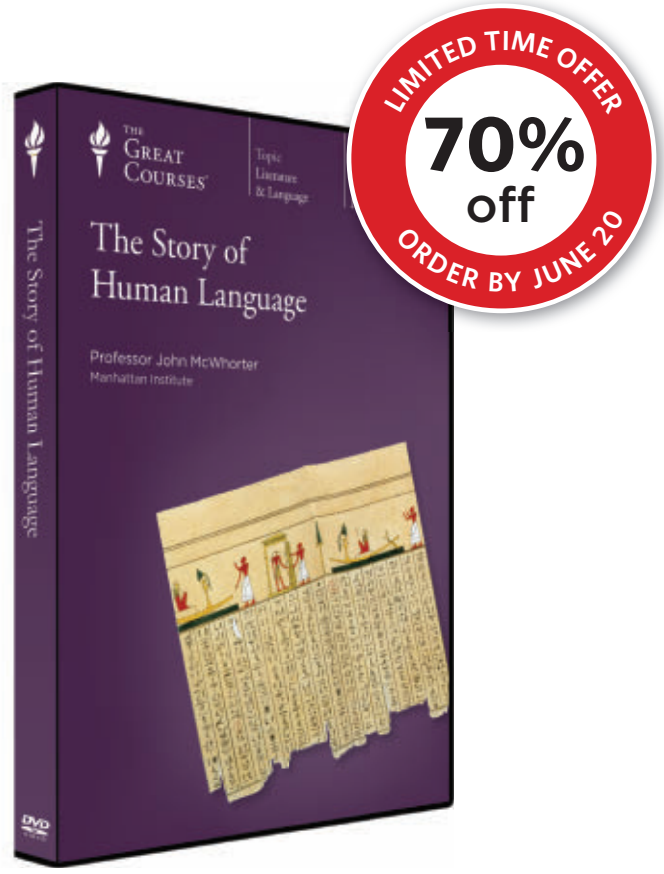

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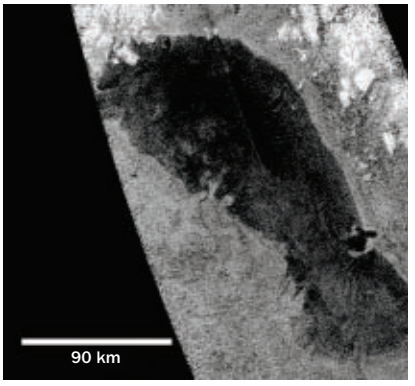

Alkanofer *al-KAN-o-fer*\ A subsurface body made of liquid alkanes, molecules such as methane and ethane that contain only single-bonded carbon and hydrogen atoms. Alkanofers are analogous to water-bearing aquifers on Earth, but are thought to exist far, far away—beneath the surface of Titan, one of Saturn's moons. Ontario Lacus (shown), the largest lake in Titan's southern hemisphere, might be shaped by a restless alkanofer. Scientists reached this conclusion by comparing the lake with Namibia's Etosha basin, a semiarid Earthly analog. Floods and droughts, combined with the rising and falling alkanofer, explain the footprint-shaped lake's flat and shallow form, scientists report in the April *Icarus*. —*Nadia Drake*

Science Past | FROM THE ISSUE OF APRIL 21, 1962

GLENN REPORTS ON FLIGHT — The brilliant light from the "fireball" Astronaut John H. Glenn Jr. saw passing the window of his space capsule was observed by more than 1,400 scientists at a symposium in Washington, D.C. A color film, showing the astronaut in his cabin during flight, clearly revealed reflections of the burning chunks of retro-pack flying off the space capsule's heatshield. The astronaut's silvery suit, his face, and instruments around him in the cabin were "washed over" with a bright orange glow every time a chunk went past the window.

Science Future

April 28
Celebrate Astronomy Day with stargazing, workshops and other events nationwide. For more information, see bit.ly/GTe2wm

May 3
An underwater archaeologist talks about surveys of pirate ships as part of a Science Museum of Minnesota series on the science and history of pirates. See bit.ly/xAPeLZ

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SCIENCE & THE PUBLIC BLOG
A court orders FDA hearings on livestock drugs. See "Growth-promoting antibiotics: On the way out?"

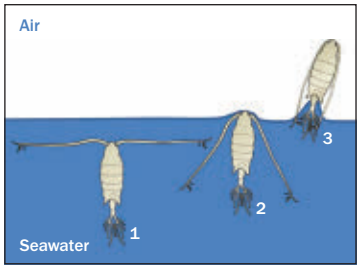
LIFE
A birdlike dinosaur (illustrated below) was iridescent. Read "*Microraptor*'s true blue colors."

ENVIRONMENT
Deep corals were harmed by the BP spill. Learn more in "The farther the better for corals after oil spill."

BODY & BRAIN
The Epstein-Barr virus may both suppress and promote lymphoma. See "Tracking the viral link to lymphoma."

How Bizarre

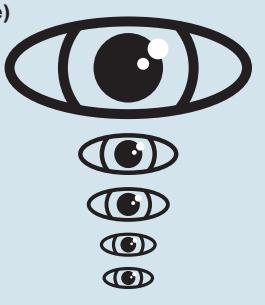
Copepods may be tiny, but they can leap predatory fish in a single bound. Researchers used cameras to record two species of these crustaceans—which don't get much bigger than 3 millimeters long—vaulting distances up to 60 times their own body length. Copepods can clear the water's surface with these jumps and reach speeds of almost a meter per second. An aerial escape carries them above and beyond the visual range of predators while expending one-twentieth the energy it would take to swim the same distance, the team reports online March 21 in *Proceedings of the Royal Society B*. —*Allison Bohac*



Science Stats | SEEING THE BIG PICTURE

The soccer ball–sized eyes of giant and colossal squid are the biggest in the animal kingdom. New research suggests that while big eyes aren't better for finding prey than smaller ones, they do give squid an advantage in spotting predatory sperm whales at a distance in dim deep-sea waters.

Diameters of animal eyes (to scale)



D.-E. NILSSON *ET AL/CURRENT BIOLOGY* 2012

CLOCKWISE FROM TOP LEFT: NASA, JPL-CALTECH; JASON BROUGHAM/UNIV. OF TEXAS; B.J. GEMMELL *ET AL./PROC. ROY. SOC. B* 2012

“The potential is very great—to use the eye to diagnose what’s going on elsewhere in the body, particularly in the brain.”
—ALISTAIR BARBER, PAGE 11

In the News

STORY ONE

Life’s building blocks can grow close to home

Complex organic chemicals may be common near stars

By Nadia Drake

The dusty disk surrounding the young star NGC 1333-IRAS 4B (illustrated) probably contains complex organic molecules formed on icy grains, a new simulation shows. Such molecules could provide the building blocks of life for many planets.

NASA, JPL-CALTECH, R. HURT/SSC AND CALTECH

Though life is a complicated brew, some of its ingredients can be plucked from Earth’s backyard instead of being imported from more distant interstellar fields.

In a new study, scientists suggest that complex organic molecules—such as the amino acids that build proteins and the ringed bases that form nucleic acids—grow on the icy dust grains that lived in the infant solar system. All it takes are high-energy ultraviolet photons to provoke the rearrangement of chemical elements in the grains’ frozen sheaths.

If making these organic ingredients happens this readily, then exoplanetary systems are probably seeded with the same fertile, organic pastures. “Anywhere you have ice and high-energy ultraviolet radiation, this process is going to take place. And those are both pretty common in the universe,” says planetary scientist Dante Lauretta of the University of Arizona.

In the new work, reported online March 29 in *Science*, researchers simulated the young solar nebula, a swirling disk of gas and dust that surrounded the sun until planets began forming, about 4.5 billion years ago. Over a 1-million-year period, the team tracked the individual movements of 5,000 dust grains, tiny organic-toting particles covered in ices made from compounds such as water, carbon dioxide, methanol and ammonia.

“We wanted to know exactly what conditions those ice particles were seeing,” says coauthor Fred Ciesla, a planetary scientist at the University of Chicago. “It’s a turbulent environment, and every particle follows its own path.”

Grains lofted above the disk’s plane met warmer temperatures and high-energy ultraviolet photons—the catalysts needed to convert elements in the simple ices to more complex molecules. In these types of reactions, photons striking chemical bonds create what study coauthor Scott Sandford calls “unhappy radicals and ions”—species that are highly reactive and ready to recombine. As warming temperatures cause the ices to evaporate, those elements can find partners and form new molecules.

Even though it’s relatively easy to create these rearranged molecules, scientists can’t really predict which will form, because the chemical reactions don’t follow familiar rules. “It’s a bit like saying, ‘I’m going to give you 10 kinds of Lego blocks, feel free to stack them in any combination you want,’ ” says Sandford, an astrophysicist at NASA’s Ames Research Center in Mountain View, Calif.

But with enough photons slamming into enough dust grains in the early solar nebula, it’s hard to avoid making complex molecules this way, Ciesla says.

Astrobiologists have identified such molecules as characters in the story of life’s origins, and there’s abundant evidence that they can survive in space. Scientists autopsying meteorites have found amino acids and nucleobases.

In the lab, researchers have shown

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how such compounds could be made astrochemically. By applying organic ices to tiny surfaces in a frigid vacuum, and then irradiating them, teams have produced an array of molecules, including one that spontaneously organizes itself into membranes, says Jason Dworkin, an astrobiologist at NASA's Goddard Space Flight Center in Greenbelt, Md.

Swirling around the young sun, organic-laden ice grains eventually clustered and clumped. The clumps grew into comets and asteroids that bore these molecules to Earth, depositing them in fiery collisions or lighting the infant skies with an organic-rich hailstorm. "I think it's well established that extraterrestrial compounds were delivered in this way," Dworkin says. It's not clear how much the space travelers contributed to the population of organic compounds on Earth, but their mode of delivery was certainly convenient. "If you want to build Lego castles, having Lego bricks falling out of the sky is not a bad idea," Sandford says.

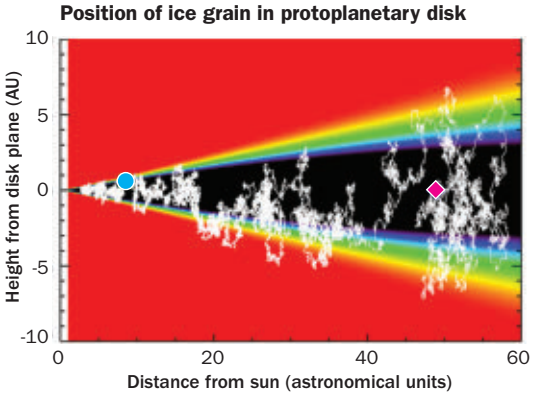
Flinging rocks at Earth is not the only way to deposit organics. "I've never felt I had to look for an extraterrestrial source of amino acids to understand how amino acids could have arisen on this planet," says geochemist George Cody of the Carnegie Institution for Science in Washington, D.C. But lots of irradiated icy particles in the solar nebula, as Ciesla and Sandford have proposed, make a tantalizing natural reservoir, he says.

Scientists are still considering whether materials made on Earth helped supply organics. It seems likely, although any complex molecules would have needed to survive the planet's violent growth spasms, marked by magma oceans and extreme temperatures. Both extraterrestrial and homegrown processes probably played a role, Ciesla says. "These organics will be there to incorporate into planets as they form, or in later delivery, after the planets form, which could be interesting in terms of astrobiology."

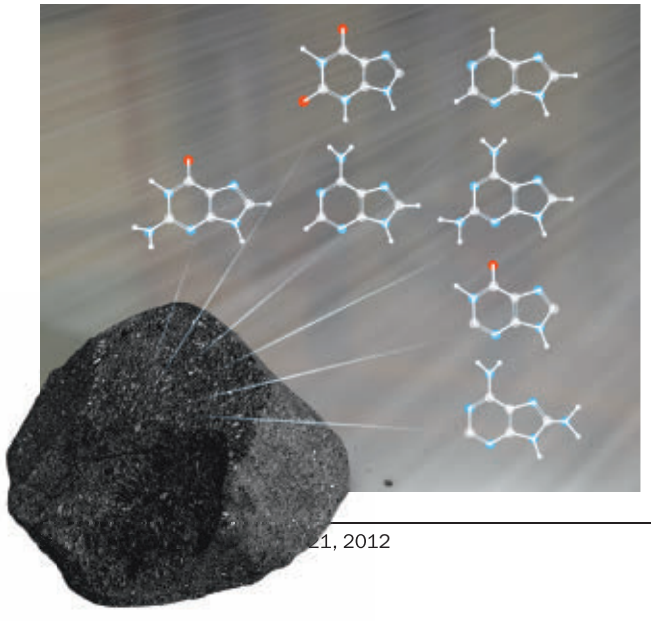
Soon, scientists should have a better idea of the array of molecules that live on asteroids. In 2016, NASA will fire the OSIRIS-REx spacecraft at asteroid 1999 RQ36 (the subject of a renaming contest this fall) to scrape off some of its surface and return the samples to Earth in 2023, providing possible clues to the solar system's early years.

"Any organic molecule is going to be interesting for deciphering the history of the solar system," says Lauretta, the principal investigator for the mission. "But for tracing the origin of life, we really focus in on the building blocks."

Life's Legos growing nearby implies a high likelihood of such organic pastures in other planetary systems. "As far as the chemistry goes," Dworkin says, "this appears universal." ■



Ice in the sun A new simulation tracked the journey (white) of an icy grain in the newborn solar system over 1 million years. The grain moves from the outer reaches of the dusty protoplanetary disk (starting at pink diamond) toward the sun (reaching the blue circle). Along the way, the particle migrates vertically within the disk. As it bounces in and out of the disk's plane, the particle encounters ultraviolet photons—dramatically more at the fringes (red) than in the center (black). These photons can catalyze chemical reactions on the grain's surface.



Back Story | SPECIAL DELIVERY

Meteorites have yielded many types of complex organic molecules over the years. In 1970 scientists found protein-building amino acids in the Murchison meteorite, which landed in Australia the year before. More recently, last August, researchers found nucleobases (shown left), ringed structures that make up nucleic acids, inside space rocks that had landed in Antarctica. Some of the rocks contained molecules that are rare in Earthly biology, which strongly suggested an extraterrestrial origin. But what's been unclear is how—and where—these molecules were cooked up. Earlier theories have pointed to synthesis in the larger cloud of gas from which the solar system formed, implying that life's ingredients had been imported from farther away. Now it appears that these molecules can be readily made in Earth's backyard—and in similar planetary neighborhoods all over the universe.

FROM TOP: F.J. CIESLA, S.A. SANDFORD/*SCIENCE* 2012; CHRIS SMITH/NASA GSFC

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Smallest planet yields surprises

Mercury has complex interior, signs of active geologic past

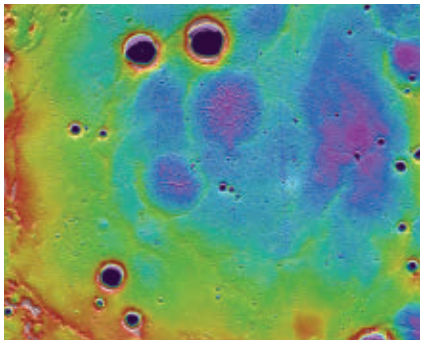
By Nadia Drake

Mercury is even weirder than expected, NASA's MESSENGER probe is showing.

For starters, the planet's interior is built differently than anything else scientists have blueprints for. Unlike Earth's, Mercury's core — which takes up 85 percent of the planet's radius — has three layers instead of two. At the planet's heart lies a probable solid layer, surrounded by a swirling liquid iron layer, encapsulated by a third, solid iron-sulfur layer.

The new results were presented on March 21 and in two papers appearing online in *Science*. One paper discusses the gravity measurements leading to the new model of the planet's interior, and the other describes surface features on the planet's northern hemisphere.

Reconciling Mercury's surface composition with its density has confounded scientists. With a standard, two-layered



Images of volcanic plains on Mercury showing areas of low elevation (purple) and high elevation (white) suggest that the planet had an active geologic past.

core, surface rocks don't contain enough heavy elements, like iron and titanium, to account for the observed density.

"So we had to ask ourselves, 'How could this be formed?'" said Steven Hauck of Case Western Reserve University in Cleveland. The iron-sulfur shell surrounding the core solves that problem by providing the missing bulk. "It sits at the base of the rock layer, and we have high-density metal that sits right beneath it as a part of the total solid," he said.

But researchers aren't positive that the innermost solid core exists. "There is room for alternative models," Hauck said. "But based on the observational data, the more probable models lead to this idea."

Scientists also identified wrinkly surface features called fold-and-thrust belts that arise when Mercury's core cools and contracts. As the core shrinks, so must the planet's outer crust, sliding bits of crust beneath other bits of crust in the process, Paul Byrne of the Carnegie Institution for Science in Washington, D.C., reported. New topographical data helped Byrne and colleagues measure the length of the sinuous crinkles, some of which cover more than 1,000 kilometers.

In addition, new topographic maps suggest that the planet had a much livelier geologic history than expected. Crater floors are tilted in some areas, and the floor of the Caloris impact basin rises above the rim in some places. Some sort of very active process inside the planet must have boosted material above the crater's rim, said Maria Zuber of MIT.

Scientists used to think Mercury was similar to the moon but now doubt that the planet quickly cooled and became a dead chunk of rock. "Mercury had a very active middle age," Zuber said.

Titan's hazy veil falls toward surface

Lower shroud around Saturn moon suggests seasonal shift

By Nadia Drake

The sky is falling on Titan. An upper layer of the Saturnian moon's hazy shroud has plunged more than 100 kilometers since the Cassini spacecraft whizzed by in 2004, suggesting that shifting seasons can do more than dump rain.

Early Cassini images revealed a smoggy world circled by a detached, hazy layer 500 kilometers above the surface. New images reveal that layer has sunk to an altitude of about 360 kilometers, Robert West of the Jet Propulsion Laboratory in Pasadena, Calif., reported on March 19.

The layer's current altitude almost precisely matches the haze's position in 1981, when the Voyager 2 spacecraft recorded images of Titan hiding beneath the clouds. "To me, that's just astonishing," said West.

One year on Titan is the equivalent of nearly 30 years on Earth — and now, one Titan year after Voyager, the moon looks more or less as it did in 1981. When Cassini first swung by in 2004, the haze had spread outward and covered the entire moon except for the wintry north pole vortex. Now, as winter comes to the south, the haze is shrinking, and images snapped by Cassini in late February reveal the beginnings of a vortex at the south pole.

"It's really spectacular," said planetary scientist John Spencer of the Southwest Research Institute in Boulder, Colo. "You're seeing this world changing before your eyes, and there are all these totally unexpected, very dramatic patterns that show up. You just can't wait to see what's going to happen next."

Scientists suspect that shifting seasons are accompanied by changing atmospheric patterns, and the collapsing haze layer could be one of a constellation of seasonal cycles. But so far, researchers haven't been able to explain the mechanics of the falling haze.

"This is new; we're seeing it for the first time with Cassini," West said.

NASA, JHUAPL, CIW-DTM, GSFC, MIT, BROWN UNIVERSITY; RENDERING BY JAMES DICKSON AND JIM HEAD

"We have a hard time working on this body and not thinking about it as a planet." — CHRISTOPHER RUSSELL

Vesta: More planet than asteroid

Resilient rock is layered, battered, Dawn spacecraft shows

By Nadia Drake

The enormous asteroid Vesta is more like a small, rocky planet than other space rocks wandering around the asteroid belt between Mars and Jupiter. Among other planetlike characteristics, Vesta's interior is probably divided into layers like Earth's — and scientists have detected traces of an ancient magnetic field.

"We have a hard time working on this body and not thinking about it as a planet," said UCLA's Christopher Russell, principal investigator of the Dawn spacecraft, which has been buzzing around Vesta since July.

Like Earth, Vesta probably has an iron core, a mantle and a crust. Dawn measurements suggest that the core's radius is between 107 and 113 kilometers, Carol Raymond of the Jet Propulsion Laboratory said on March 22. Vesta is about 530 kilometers across, so the core occupies almost half its diameter. And new gravity maps from Dawn reveal areas in the crust where there's "likely mantle material close to the surface," Raymond reported.

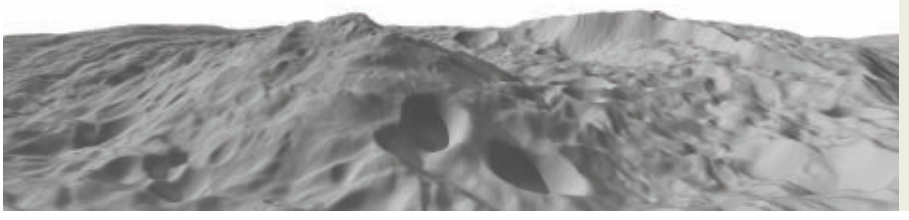
Other reports relied on data from bits of Vesta that had crashed to Earth. Two chips off the old Vestal block contain traces of a strong magnetic field, said Roger Fu, an MIT graduate student who studied meteorites known as Millbillillie (which landed in Australia in 1960) and ALHA 81001 (found in Antarctica in 1981). The field's strength suggests that an active, liquid metallic core generated the magnetic signature, which became locked into Vesta's crust as the asteroid cooled. "There was a magnetic field on the surface of Vesta after 3.6 billion years ago, and there probably still is," Fu said.

Vesta also bears multiple scars from two giant impacts, including mammoth basins in its south pole and equatorial troughs that formed as the rocky crust reverberated from the impact.

The larger basin, called Rheasilvia, is well-known. It is 505 kilometers across, consuming essentially the entire south pole, and hosts one of the tallest mountains in the solar system, which towers 20 kilometers above the basin's floor.

But the second impact basin, beneath and slightly to the side of Rheasilvia, is a newly named structure called Veneneia, Paul Schenk of the Lunar and Planetary Institute in Houston reported. It is about 395 kilometers across. The double bull's-eye at the south pole suggests that Vesta must be incredibly resilient, Schenk said.

Even so, the impacts probably penetrated Vesta's crust and scattered minerals that normally live deep underground over the surrounding surface. Scientists will continue studying and characterizing these details because even though Vesta might resemble Earth, it embodies one crucial difference: Pages from its history aren't erased. Instead, the asteroid's biography still contains records of its evolution dating back to the dawn of the solar system.



This image of Vesta, based on data from the Dawn spacecraft, shows the topography of the south polar region with the asteroid's curvature removed.

NASA, JPL-CALTECH, UCLA, MPS, DLR, IDA, PSI

MEETING NOTES

Action on Saturn moon

Dione, a lesser-known Saturnian moon, has been — and might still be — geologically active. Evidence from the Cassini spacecraft suggests that the small moon isn't just a staid icy rock, said Bonnie Buratti of the Jet Propulsion Laboratory on March 19. For one thing, charged particles emanate from the moon's surface. Other areas are riven with what Buratti calls "paleo-tiger stripes" — features reminiscent of the steamy fractures on another moon of Saturn, Enceladus. There's a feature that looks suspiciously like a cryovolcano, or something that spews ice and other cold materials instead of lava; nearby areas are smooth, suggesting that they might have been covered by a frigid eruption. And there's evidence for a tenuous oxygen atmosphere. Such observations suggest "recent and/or ongoing activity on Dione," Buratti said. — *Nadia Drake*

Bright spots after Titan's rain

Titan, a behemoth Saturnian moon with its own weather systems, has tossed scientists another curveball. Though seasonal rains wet and darken Titan's surface, some areas become brighter after a storm, Jason Barnes of the University of Idaho reported on March 19. He and colleagues studied Cassini images of Titan after a September 2010 cloudburst. After a dark phase that lasted for a few weeks, two areas, Hetpet Regio and Yalaing Terra, became whiter. The light terrain persisted for about a year before fading. Barnes thinks that evaporating liquids might cool Titan's surface, causing frost to form. — *Nadia Drake*

Body & Brain

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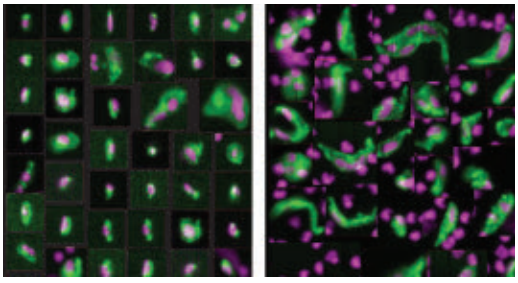
Sick cells could signal heart risk

Sensitive method spots abnormalities that foretell attacks

By Nathan Seppa

Certain cells in blood might help identify patients who remain at risk of a heart attack despite passing diagnostic tests when experiencing chest pain.

In the opening throes of a heart attack, endothelial cells from the inner lining of blood vessels get set adrift in the bloodstream, scientists report in the March 21 *Science Translational Medicine*. Heart attack patients have more of these endothelial cells in their blood than healthy people, and the cells take abnormal shapes, says Eric Topol, a cardiologist at Scripps Research Institute in La Jolla, Calif. "These are sick cells that have been subjected to profound inflammation."



Endothelial cells (green) found in the bloodstream of healthy people (left) differ from those taken from heart attack patients (right), which tend to cluster and have multiple nuclei (shown in pink).

Topol and colleagues found the abnormal cells using a new cell-sorting technology that can detect a single endothelial cell among millions of blood cells. Researchers sampled blood from 50 people with a median age of 58.5 who had chest pains that turned out to be heart attacks, and also tested 44 younger healthy volunteers and 10 healthy people age-matched to the heart attack patients.

The tests found four times as many circulating endothelial cells in the heart attack group as in the healthy volunteers. The unusual cells also clustered together and often contained multiple nuclei.

"This is a fascinating insight," says cardiologist Christopher Boos at Poole Hospital in Dorset, England. "But this is very much in the exploratory phase," as researchers have yet to prove that the abnormal cells come from the coronary arteries. Heart attacks occur when plaque in a coronary artery tears loose, inducing clotting that blocks the artery and disrupts blood flow to the heart.

But sometimes, Topol says, a person gets chest pain with no other evidence of a heart attack. The patient's heart rhythm is good, blood flow is adequate and blood analysis shows no telltale signs of dying heart cells. In these people, the body has often dissolved a clot before any heart damage could occur, Topol says.

He hopes to investigate whether these people have abnormal endothelial cells in circulation. Evidence of that would suggest an unstable coronary plaque — a heart attack still waiting to happen.

Mice react to fake memories

Neuroscientists show how to synthesize recall of fear

By Laura Sanders

In the movie *Eternal Sunshine of the Spotless Mind*, scientists erase troubling memories from Jim Carrey's head. In real life, scientists have done the opposite.

By reactivating certain nerve cells, researchers can make artificial memories pop into mice's heads. The results, published in the March 23 *Science* and online March 22 in *Nature*, offer insights into how the brain creates and uses memories.

Memory research often studies natural memories or disrupts them. In the new work, memories are actually created, says neuroscientist Richard Morris of the University of Edinburgh. "This is an extremely important step forward."

Both teams created a false memory of a fearful situation in mice. The study in *Nature*, led by Susumu Tonegawa of MIT, used a genetic trick to mark memory-making nerve cells with molecules that respond to light. This allowed scientists to reactivate those cells later using light.

The team exposed the mice to shocks in one room. A day after the fearful experience, the animals were placed in an entirely different room. Yet, when the light was turned on and the artificial memory called to mind, the animals froze in fear. The flash of light "led to the entire recall of yesterday's terrible experience," says Tonegawa. Once the light was turned off, the mice moved normally.

In the work reported in *Science*, neuroscientist Mark Mayford and colleagues used a different method to mark the cells that formed a scary memory and reactivate those cells later.

Mice first explored a square room with opaque white walls and floor, and no particular odors. Researchers tagged these memories and then put the mice in a wintergreen-scented room with a black-and-white checkered wall. Here, the mice were subjected to shocks and learned to freeze.

Activating the memory of the odor-free room during the shock session taught the mice to associate the combination of the reactivated memory and the scented room with a shock, forming a hybrid memory. Later, these mice froze only when researchers placed them in the second room and simultaneously reactivated the artificial memory. "We've essentially created a synthetic memory," says Mayford, of the Scripps Research Institute in La Jolla, Calif.

S. DAMANI *ET AL*/*SCIENCE TRANSLATIONAL MEDICINE* 2012

"Bald people will have to be patient a little longer." —KURT STENN

The yin and yang of male baldness

Family of molecules can stimulate or stop hair growth

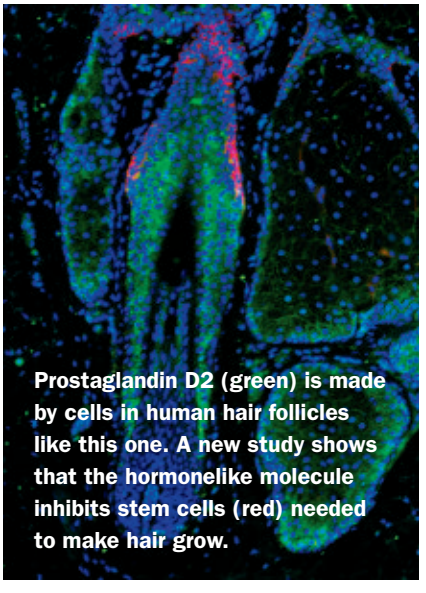
By Tina Hesman Saey

Just because a man is bald doesn't mean nothing's going on in his scalp. Men with male pattern baldness have higher levels of a molecule called prostaglandin D2 in the bald parts of their scalps than in parts still covered in hair, a new study shows.

Prostaglandin D2 stops the growth of stem cells that produce hair follicles, George Cotsarelis of the Perelman Center for Advanced Medicine at the University of Pennsylvania in Philadelphia and colleagues report in the March 21 *Science Translational Medicine*.

Cotsarelis' group had previously found that bald men still have hair follicle stem cells, but that those cells are dormant in bald areas of the head. The researchers reasoned that either the stem cells lacked growth stimuli or that an inhibitor prevented the cells from growing.

To find out which, the team analyzed gene activity in scalp samples taken from men undergoing hair transplants.



COURTESY OF LUIS GARZA AND G. COTSARELIS

Prostaglandin D2 (green) is made by cells in human hair follicles like this one. A new study shows that the hormonelike molecule inhibits stem cells (red) needed to make hair grow.

The researchers found 81 genes with higher activity in bald portions of the scalp compared with hair-covered areas. Among the more active genes was one that makes prostaglandin D2.

Other scientists had previously found that a synthetic version of a different prostaglandin called F2alpha stimulates growth of eyelashes. "Prostaglandins often have a yin and a yang," Cotsarelis says: One prostaglandin may stimulate hair growth, but another might stop it.

In the new study, prostaglandin D2 inhibited hair growth in human hair follicles in the lab and slowed hair growth in mice when applied to their skin. And mice genetically engineered to make a lot of prostaglandin D2 in the skin go bald.

Prostaglandin D2 works in the stem cells through a protein called GPR44. That protein, a receptor, sets off a biochemical chain reaction when it detects the presence of prostaglandin D2. Hair growth in mice that lack the receptor wasn't inhibited by prostaglandin D2, suggesting that drugs that block GPR44 might help treat baldness, the researchers say.

That doesn't mean a cure for baldness is right around the corner, says Kurt Stenn, a hair biologist at the Aderans Research Institute in Marietta, Ga. "Bald people will have to be patient a little longer," he says. The study raises many questions, including why levels of prostaglandin D2 increase in the first place, how the molecule interacts with testosterone (which is known to be necessary for male pattern baldness), and which other proteins might be involved in the balding process, Stenn says. "It's a beginning study, but a wonderful beginning study."

Retina offers eye on brain health

Diseased retinal blood vessels linked to mental problems

By Laura Sanders

The eyes are a window to the soul, and also to the brain. The health of easy-to-check blood vessels in the retina reflects the health of blood vessels deep in the head, raising the prospect of a simple eye exam to catch early signs of brain trouble.

"The potential is very great — to use the eye to diagnose what's going on elsewhere in the body, particularly in the brain," says Alistair Barber of Penn State College of Medicine in Hershey. "The retina is relatively easy to see. The brain is not."

The findings, in the March 27 *Neurology,* add to studies focusing on blood vessels that link eye and brain health.

Over 10 years, scientists led by biostatistician Mary Haan of the University of California, San Francisco examined the retinas of 511 women at least 65 years old. After the exams, 39 women, or 7.6 percent of the total, were found to have diseased blood vessels in the retina. This condition, called retinopathy, is a symptom of diabetes and high blood pressure, two disorders that if left untreated are known to affect brain function.

Over the decade of testing, women with retinopathy scored about 10 to 15 percent lower on questionnaires that tested brain functions such as memory and verbal fluency than did women without the eye disease. What's more, MRI scans revealed that women with retinopathy had more blood vessel damage in their brains — and also more areas of damage to brain tissue, possibly from tiny strokes. "Vascular health has a direct effect on the brain, and you can see those developments when you look at the eye," says Haan.

Although the study spanned 10 years, it wasn't designed to figure out whether eye disease shows up before brain problems. More studies are needed to clarify the timing of the disorders.

Molecules

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Imaging opioids' molecular magic

3-D views may speed search for nonaddictive painkillers

By Devin Powell

Proteins turned on by opium and similar substances in the body have been caught in action. Two new snapshots show how cellular proteins lasso molecules in the opium family, revealing the 3-D structure of such pairings for the first time.

The work represents a major step toward designing drugs that lack opioids' nasty side effects, two teams of researchers report online March 21 in *Nature*.

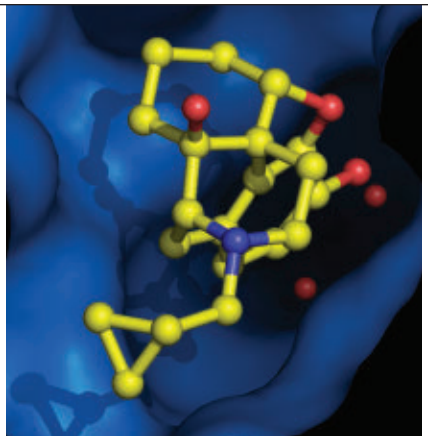
"Everyone in the field has been waiting to see these crystal structures," says Jane Aldrich, a medicinal chemist at the University of Kansas in Lawrence. "Now we can look at how particular parts of the molecules interact."

Proteins that respond to opium and opiumlike molecules protrude from cell surfaces in the brain, spinal cord and gut. Hormones and brain chemicals such as endorphins attach to these receptor molecules to control pain, regulate breathing and change mood.

Many of today's most powerful painkillers work by activating one of these proteins, the mu opioid receptor. But derivatives of opium, such as morphine and codeine, are addictive and can cause breathing problems and constipation.

To better understand these drugs, researchers crystallized a small morphinelike molecule attached to a mu receptor. X-rays revealed how one molecule lined up with the other.

This structure "may prove to be important in understanding why some opioids are more addictive than others," says coauthor Sébastien Granier, a molecular biologist now at the Institute of Functional Genomics in Montpellier, France. Although the small molecule his team worked with has the opposite effect of morphine — it deactivates the mu receptor — knowing how the molecule docks should help improve computer simulations of various drugs that can turn the protein on or off.



Knowing how a morphinelike molecule fits in the pocket of the protein it interacts with (blue background) could help scientists find less-addictive painkillers.

In the second study, Seva Katritch of the Scripps Research Institute in La Jolla, Calif., and colleagues looked at how the drug JDTic deactivates a kappa opioid receptor, which is turned on by the hallucinogen salvinorin A. "Kappa opioid receptors are especially interesting because of their ... role in regulation of stress," says Katritch. JDTic is being tested as a treatment for drug abuse.

Polymer power drives tiny reaction

Squeezing plastic ingredient generates energy for chemistry

By Rachel Ehrenberg

In the quest to wring energy from every source imaginable, scientists are putting the squeeze on a common plastic ingredient. Applying force to polymers in water generates enough energy to drive chemical reactions, a team reports online March 1 in *Angewandte Chemie*.

The technique offers a way to harness the wisps of unused energy generated by everyday endeavors, like walking or compacting plastic bags. Capturing such energy could lead to cheap, clean ways to sanitize a small container of water, or to run a simple lab-bench reaction.

Scientists knew that when mechanical force is applied to a polymer, bonds can break to generate free radicals, molecules with unpaired electrons. The new work shows that when a polymer is squeezed in water, the free radicals migrate and react with the water, generating enough hydrogen peroxide to spur other reactions.

Energy generated by walking in this sneaker created free radicals, driving a reaction to make the polymer sole glow.

The researchers squeezed various polymers, including the silicon-based polymer PDMS. Squeezing PDMS tubes filled with water containing gold and silver salts created gold and silver nanoparticles. The researchers also injected the sole of a Nike LeBron sneaker with water and a compound that fluoresces when cleaved. Half an hour of walking produced free radicals that made enough hydrogen peroxide to cleave the fluorescing compound and make the sole glow.

"People predicted that the energy efficiency would be minute," says study coauthor Bartosz Grzybowski of Northwestern University. But converting the mechanical energy of polymer squeezing into energy for driving reactions can be as efficient as 30 percent.

FROM TOP: KOBILKA LAB; H.T. BAYTEKIN AND B. BAYTEKIN

"It's a step ... towards getting to a place where we can realistically look at ways of using hydrogen." — JONATHAN HULL

Molecule holds hydrogen in liquid

New method may offer way to store gas in large quantities

By Rebecca Cheung

The dream of using hydrogen gas as a clean fuel on a large scale just got a little bit closer to coming true. Chemists have developed a new molecule that can drive chemical reactions to store and release hydrogen under mild temperatures and pressures.

"It's a step towards getting a hydrogen economy, towards getting to a place where we can realistically look at ways of using hydrogen," says Jonathan Hull, a research chemist at Brookhaven National Laboratory in Upton, N.Y. Hull and his colleagues describe the findings online March 18 in *Nature Chemistry*.

No harmful emissions are released when hydrogen is burned; only water and energy are produced. But transporting useful quantities of hydrogen gas requires keeping it at very high pressures, a process that takes a lot of energy. For these reasons, scientists are interested in finding safer, easier ways to store it.

In the new study, Hull's team created a water-soluble molecule that contains atoms of the metal iridium. That new molecule triggers hydrogen to be converted to a form that remains stored in liquid, even at low pressure. Adding a base such as baking soda to water along with this molecule, which acts as a catalyst, turns the storage process on. The scientists think that the molecule's chemical limbs, called hydroxyl groups, help break apart the bonds between two hydrogen atoms so hydrogen can be stored in a liquid.

What's more, the catalyst can also drive the opposite process. Adding an acid to the solution released hydrogen gas from its storage liquid.

By measuring the amounts of starting ingredients and end results for these reactions, the team found that this molecular switch efficiently packed and unpacked hydrogen. Also, the catch-and-release processes could be carried out at lower temperatures and pressures than can other, previously developed chemical switches that trigger these reactions.

The work "is an advance that will direct research in the future," says Amanda Morris, a chemist at Virginia Tech in Blacksburg. She adds that the hydrogen packing and unpacking reactions described in the study could have potentially useful applications in making hydrogen-fueled cars. ■

Life

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Triceratops reclaims adult status

Fossil comparison indicates dino isn't a baby *Torosaurus*

By Devin Powell

Triceratops may no longer have an identity crisis. As paleontologists lock horns on whether it was just a young version of the larger *Torosaurus*, the latest clues suggest the two were indeed separate types.

A new study reveals immature and adult examples of both *Triceratops* and *Torosaurus*. "I don't see any clear fossil evidence that one dinosaur turned into the other," says Nicholas Longrich. He and fellow Yale paleontologist Daniel Field make their case online February 29 in *PLoS ONE*.

Comparisons between the dinos, which both lived 65 million years ago in western North America, start with their skulls. Like many horned dinosaurs, *Torosaurus* sported a sizable frill of bone perforated with two big holes. *Triceratops* wore an unusually short and solid crown.

Searching for adult *Triceratops*, Longrich and Field grouped 35 skulls based mainly on how fused together the bones were. Several *Triceratops* skulls had completely fused, a sign of maturity in modern animals. Some *Torosaurus* skulls showed bones still joined by sutures, which are hints of youth.

Skulls have been found of old and young individuals for both *Torosaurus* (top) and *Triceratops* (bottom), challenging the claim that one dinosaur is merely the younger version of the other.

But fused bones may not be a reliable way to gauge age, says paleontologist John Horner of Montana State University in Bozeman. "We recently collected 100 new *Triceratops* specimens they haven't seen," he says. "We see a lot of variety in bone fusion."

In 2010 Horner blamed *Triceratops*' unusual frill on youth. Patches of thinning bone on some skulls were steps toward full-fledged holes and a *Torosaurus* adulthood, he and Montana State colleague John Scannella argued.

Triceratops' skull would have had to change dramatically to achieve this transformation. The depressions form in different places than the holes.

Finding a skull halfway between existing specimens with small holes would show that such remodeling is possible. A transitional specimen matching this description has been discovered, says Horner. But Longrich and others believe the strange skull in question — which has no horn and extra holes in bizarre places — belonged to a sick *Triceratops* or another dinosaur called *Nedoceratops*.

Carnivores often lack sweet tooth

Mutations in some species mean loss of taste for sugar

By Susan Milius

As a rough rule of tongue, animals that have lost the power to taste sweetness tend to be specialized meat-eaters.

A gene crucial for detecting sweet taste carries disabling glitches in seven of 12 mammals analyzed in a new study. The sweet-blind animals are spotted hyenas, Asiatic small-clawed otters, catlike wild hunters (fossa and banded linsang), sea lions and seals — all predators.

A sweet detector probably wouldn't give these carnivores much of an advantage as they hunt, speculates study coauthor Gary Beauchamp of the Monell Chemical Senses Center in Philadelphia. So mutations in that sweet detector gene, *Tas1r2*, could easily spread through populations, Beauchamp and colleagues propose in the March 27 *Proceedings of the National Academy of Sciences*.

This loss isn't universal among dedicated meat-eaters, though. Red wolves, Canadian otters and aardwolves (hyena relatives that stalk termites) turn out not to have lost their genetic sweet spot. "Or haven't lost it yet," Beauchamp says. Raccoons and spectacled bears, which eat broader diets, also have intact genes to taste sweetness, the researchers found.

Vegetarian animals such as the bamboo-loving giant panda also can detect sweetness in their diet. Instead, the great panda has lost the ability to detect umami, the protein-related flavor of MSG.

From the opposite point of view, some animals that don't specialize in meat nevertheless may have lost their ability to taste sweetness. For instance, chickens, which eat both plant and animal foods, don't seem to notice sweetness in their food and appear to lack the functional sweet gene, says Peihua Jiang, also of Monell and a coauthor of the new study.

Chickens are just one reason that Huabin Zhao of Wuhan University in China isn't convinced by the meat-eater/sweet-loss scenario. He has also found sweet loss among vampire bats, which are blood feeders. Narrow diet specialization might be a better explanation, he suggests.

N. LONGRICH AND D. FIELD/*PLOS ONE* 2012

36 decibels | Noise level at flower sites 125 meters from quiet gas wells

49 decibels | Noise level at flower sites 125 meters from noisy gas wells

Industrial noise disrupts plants

Effects on animals alter dispersal of seeds, pollen

By Susan Milius

Noise pollution can stomp its soundprint on plants, a study of motors chugging in a Western forest finds.

Of course, plants don't have ears, but birds and other animals hear the throb of humankind's machines. The uproar drives away some species and sometimes encourages others, swapping their various influences on plants, says Clinton Francis of the National Evolutionary Synthesis Center in Durham, N.C.

Around noisy gas wells in a northwestern New Mexico woodland, Francis and his colleagues found that the reshuffling of birds and small mammals changed the odds of success for crucial steps in plant reproduction. Hummingbird pollination, important for certain wildflowers, increased. Yet birds likely to spread around pine seeds without eating all of them largely gave way to mice that eat more of their seed cache, Francis and his colleagues report online March 21 in the *Proceedings of the Royal Society B*.

The new experiments are the first to show that sounds affect the structure of a whole biological community, says behavioral ecologist John Swaddle at the College of William and Mary in Williamsburg, Va. With such cascading consequences, "whole ecosystems can be restructured by noise pollution," he says.

The automated gas wells create a natural experimental setup for separating the effects of noise from other quirks of landscapes, Francis says. About half the wells need compressors that run day and night and blast such a din that anyone working up close needs ear protection. The rest of the wells don't use compressors but have the same basic setup.

Earlier work concluded that noise matters for bird nesting. About the same number of birds nested around both roaring and quieter wells, but quieter neighborhoods had a greater variety of species. Western scrub jays hardly showed up around the noisy sites, possibly because noise masked the jays' hunting cues. But house finches and black-chinned hummingbirds were more common there, perhaps avoiding noise-averse predators.

Francis and colleagues created a red artificial flower similar to the scarlet gilias that hummingbirds pollinate. Using a fluorescent dye representing pollen, the researchers found more hummingbird pollination at the noisy sites.

Black-chinned hummingbirds (left) are more common near noisy gas wells than near wells with quieter equipment. Tests with fake flowers (right) reveal more hummingbird pollination near noisy wells, perhaps because fewer predators lurk there.

FROM TOP LEFT: C. FRANCIS; C. FRANCIS *ET AL*/*PROC. ROYAL SOCIETY B* 2012; ANTHONY O'TOOLE

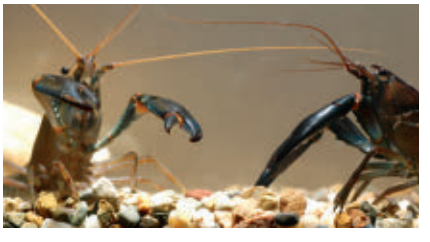
Deception aids crayfish fighters

Smaller of two claws doesn't always pack less of a punch

By Rebecca Cheung

When it comes to male crayfish, not all claws are created equal. In these crustaceans, the left and right claws might be very different sizes — and the larger one isn't necessarily stronger, researchers report online March 14 in *Biology Letters*.

This deceptiveness could help crayfish bluff or trick an opponent during a fight, says study coauthor Robbie Wilson, a biologist at the University of Queensland in Brisbane, Australia. What's more, the findings suggest that within a species, "dishonesty occurs in nature more commonly than we expect," Wilson says.



Clashing male crayfish size up their adversary's claws, but a bigger claw doesn't necessarily mean more muscle.

During a clash, a male crayfish sizes up his opponent when deciding to fight or flee. Previously, scientists found that stronger, smaller-clawed crayfish would back down from weaker, larger-clawed opponents. So some bluffing clearly occurred between these crustaceans.

In the new work, Wilson and Michael Angilletta Jr. of Arizona State University compared claw size and strength in the slender crayfish *Cherax dispar*. In some cases, one of an animal's two equally sized claws was much stronger. In other cases, a larger claw was weaker than the smaller limb. This misleading size and strength in the two claws might provide an advantage during combat, says Wilson.

Genes & Cells

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Going ape offers better family tree

Gorilla, chimp genomes suggest twists in primate evolution

By Tina Hesman Saey

Comparing a newly compiled genetic blueprint of a western lowland gorilla named Kamilah with the blueprints of humans and chimpanzees shows that the three species didn't make a clean break when splitting from a common ancestor millions of years ago.

Although humans are more closely related to chimps across about 70 percent of their genetic blueprints, or genomes, about 15 percent of the human genome bears a closer relationship to gorillas. An international team reports the findings, from the first gorilla genome to be deciphered, in the March 8 *Nature*.

A separate study of western chimpanzees, published online March 15 in *Science*, also has implications for understanding the human-chimp split. The new work shows that humans and chimps have different strategies for shuffling their genetic decks before dealing genes out to their offspring. Neither humans nor chimps shuffle genetic material randomly across the genome. Instead, both species have what are called hot spots, locations in the genetic material where matching sets of chromosomes recombine most often, Gil McVean, a statistical geneticist at the University of Oxford in England, and colleagues report.

Recombination is an important part of sexual reproduction. In making eggs and sperm, chromosome pairs are matched up and DNA is exchanged. Such shuffling of chromosome parts ensures that offspring will have combinations of genetic variants that differ from their parents. Changing recombination patterns may help keep newly separated species genetically distinct from each other.

McVean's team found that chimps mix and match genetic material in regions where genes are most active. Humans tend to confine genetic shuffling to parts of the genome with inactive genes.

The genetic blueprint of a gorilla named Kamilah (shown) reveals that about 15 percent of the human genome is closer to that of gorillas than chimps.

Chimpanzees' shuffling pattern is similar to that seen in some previously studied organisms, while the human pattern is unusual, McVean says. In humans, the location of recombination hot spots is determined by where a protein called PRDM9 latches onto DNA, but that protein doesn't appear to be the driving force for recombination in chimps. "Everything points to humans being the odd ones out," he says.

Genes differ in extrovert bees

Scouting behavior suggests insects have personalities

By Rachel Ehrenberg

That honeybee lazily probing a flower may actually be a stealth explorer, genetically destined to seek adventure.

Bees who consistently explore new environments for food have different genetic activity in their brains than their less-adventurous hive mates, scientists led by entomologist Gene Robinson of the University of Illinois at Urbana-Champaign report in the March 9 *Science*.

Honeybees that scout out food show different gene activity in the brain than less-adventurous bees.

The scientists placed a hive in an enclosure with a brightly colored feeder full of sugar water and marked the bees that visited. A few days later, the researchers added a new feeder to the enclosure, while keeping the original one full of fresh sugar water. Some bees discovered the new feeder and were also marked. Then the researchers removed the new feeder and added a different one in a new place. Again, some of the bees discovered this new feeder. The bees that found the new feeder both times were considered scouts; bees that ate only at the original feeder were considered nonscouts.

The researchers then looked at what genes were active in the brain tissue of scouts and nonscouts. "We saw massive differences in over 1,000 genes," says Robinson. Some of these genes relate to the same molecular pathways implicated in thrill-seeking in humans, suggesting that evolution may use the same genetic toolkit across species for behavioral traits. And the work adds to growing evidence that humans aren't the only species that has personalities.

"If you ask people if they think a squid has personality, they usually say no," says psychologist Sam Gosling of the University of Texas at Austin. But individual squid, and apparently bees, may consistently seek new things. In animals, scientists call that "novelty-seeking," while people who exhibit similar traits get labels like "extrovert."

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Nanopollutants harm vessel health

Tiny particles and tubes diminish arteriole response in rats

By Janet Raloff

Exposure to nano-sized particles can impair the responsiveness of very tiny blood vessels, new studies in animals show.

Vessels called arterioles don't dilate or constrict appropriately after recent nanoparticle exposure. The changes are small "but equate to a level of impairment that would preclude affected tissues from functioning normally," said microvascular physiologist Timothy Nurkiewicz of West Virginia University in Morgantown.

His team described the new experiments March 13.

The West Virginia researchers "have a unique set of findings that are pretty powerful," said Alex Carll, a toxicologist at the University of North Carolina at Chapel Hill. The data "offer further demonstration that air pollutants can impair cardiac function."

> The data "offer further demonstration that air pollutants can impair cardiac function."
>
> ALEX CARLL

In one set of tests, physiologist Travis Knuckles of West Virginia University exposed rats to airborne titanium dioxide nanoparticles — spheres 100 billionths of a meter across — for four hours on two consecutive days. The particles appear in a range of common materials, including sunscreen and cosmetics. Although not in a range considered toxic, the pollutant doses were high enough to probe the possible effects of occupational exposures to such engineered materials and nanopollutants associated with mountaintop mining.

Twenty-four hours after the second day's exposure, Knuckles stimulated the animals' muscles to contract. This process triggers arteriole dilation, increasing blood flow. But compared with changes witnessed in rats that had breathed only clean air, vessel dilation in those that had inhaled nanoparticles was lessened.

This diminished vessel relaxation is similar to what elicits a muscle cramp, chest pain in the heart or transient stroke in the brain, Nurkiewicz said.

In another experiment, rats inhaled or ingested particles known as multiwalled carbon nanotubes. Made from rolled-up sheets of carbon, these tubes are about 50 billionths of a meter across and are being explored for use in delivering drugs via the nose, mouth or injections. As with the nanospheres, the nanotubes made it harder for arterioles to dilate. The nanotubes also exaggerated constriction when the body commanded arterioles to reduce blood flow.

Effects peaked at about 24 hours after exposure to the particles, after which the arterioles' responsiveness began to improve. However, even a week later, the vessels hadn't fully returned to normal, reported Phoebe Stapleton, a toxicologist on the West Virginia team.

The findings also showed that vessel impairments did not require lung exposures: In these experiments, ingested nanotubes produced the most dramatic change in arteriole reactivity.

Other teams at the meeting reported preliminary evidence of toxic immune responses in animals and isolated cells to other nanoparticles being developed for releasing medicines.

Taken together, Nurkiewicz said, these new data suggest that researchers should consider not only how much of a nano-delivered drug to give, but also the recipe of the nanomaterial used to ferry it. ■

MEETING NOTES

Fungus products among us

Fungal-derived estrogen mimics may delay puberty in girls, an ongoing study concludes. Experts have widely believed that the compounds would never be detectable in humans. Yet urine from 58 adolescents tested as part of a project called the Jersey Girl Study contained the estrogen mimics zearalenone — which is produced by fungi that infect grains — or zeranol, a synthetic muscle-boosting analog administered to livestock. Girls who ate beef the day before the testing excreted zeranol, and eating popcorn was linked to zearalenone. Compared with others their age, the girls most exposed to these compounds had shorter stature and were less likely to have reached puberty, Helmut Zarbl of the University of Medicine and Dentistry of New Jersey in Piscataway reported March 12.
— Janet Raloff

Bee-deviled by pesticides

Supposedly nontoxic quantities of crop pesticides can subtly disrupt honeybee behavior, new data show. Louisa Hooven of Oregon State University in Corvallis applied a trio of the chemicals to hive wax. All three widely taint U.S. hives. Queen bees tried to avoid the pesticide-laced wax, Hooven reported March 12 — dramatically shifting where they laid eggs. Nurse or caretaker bees, which develop important daily activity cycles called circadian rhythms only as they mature into foragers, took substantially longer to develop the cycles if exposed to tainted wax. The higher the bees' pesticide exposures, the longer the delay. *— Janet Raloff*

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High-speed videos capture rocks flying at unheard-of rates

By Alexandra Witze

The fiery fountains of erupting volcanoes seem tailor-made for the Discovery Channel. But scientists, too, are interested in capturing footage of these natural spectacles, especially for what it can reveal about how superheated gas and rock blast out at up to supersonic speeds.

New high-speed videos from Italy's Mount Stromboli show that its continual eruptions can belch stuff out more than twice as fast as scientists had thought. This surprising finding is bolstered by laboratory experiments that grind up rock and eject it at high pressure, in a sort of tabletop eruption. "We think we're getting close to what's going on in the throat and gut in a volcano," says Donald Dingwell, a volcanologist at Ludwig Maximilians University Munich whose team has done much of the lab work.

The research suggests new ways to think about natural hazards, such as how far away people should stay from an eruption and how tiny ash fragments can be lofted kilometers high — potentially shutting down airspace, as the Icelandic volcano Eyjafjallajökull did in 2010.

Scientists have long listened to the heartbeat of many of the planet's most awesome volcanoes, from Mount Etna in Sicily to Kilauea in Hawaii. On the surface, seismometers measure tiny quakes that could signal magma starting to rise from deep in the ground. Overhead, satellites watch for the landscape rising or deflating like a giant geological breath, another possible indicator of an imminent eruption. And plenty of cameras have shot gorgeous imagery of fire sprays, oozing lava and other volcanic wonders.

But researchers don't yet understand the physics of what happens in the volcano's throat at the moment when magma spurts through a vent, shattering into tiny fragments and larger, more deadly "bombs" that hurtle into the air. By definition an explosion happens quickly, making it hard to study. So recently Jacopo Taddeucci of the National Institute of Geophysics and Volcanology in Rome decided to lug a high-speed camera to an eruption to take a look.

Such sensitive cameras, built to photograph high-speed processes in more tame environments, weren't meant for the toxic gases and ash falls atop an active volcano. At first, Taddeucci says, "I was so worried about destroying the camera or breaking it." But eventually he and his colleagues developed a lightweight, rugged version that they hauled first to Stromboli, off the coast of Sicily. They set up shop several hundred meters from the active vent and started filming the rocks zooming in all directions. "When you're there, you're not as scared for the camera as for yourself," Taddeucci says.

Projectile paths

By videotaping explosions at up to 1,000 frames per second, dozens of times faster than the film speed for a Hollywood movie, Taddeucci could trace how quickly particles flew from Stromboli's throat. The ash bits whizzed at up to 405 meters per second, more than twice that ever measured before. He captured particles being lofted upward by convective air currents. He saw the crater floor seething restlessly just before it exploded. He could even watch shock waves coming out, one after another, as gas pockets gave way and let out fresh material, his group wrote in January in *Geophysical Research Letters*. No one had ever before seen these explosive moments in such detail.

Along with the high-speed camera, the scientists also set up a thermal camera to measure the temperature of particles and a microphone to record the booms. Together, the new data offer one of the first glimpses into volcanic processes that have been almost entirely unknown to science until now. "This really opens a new range of perspectives on explosive volcanism," Taddeucci says.

Bruce Houghton, a volcanologist at the

COURTESY OF M.A. ALATORRE-IBARGÜENGOITIA

Lab-made volcanic eruptions (shown) support field data showing rocks flying out of a volcano at breakneck speeds.

University of Hawaii at Manoa, agrees; he is trying to get money to pay for a similarly sophisticated camera setup at the Big Island's Kilauea. "It is really a spectacular advance," Houghton says.

Experiments in Dingwell's lab show the same kind of explosive moments going on. After collecting and grinding up rocks from real-world eruptions, the researchers put the rock powder into one high-pressure tube meant to simulate the insides of a volcano and then let the material rapidly decompress into a second tube. The team has a front-row seat for this explosion. "This time we're watching and deciding when and how," Dingwell said in February in Vancouver at a meeting of the American Association for the Advancement of Science.

A high-speed camera captures the size and speed of accelerating particles. The lab videos show shock waves, like those Taddeucci sees at Stromboli, driving pulses of material from the eruption. Careful measurements show that the pulses are dictated by the size of particles being destroyed as gas pockets blow out. "That's why it's interesting that our lab is observing what Jacopo is also seeing," says Miguel Alatorre-Ibargüengoitia, a researcher in the lab. "We can really replicate what's going on."

In the lab experiments, Alatorre-Ibargüengoitia knows exactly what pressure the rocks exploded under, data he can use to calculate the depth from which the simulated magma erupted. "In nature, we don't know any of these parameters," he says. The work shows, for instance, that particles shooting out of the eruption drop off in speed proportionally to the depth from which they were ejected. That information, in turn, can help pin down how much magma is spewing out of an eruption, along with how much gas it contains and at what pressures. Alatorre-Ibargüengoitia and colleagues described the work last year in *Earth and Planetary Science Letters*.

The team is also working to see what factors control how far large rocks get ejected from volcanoes. By measuring the pressure needed to throw a lab rock of a certain size a certain distance, the scientists can better calculate the immense forces that fuel eruptions such as those at Mexico's Popocatépetl. Alatorre-Ibargüengoitia has measured rocks traveling up to 400 meters per second, the same sort of speeds recorded at Stromboli for much smaller particles. These larger "volcanic bombs" can land as far as five kilometers from the actual eruption vent.

> "When you're there, you're not as scared for the camera as for yourself."
> JACOPO TADDEUCCI

Safety first

Eventually, the scientists hope to see their lab work and occasional videotaping translate into better monitoring of live volcanoes. "There's still an important gap between experiments and the real world," says Alatorre-Ibargüengoitia. "We are trying to close this gap."

For instance, colleagues at the University of Hamburg have been tracking the speed of stuff flying out of volcanoes using Doppler radar, finding that some standard monitoring techniques don't always accurately reflect the size and energy of an explosion. (Not that better information always results in safer conditions; at Etna's current eruption, tourists have regularly brushed past warning signs and continued dangerously close to the summit to take pictures.)

For their part, Taddeucci and his colleagues have already taken their high-speed camera to three other volcanoes, in Guatemala and in Vanuatu in the South Pacific, and seen similarly fast ejections there. Next, Taddeucci wants to clock some of the biggest and baddest things in volcanology: pyroclastic flows, or massive avalanches of gas and rock that catapult down the sides of mountains.

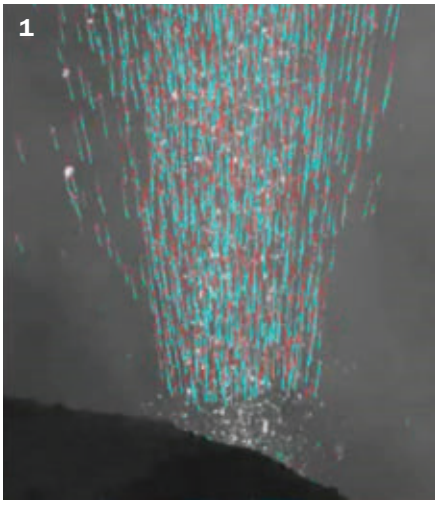
Such flows have taken the lives of volcanologists, including experienced photographers Maurice and Katia Krafft in 1991. "You have to find a suitable volcano that you can look at without dying," says Taddeucci. ■

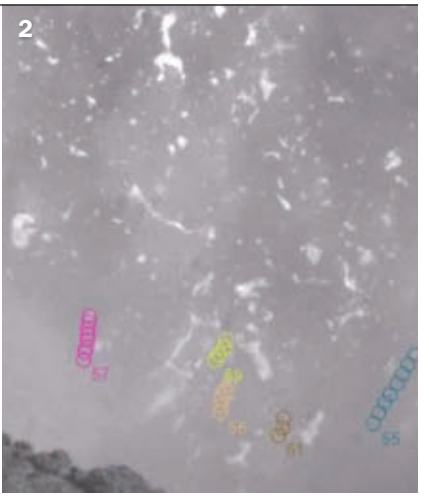
Explore more

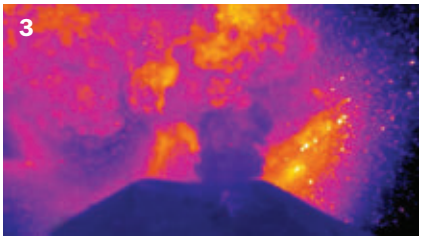
- Mount Stromboli info and webcam: www.eolnet.it/ita/webcam2.asp

Explosive views

Lugging sophisticated cameras to volcanic eruptions has paid off big for scientists. **1.** A team has tracked the velocity, size and angle of spewed particles at Stromboli in Italy. **2.** Single particles are tracked manually in a video from Yasur in Vanuatu. **3.** A thermal camera captures volcanic bombs leaving Fuego in Guatemala.







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Throat therapy

Scientists seek a cough remedy that really delivers relief

By Laura Beil

Each year more than 26 million people in the United States go to a doctor complaining about a cough. Most have colds and will just have to wait it out. Other people cough because they have allergies, asthma, bronchitis, pneumonia or even cancer. In rare instances, there is no known culprit — a person simply starts coughing and can't stop.

What all these patients desperately want, and what doctors don't have, is a way to just make the cough go away. Americans end up spending $4 billion a year on over-the-counter remedies that the American College of Chest Physicians says show little evidence of effectiveness.

As common as coughing is, it turns out not to be very well understood. "Cough in general has until recently been grossly under-researched," says pulmonologist Peter Dicpinigaitis, who heads the Montefiore Cough Center in New York City, one of the few such centers in the country. He notes that the latest new medicines approved to treat a cough, such as dextromethorphan (the active cough-suppressing ingredient in Robitussin), entered the market more than a generation ago. Over-the-counter cough suppressants are considered weakly effective, when effective at all, and prescription medicines are fraught with side effects.

But compared with previous decades, the last few years have yielded significant insights into cough science, encouraging more researchers and pharmaceutical companies to have a look. (Given how much money is spent on cough suppressants, pharmaceutical companies recognize that a better, safer syrup would be a blockbuster.)

Studies so far have found molecular on-and-off cough switches on the surface of the respiratory tract, although none have yet led to new cough medicines. New findings also show that coughing is a complicated event that shares some of the same neural circuitry with other basic body functions, like pain and temperature sensitivity. And brain scans are revealing a neural network for coughing that goes beyond a mindless impulse.

> **"Cough in general has until recently been grossly under-researched."**
> **PETER DICPINIGAITIS**

"It's been a remarkable decade," says Brendan Canning, a pulmonologist at the Johns Hopkins Asthma and Allergy Center in Baltimore. In 2005, a new scientific journal, called *Cough*, was launched in response to a sudden burst of interest in the field.

Hard to swallow

Cough medicines now on the market work in the brain, not the airways. In addition to dextromethorphan, opiates such as codeine and hydrocodone are also prescribed for cough. Both treatment types act in the brain stem by interrupting communication between nerve fibers coming from the lungs and the nerves projecting to the muscles that prompt a cough. The problem is that the target molecules that dextromethorphan and opiates attach to — their "receptors" — appear on nerve cells all over the brain, so the drugs produce other effects, such as drowsiness and labored breathing.

Current cough syrups also have the potential to be addictive, which makes policy makers and doctors hesitant to rely on them. Prescription drug abuse with opiates has become a national epidemic in the United States, and some lawmakers have moved to ban the sale of over-the-counter cough syrups to minors to prevent teens from getting high on dextromethorphan.

A new approach to cough treatment could more directly act in the airways or could still target the brain, but without such widespread side effects. But here's the tricky part: Coughing is the body's mechanism for defending its lungs, so a medicine can't work too well for the body's own good.

"There's a devastating need for new drugs," Dicpinigaitis says. People plagued with constant coughing get so desperate for relief, he says, that he occasionally walks into his New York office and sees suitcases in the waiting room from out-of-state patients who have Googled him and come for a visit. "Most cough is acute cough associated with the common cold," he says. "But in a subgroup of those folks, the cold comes and goes, but the cough comes and stays." Some of his patients have spent more than a decade watching their sleep and social lives dwindle from too much coughing.

A new cough remedy might be easier to find if coughing were an easier thing to study. Rats and mice, the standard models in medical research, don't cough the way people do. Even animals that do readily cough go quiet when placed under anesthesia, just like people. When an awake volunteer in an MRI scanner coughs, it's challenging to keep the person still enough to get a good image of the brain.

"It's been hard going, and for years there was no fruit coming from people's

NICOLLE RAGER FULLER

A viral infection such as the common cold (green) can lead to irritated and inflamed airways — and a nasty cough.

efforts," says Stuart Mazzone of the University of Queensland's St. Lucia campus in Australia. "I think for a long time it was in the 'too hard' basket. People just gave up."

That is, until some accidental victories.

A hot field

One of the early milestones in the search for new treatments came in the late 1990s, when researchers from the University of California, San Francisco announced the first discovery of a receptor that later turned out to have a role in generating a cough. Receptors are proteins that poke out from the surface of cells like icebergs, waiting for a molecule that will attach to them and set off a whole chain of events within the cell.

A substance that can trigger a cough — an irritant like smoke or a hot pepper — locks on to receptors on nerve cells after getting sucked into the airway. The joining of molecule to receptor then activates nerves that run from the respiratory system to the brain stem. Nerves in the brain stem alert nerves connecting to muscles in the chest to immediately contract. (Exactly how a cold makes you cough is still not clear, but it probably also has something to do with the irritation of nerve fibers.)

The California researchers who described the new cough receptor, called TRPV1, were not pursuing a cough molecule, but were instead interested in chili peppers. The compound capsaicin, which gives peppers their punch, is well known for its array of potent neurological effects: sweating, racing heartbeat, pain — and coughing. Research teams had been searching for the receptor that could single-handedly release such potent reactions, with the idea that it could be an attractive target for pain treatment and other problems.

"It was obvious there was going to be a receptor for capsaicin," Canning says. And TRPV1 proved to be even more versatile than researchers had predicted. It also responds to protons, the calling card of acid rising into the esophagus. "Acid from the stomach will activate a cough," Canning says, which is one of the reasons that people start to cough when choking.

TRPV1 generated a flurry of attention for its potential to be the target of new drugs, especially for pain. It also kicked off new interest in cough, pulling researchers into the field. Blocking the receptor, it was thought, could stop a cough at its source.

It wasn't long before researchers developed molecules that could park themselves on the TRPV1 receptor. Soon after, Canning says, a huge glitch emerged. Besides inducing cough and sensing pain, TRPV1 has a major role in allowing the body to detect its own temperature.

Thermoregulation happens to be a hallmark of other receptors in this family of molecules. The receptor TRPM8, a distant cousin of TRPV1, was isolated in 2002. It produces a cooling sensation when activated, in the same way TRPV1 causes a burn. The yin and yang goes further. Just as TRPV1 activates cough, TRPM8 can suppress it. This explains why eucalyptus and menthol lozenges help calm some coughs — they are natural activators of TRPM8. (In fact, many public health experts believe that menthol cigarettes should be banned, because the cough-suppressing, soothing feeling of the menthol aids smoking and addiction.)

But the relief from TRPM8 activation is temporary; menthols quickly disappear from the body. What's more, activating the receptor won't relieve chronic cough.

TRPV1 would be a good candidate but has proved problematic. Without that receptor, the body has trouble regulating its own temperature, or detecting the temperature of outside substances. Volunteers in clinical trials were inclined to perceive the temperature of very hot liquids (such as bathwater at 120° Fahrenheit) as "optimal." Reporting on initial tests of a TRPV1 blocker last year in the journal *Pain*, an international research team noted that, "it is not possible to know whether or not the observed changes in core body temperature, heat pain threshold and perception of hot liquids foretell a significant clinical risk of fever or burns."

The success of using TRPV1 inhibitors depends on the ability to overcome the side effects of impaired thermoregulation while still blocking cough or pain, Canning says. "Quite frankly, I think a lot of companies got scared off."

Enthusiasm for TRPV1 may be cooling, but interest in other receptors,

Cough causes

Cough can often be relieved by treating the underlying cause, of which there are many. In some cases, though, a cough lingers for no apparent reason.

Smoking can irritate the airways and cause cough. Other irritants include air pollution, perfumes or allergens.

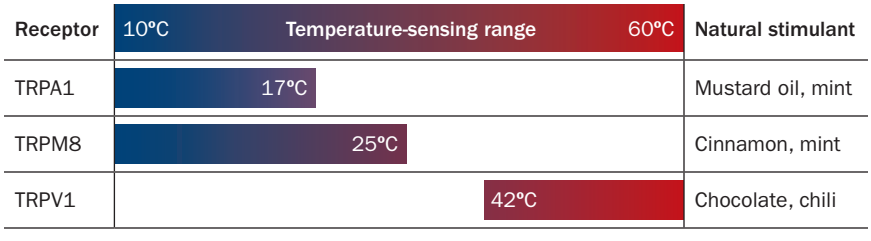
Asthma can cause a cough that becomes worse when a person is exposed to other irritants or cold air.

Gastroesophageal reflux disease occurs when stomach acids flow into the esophagus. These acids can trigger cough receptors.

Infections including flu, pneumonia, the common cold and whooping cough can produce a cough that sometimes lingers.

Heart failure can lead to fluid buildup in the lungs, causing chronic cough.

Receptor relief Various receptor molecules that play a role in regulating body temperature have received attention as potential off switches for cough. These receptors are triggered by a range of stimulants (some listed), but blocking temperature sensing along with cough may prove problematic.



SOURCE: M.G. BELVISI *ET AL*/*CHEST* 2011

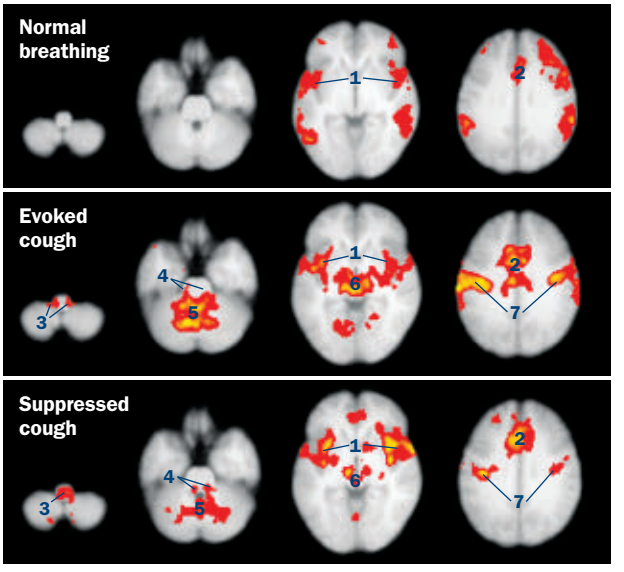
particularly one called TRPA1, remains hot. Like those before it, TRPA1 was not discovered by researchers who had a particular interest in cough. A Swiss research team screening potential cancer drugs discovered the molecule more than a decade ago, although the scientists did not know its function or location in the body. Researchers from the Scripps Research Institute in La Jolla, Calif., and elsewhere soon found that TRPA1 was located in sensory nerves throughout the body. In 2004, a research team led by Sven-Eric Jordt, now of Yale University, reported in *Nature* that TRPA1 was the target of a pungent ingredient in mustard oil and wasabi. "We also found later that it was activated by a very broad range of respiratory irritants," Jordt says, including garlic and tobacco smoke.

Research groups are now testing molecules that block TRPA1, mostly with the idea of developing pain drugs. But scientists are acutely aware that curing coughing would be a big bonus. If drugs are developed and approved for pain, Jordt says, companies would then have an easier time getting approval for cough treatment with the same compound.

A review last year in the journal *Chest*, from scientists at Imperial College London, called TRPA1 "one of the most promising targets currently identified for the development of novel anti-tussive drugs." It's still too early to know whether TRPA1 has the same drawback of interfering with the ability to detect temperature, though Jordt says animal studies so far are reassuring.

The best approach for a TRPA1 blocker as a cough suppressant may be to develop a drug that can be administered at a low dose and will target the receptors only where needed. "What I think may be better for cough is producing a formula that has to be inhaled," Jordt says.

But targeting any particular receptor in the windpipe might still present problems of disabling a cough too much, cautions Queensland's Mazzone. "We don't want complete abolition of cough, but to suppress cough back to a level that is normal," he says. Also, a healthy cough is so vital for survival that the body probably has many as yet undiscovered mechanisms to make sure it happens. One drug might have problems covering all the pathways to a cough.



Cough override

Understanding what brain regions are active when a cough is held back may point to a way to block the urge. The mid insula (a portion of the insular cortex) shows stronger activity when a cough is suppressed than during evoked coughing or normal breathing.

1. Mid insula
2. Cingulate cortex
3. Medulla
4. Pons
5. Cerebellum
6. Midbrain
7. Primary sensorimotor cortex

S.B. MAZZONE *ET AL/J. OF NEUROSCIENCE* 2011

Brain suppressant

Instead of looking in the airway for clues to temper a cough, Mazzone studies the brain, looking for targets beyond the brain stem. "What we are beginning to learn is that there is more to coughing than being a reflex," he says. "A lot of the cause is behavioral. Often if you have a respiratory infection, you'll be aware of the irritation and it will drive you nuts, but you do not cough every second. You make decisions whether to allow the cough to proceed or to voluntarily suppress it."

When the drive to cough is not overwhelming, some mechanism in the brain is able to override the signal. This is the response that Mazzone wants to understand. "Something about the cortex and the higher brain is very important to coughing, and this hasn't been looked at a great deal," he says.

Using a kind of herpesvirus modified to glow fluorescent among connected nerve cells in rodents, and then examining the areas of the human brain active during a cough, Mazzone has developed a map of the brain structures involved in coughing. Writing last year in the *Journal of Neuroscience*, he and his colleagues described an experiment in which volunteers, their heads secured by foam padding, were given a dose of capsaicin while in an MRI scanner. It wasn't just the brain stem that lit up during a cough, or during an urge to cough, but regions in higher parts of the brain. Other parts of the brain, such as portions of the insular cortex (an area that has a large role in depression), were more active when trying to hold back a cough.

"What we're just starting to do now is study people with chronic cough," says Mazzone. Volunteers with persistent coughing are being looked at with MRIs taken as they are asked to keep from coughing. They appear to show much less activity in the parts of the cortex that appear important in cough suppression. All of these results make Mazzone optimistic about one day stimulating a natural cough-suppressing mechanism.

Whatever form the next generation of cough suppressants eventually take, millions of patients are waiting, breathlessly. "The good thing about cough is that if you asked me 10 or 12 years ago what is going on, I would have said, 'Nothing,'" says Dicpinigaitis. "At least now people are looking." ■

Explore more

■ For video of a cough's steps, see http://1.usa.gov/coughtherapy

mixed results

Having the right blend of animal personalities can make or break a group

By Susan Milius

Watching coworkers in paper masks swim among the office cubicles acting out fish personalities turns out to be pretty informative.

Admittedly, "informative" didn't seem to be the word on the tip of the tongue of *Science News*' editor in chief when, in the grip of urgent editorial business, he charged up the stairs and happened upon writers neglecting their keyboards for make-believe group swims. After some hasty smoothing over, though, he joined in as a virtual predator, sending fish of all personality types scattering for shelter.

Predators, information, group-ups and even games all have their place in studies of animal personality, including the mosquito fish research that inspired the office fish simulation. Even though fish dynamics over generations were mimicked by just a few terrestrial mammals between deadlines, the mix of personalities proved as important for animal welfare in cubicles as in real waterways.

Differences in the ways individual fish act, once groaned about as the inevitable messiness of gathering data on real animals, have in recent years become their own topic of research. Geese, hissing cockroaches, cichlids, great tits, mallards, sparrows and European rabbits have all starred in such studies.

Now that the idea of individual animals having a version of personality — or, more formally, "behavioral type" — has become unsurprising in scientific discourse, the next wave of research is looking at the consequences of the mix of personalities in a group.

Any non-hermit can tell tales of how the blend of personalities among human peers can lead to success or utter failure. Certain committees, task forces, condo boards and so on mire in infighting while others motor through their agendas. But this mix may matter even more directly among other animals. In flocks, schools or herds, the melding of behavioral types can be a matter of life and death, thus nudging a species' evolutionary trajectory. An individual animal's chances of finding food or starving, wooing a mate or dying without offspring, dodging a predator's jaws or becoming lunch have been found to change with different blends — as has the fate of a group as a whole.

Clever and cagey pets

Before getting into what personality might mean for animals in general, it's worth dealing with pets. Just about every magazine article on nonhuman behavioral types inspires at least one reader to write a letter to the editor fulminating about how scientists are such idiots. Anybody who has ever had dogs, cats, horses, parrots, etc., knows that they have personality.

Science, however, requires rigorous definitions and proofs, says behavioral biologist Margaret Wray. Now based in Atlanta, Wray studies personality in honeybees, but she often hears about clever cats and so on from pet lovers she knows. Finding a way to define an animal companion's lovable idiosyncrasies

A sociable mosquito fish that tries to hang out with loners may have better access to food than a social fish that travels with other fish of its type.

so they can be tested in a meaningful way isn't easy, she explains. It's hard to say whether a cat that snags open the kibble cabinet is displaying a cool, analytical approach to life, or whether trial and error has simply led to success this time around.

While psychologists describe human behavior in five dimensions (conscientiousness, agreeableness, neuroticism, openness and extraversion), personality testing for nonhumans tends toward simpler terms. Nonhuman animals can be shy or bold, aggressive or docile, social or asocial, and so on.

The key to distinguishing a personality amid all of a creature's behaviors is whether the individual responds consistently across time. A fish that hangs back in the reeds today might be considered shy if it does so next week and the week after. Researchers differ in the terms they use to describe such consistent behavioral tendencies, using "behavioral type," "temperament" or "personality." To capture more complicated effects, Andrew Sih of the University of California, Davis has pioneered the idea of "behavioral syndrome," which describes suites of behaviors linked in different situations, such as voracious feeding during foraging and frequent cannibalizing of suitors during courtship.

A fishy test

Whatever terms are used for consistent behavioral trends, mosquito fish have them. What's more, recent work suggests that the fortunes of any individual loner or clinger can vary depending on the blend in the neighborhood.

Two groups of journalist-fish, told nothing about results from mosquito fish studies, were persuaded to try an exercise in mixing up types. Each put on a mask and drew a personality profile out of a hat. Social fish had to stay near others as they swam along, foraging for animal crackers and chocolate kisses hidden among the reeflike environment of cubicles, journal stacks and crevice-rich hallways. Loners were instructed to dart off into more open water if two other fish crowded nearby.

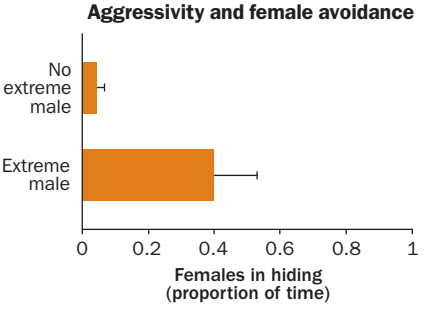
Behavioral ecologist Sean Fogarty, who agreed to a debriefing by phone after the event, said that some of the office results replicated effects he sees in his computer simulations, which are based on real mosquito fish living in experimental pools at UC Davis. Most telling was a remark by fish AB/S (known as editorial assistant Allison Bohac in her human form), who said that as the only social fish in a loners' group, she had scrounged her snacks from caches discovered by the elusive loners she was trying to swim with. In his computer simulations, Fogarty finds similar behavior among social fish surrounded by loners — in effect, a rarity bonus.

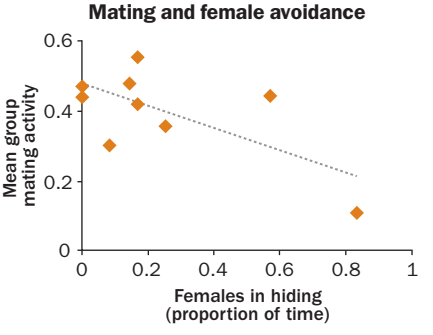
Each personality type gets some form of bonus when it's rare, but benefits dwindle when the type becomes too common. If social fish are rare, just about any individual they try to buddy with will probably be a loner, prone to discovering new food patches. So social fish should grow and prosper in a largely loner world, Fogarty says. Conversely, a loner fish should have an advantage when social types abound because types that club together fail to cover maximum ground, leaving plenty of food patches for a loner to discover.

Had the editor-predator been permitted to eat a fish, the office simulation would have shown another important dynamic, Fogarty says. In fish-rich hallways, the victim would probably have been one of the loners (the asocial fish KT/L aka editor Kate Travis and RE/L writer Rachel Ehrenberg did have close calls). Loners don't have the protective cluster of buddies that can distract hungry newsroom management. In dense populations, asocial fish face greater risks, Fogarty says, and the size of those risks will nudge the ultimate balance of fish types. In the fish world, then, socials and loners could see their local mix affect how well they eat and whether they are eaten.

Under what circumstances a rarity bonus will actually show up among behavioral types in the real world is turning out to be tricky to predict, though. Both bold and shy barnacle geese could, in theory, nibble more food when surrounded by their opposite type, Ralf H.J.M. Kurvers of the Leibniz Institute of Freshwater Ecology and Inland Fisheries in Berlin predicted before testing real birds. He found something else: Geese, shy or bold, found more food when keeping bold company, Kurvers and colleagues reported in the January-February *Behavioral Ecology*.

One bad strider One hyperaggressive male water strider can spoil success for the whole bunch. Females spend more time avoiding a group of males when one member has this extreme trait. The avoidance means less mating activity for the group.





SOURCE: A. SIH AND J.V. WATTERS/*BEHAVIOUR* 2005

Shared fates

It's not just the dinner of a particular goose or fish, but the fate of the gaggle, school or group that can change depending on the particular mix of personality types within.

A classic demonstration of group-level effect comes from the leggy *Aquarius*

FACING PAGE: JOEL SARTORE/NATIONAL GEOGRAPHIC STOCK; THIS PAGE: HERMANN EISENBEISS/PHOTO RESEARCHERS, INC.

remigis water striders that skim over the surface of ponds and streams throughout much of North America. "A noble beast," says animal behaviorist Jason V. Watters, now at Brookfield Zoo in Illinois. He is a coauthor with Sih of a widely cited 2005 paper on water strider groups. "During the main water strider–watching season," Watters says, "you see far more exciting behavior than you do in most hours of lion watching."

Sih and Watters divided male striders into groups based on their aggressiveness and activity level, and settled each cluster with some females in its own pool. Groups with the more aggressive males tended to dash about more actively, exploring for food and females, than pool-potato groups did. In theory, all that activity could have meant more mating, but that's not what happened in the rambunctious clusters. They failed to reap any activity bonus in mating, Watters says.

What made the biggest difference in a group's courtship success was whether any of the males turned hyperaggressive in his new cluster. In five of the 10 groups, a male went macho to the max, attacking poolmates and approaching females so relentlessly that all of them fled to swift-flowing water unsuitable for mating. "These guys are crazy," Watters says, and their harassment dimmed the chances for all males in the group.

In the most extreme case, researchers tracked one group with a single overexcited macho type among extremely passive males. This group ranked very low in mating activity, even below the cluster intentionally set up with highly aggressive males.

***A. studiosus* spiders of the docile type slyly steal food from neighbors of a different species. Such theft can boost reproduction in spider groups.**

Spoiling reproduction isn't the only way extreme behavior in a group can nudge it toward prosperity or extinction, says behavioral ecologist Jonathan Pruitt of the University of Pittsburgh.

He has worked with the comb-footed spider *Anelosimus studiosus*, which lives along riverbanks from New England to Argentina. The spiders are small but competent predators, and "you can do things with them you can't do with prides of lions," Pruitt says.

Some females live solitary lives in their own webs, but others share weaving and hunting duties with one to dozens of roommates. It's these colonial setups that Pruitt and his colleagues have published on recently. The webs attract other species of spiders and can form a whole silken reef of interacting species. Whether relationships with the other species are beneficial or disastrous depends on the mixture of personalities among the little comb-footed spiders, Pruitt and colleagues argue in recent papers in *Ecology* and *Functional Ecology*.

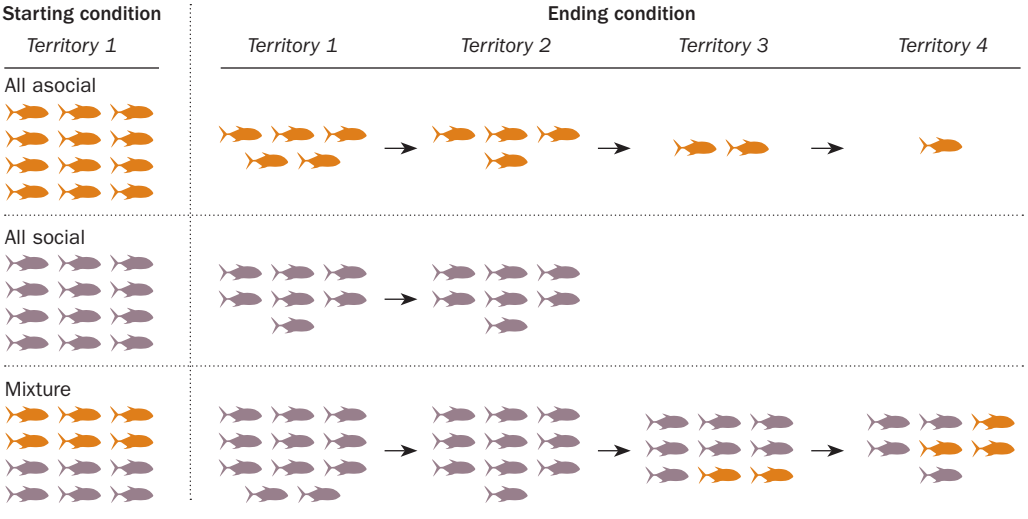
In multispecies webs, some of the comb-footed spiders show a strong aggressive streak, while others share space in apparent contentment. Aggressive types readily pick fights even with species 20 times their size. And fights often turn into brawls that draw in the roommates of the original combatant. Colonies engineered by Pruitt to contain all or half of these scrappy females fared poorly overall when sharing their home with other species. The cranky groups produced fewer offspring and faced greater risks of just dwindling away than clusters of more serene spiders did.

For a group of docile spiders, neighboring species could be a boon, at least at first. A key to this effect was a stealthy side to the more placid spider types. They're great thieves, Pruitt reports. When a member of one of the big neighboring species lands some magnificent prize, like the vast carcass of a butterfly, a small, docile spider slowly, daintily, excruciatingly patiently tiptoes up to some corner of the catch and, apparently unremarked, has a fine feast.

These illicit windfalls let colonies of docile spiders reproduce abundantly. The downside, though, Pruitt notes, is that a

Divide and conquer

Because of their loner nature, asocial mosquito fish tend to spread to new territories. But an all-loner blend is not the best for taking over new waters. Loners keep moving so they don't build up big numbers (top). At the other extreme, a group of social mosquito fish tend to clump close to home (middle). But in a social-asocial mix (bottom), loners reach new territories and social followers build up the populations there.



SOURCE: J. COTE *ET AL*/ *PROC. ROYAL SOC. B* 2011

FROM TOP: COURTESY OF DAN AND ELLIE BODOR; T. DUBÉ

large group of docile spiders isn't so good at defense against attack. A largely docile colony may swiftly grow larger than clusters with some crankier spiders, but it may also wink out when under siege.

Swim west, oh fish

With the right mix of behavioral types, a group can do more than persist. It can conquer new worlds, altering the range of territory covered by its species.

Mosquito fish have been all too good at conquering worlds, Fogarty says. Popular as biocontrols for mosquitoes, the fish have been bred and coddled and carried just about everywhere. Local governments in California maintain supplies to pour into swimming pools of foreclosed homes, and farmers stock the fish in rice paddies. The fish do gobble mosquito larvae, but if they make it into wild waterways will also savage just about anything else. "Pretty terrible," Fogarty says.

The fish are wonderful, though, for studying how behavioral types influence the spread of invasive species. Fogarty and his team set up different mixes of social and asocial fish at one end of artificial waterways with miniature pools connected by swifter-flowing riffles to see how far and how fast populations would expand from pool to pool.

Asocial fish did indeed flee the crowds and move readily into new territories. "It's like the grizzled pioneer," Fogarty says. When a population builds up, the asocial mosquito fish get crowded and get out of Dodge.

Yet, combining the studies and computer simulations, Fogarty and colleagues conclude that the most potent mix of types for fueling invasions turns out not to be dominated by loners. They just keep drifting on from one frontier to the next without really building up big numbers in one place, the researchers reported in the March 2011 *American Naturalist*.

For the best — or worst — invasions, a substantial proportion of social fish need to be mixed in with the less social ones, Fogarty says. Thus the loners swim away from the crowd and move into open habitat. When the social fish numbers get high and some of them spill over, there are already others of their kind, albeit grizzled oddballs, around to keep the frontier from feeling so lonely. The population with the social fish thus sends in a second wave to build up the next crowd. Invasions progressing this way bring big numbers of the incoming creatures pushing across the landscape.

In this way, the mix of personalities can govern not only a group's movements, but also a whole species' range — and life for the rest of the communities residing alongside. Draw different personalities out of a hat and there goes not just dinner or neighborhood welfare, but the tenor of the entire ecosystem. ■

Explore more

- R. Bergmüller and M. Taborsky. "Animal personality due to social niche specialisation." *Trends in Ecology & Evolution*. September 2010.

Group personalities

Margaret Wray actually has a reasonable explanation for why she dropped bricks on beehives. (Do not even think about trying this at home, or anywhere else really.)

Wray, now based in Atlanta, recently finished a Ph.D. at Cornell University on personality in honeybees and how it matters to their welfare. Bee colonies do differ from each other — beekeepers have plenty of tales. These quirks of particular colonies emerge from the collective behavior of the member bees. But instead of testing each bee for personality, Wray treated each of 25 colonies as a superorganism and devised super-personality tests. Researchers studying ants are also working along these lines.

For some of the tests, Wray sampled clusters of bees in each colony. She checked what beekeepers call "runniness," the average degree to which bees dash around in seething activity when someone temporarily lifts out a section of their home. And she scored some tests for the colony as a whole, such as how diligently bee corpses were removed at each hive.

For a measurement of how vigorously a whole colony responded to a threat, Wray (wearing a full protective suit) presented a whiff of bee alarm pheromone and dropped a brick on the roof of a hive. Results varied widely among colonies. "Some would barely respond, and some — you'd get out of there really fast," she says.

To see if a colony's personality might matter to its survival, Wray looked for patterns in the personality traits of colonies that survived outdoors during a winter in Ithaca, N.Y., versus those colonies that died. Fourteen out of the 25 colonies studied lived until spring, she and colleagues reported in the March 2011 *Animal Behaviour*. The traits that best predicted success were highly active foraging for food and a strong defensive response to researchers dropping bricks.

It's easy to see how foraging affects a colony's fate, Wray says. Honeybees need to collect enough food to sustain their colony during cold, snowy, flowerfree months. Winter food demands aren't trivial as the bees work hard flexing their muscles to generate the heat that keeps huddled bodies warm. Finding a way to explain how defensive behavior fits with survival, though, still has Wray thinking. — *Susan Milius*

FROM TOP: NOAM ARMONN/SHUTTERSTOCK; PETER WATERS/SHUTTERSTOCK

Quiet: The Power of Introverts in a World That Can't Stop Talking

Susan Cain

At least one in three people are introverts, and this book may prove a revelation for them and everyone who lives, works or interacts with them. *Quiet* cites a wealth of new and ongoing research about this psychological trait: who is an introvert, how these introspective souls got that way, and why they can be ideally suited to become scientists, engineers, journalists, therapists and money managers.

Cain, an admitted introvert, highlights often-overlooked positive characteristics of quiet people. These include a propensity for listening carefully, for focusing deeply on problems, and for identifying details, subtle trends and hidden subtexts.

Extroverts also have their strengths, and Cain argues forcefully that society benefits from having a strong mix of both personality types. But over the last century, Western cultures have gone from prizing self-effacing analytical introverts to valuing bold extroverts. Cain chronicles the emergence of the Dale Carnegies and others who have (for a fee) offered to teach shy people to exude charisma and self-assurance.

The problem with this, Cain reports from extensive interviews with introverts, academic psychologists and therapists: Introversion has no cure.

Some introverts cope by assuming an alter ego. Cain cites one popular speaker — a Harvard psychologist — who convinced the lecture circuit that he reveled in public speaking when in fact he was a reluctant orator who retreated to private quarters as soon as he finished his spiel.

Acting out such roles can be exhausting and requires quiet time afterward to recuperate. But using such techniques can allow even extreme introverts not only to take on, but even to thrive at social activities, from the playground to the courtroom and stage. — *Janet Raloff*

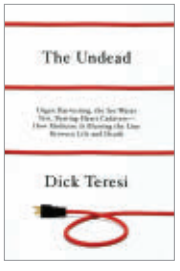
Crown Publishers, 2012, 333 p., $26

The Undead

Dick Teresi

"Are you dead or alive?"

The Undead opens with a question that seems like it should have an easy answer. But Teresi, a science writer, argues that in today's age of beating-heart cadavers that can breathe, urinate and even give birth while legally dead, it can be hard to tell.



Historically, Egyptians and ancient Greeks considered a heartbeat to be the telltale indicator; Christian and Hebrew interpretations of the Bible pointed to breath. The Samburu people in Africa still contend that someone is not dead until hyenas will eat the body.

In the modern era, Teresi says, the need for organ donors has brought about a new kind of death: the "loss of personhood," or brain death. Coma patients who require ventilators to breathe can be declared dead long before their hearts stop beating on the basis of simple, low-tech exams — a Q-tip touched to the surface of the eye, a splash of ice water in the ears, a gag reflex test. Despite this, researchers disagree on how "dead" a brain-dead person really is. For instance, some still show EEG activity when tested. "If you are finding any dead people with brain waves," Teresi asks pointedly, "what's waving?"

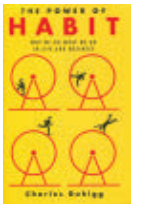
Teresi is critical of this hard-to-define state of personhood, and his investigations into the matter can make the book an uncomfortable read at times. With all this debate over who's dead and who's not, one might start to see the wisdom in letting the hyenas decide. — *Allison Bohac*

Pantheon Books, 2012, 350 p., $26.95

The Creative Destruction of Medicine

Eric Topol

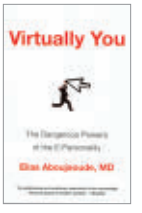
A look at new technologies such as genome sequencing and organ growth suggests that digital advances could usher in a new age of personalized medicine. *Basic Books, 2012, 304 p., $27.99*



The Power of Habit

Charles Duhigg

A journalist explores research on how habits are formed in the brain, how to create new ones and what it takes to break them. *Random House, 2012, 371 p., $28*



Virtually You

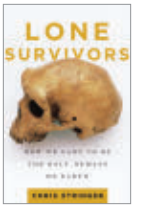
Elias Aboujaoude

A psychiatrist examines online alter egos and how they can affect life offline, sometimes for the worse. *W.W. Norton, 2011, 349 p., $17.95*

The Quantum Universe

Brian Cox and Jeff Forshaw

Two physicists use simple analogies to explain the weird world of quantum theory. *Da Capo Press, 2011, 256 p., $25*



Lone Survivors

Chris Stringer

A paleoanthropologist argues that multiple early human groups arose and competed in Africa. *Times Books, 2012, 320 p., $28*

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Consciousness series pondered

Hofstadter's "strange loop" and other ideas presented in the article "Self as symbol" (*SN: 2/11/12, p. 28*) suggest, but never say, that the notion of "I" exists in the dimension of time, not space. Obviously then, consciousness is not a tangible object — not any part of the brain. Rather, the "I" phenomenon is a process, a happening, always actualized with verbs like *think*, *remember* and *exist*. This idea is evident when one considers that self-awareness is always "now," carried along the arrow of time. Just as movie cels projected in sequence can create a story, brain activity, regulated by biology, generates an evolving self-perception, a "strange loop" called human awareness.
James Wegryn, Dimondale, Mich.

"You and I are mirages that perceive themselves," a statement by Douglas Hofstadter, is presented as a puzzle of "loopiness" in "Self as symbol." It seems to the simple layman that the answer is clear. Mirages don't perceive.

Stephen Hawking and Leonard Mlodinow talk about the problem in their book *The Grand Design* and discuss "awake" brain surgery. Stimulating a particular area of the brain creates the experience of the self wanting to move the foot or open the mouth and talk. It does not cause the foot to move; it creates the experience of "I wanting to" and "I thinking about" moving the foot. The self is part of the experience created by the brain as if the brain were the owner of the motivation and the creator of the thought, but it isn't. That was done with an electrical impulse.

All "self-awareness" means is that the human brain creates an experience of self as part of the process of responding to physical reality. It's just a pattern of neurons firing among many patterns of neurons firing. There is no actual self-referential mystery going on, unless you can't give up for a moment the illusion of the free-willed agent in your head.
Gregg Wilson, Oberlin, Ohio

"Consciousness emerges" (*SN: 2/25/12, p. 18*) describes the concept of the "remembered present," meaning that what we experience consciously is mostly a dynamic orchestration of memory, guided by much thinner slivers of perception. Such an arrangement can also speed reaction time and increase efficiency, since a sufficiently predictive simulation can grasp and respond to critical slivers of input by framing them in terms of what is most likely to happen next. This is in sharp contrast to most robotic systems, where the majority of energy and processing resources are put into interpreting massive sensory inputs, only to find that 99 percent were meaningless.
Terry Bollinger, Ashburn, Va.

All this brouhaha regarding "the awareness of self-awareness" that is of immense concern to the major minds present and past is akin to clapping with one hand. Professor E.O. Wilson, the father of and author of *Sociobiology*, probably hit closest to the mark in the infamous chapter where he characterized humans as intensely social beings who exist only in terms of their relationships (think Facebook, et cetera). This is probably why solitary confinement is a punishment worse than death (or reading another such article).
William Thompson, Edwards, Colo.

"Enriched with information" (*SN: 3/10/12, p. 22*) reports that scientific theories of consciousness as information have caught up to C.S. Peirce's 19th century proposal that "rather than saying the thought is in me, better to say that I am in thought." In philosophy there has been an over 70-years-long demolition of the idea that the mind is "in the head," beginning with the analysis of Ludwig Wittgenstein, through those of Hilary Putnam, Fred Dretske and others, to the current information theories of Luciano Floridi. There is a treasury of subtle and suggestive argument in that development. I propose that the stability and coherence of consciousness is to be found in publicly accessible social structures (institutions) cashed out as networks of relations. The "stuff" of consciousness is gone.
Ken W. Gatzke, New Haven, Conn.

The articles on consciousness in the February 11 and 25 issues are an extreme example of scientific reductionism. Hofstadter observed that consciousness is an example of a feedback loop that, like Gödel's incompleteness theorem, can never be solved. Perhaps another way to view the entire matter is that "the whole is bigger than the sum of its parts." That appears simpler to me and doesn't get bogged down in such things as information theory, brain chemistry or interpretation of fMRI scans.
Victor Arnold, Sugar Land, Texas

Just read "Self as symbol" and loved it! I have been a subscriber for many years and this was one of the clearest and, yes, most "inspiring" articles I have ever read. My work as a psychotherapist (with an early background in physics and engineering) has been notably enhanced by the point of view that you have so elegantly contributed.
Paul Solari, Broomfield, Colo.

Tom Siegfried's article "Self as symbol," while quite interesting and insightful, assumes that consciousness and sense of self are purely human phenomena. Many nonhumans with complex brains clearly possess consciousness too, of which we as yet have little understanding. And there are good arguments for ascribing self-awareness of some kind to at least the great apes and probably cetaceans. The article also treats human consciousness as the pinnacle of evolution, but surely evolution either has no goal or it has many. The idea of evolutionary progress is in any case a value judgment, not a scientific one.
Michael Allen Fox, Armidale, Australia

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From the Archive

To read the full 1957 article, visit
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Suggest Cancer Preventive

Cancer could be drastically reduced if people were not such gluttons and if increasing income and food supply did not overfeed the average person.

This way to reduce the second most common cause of death is advocated in an authoritative publication of the Nutrition Foundation by Dr. Harold P. Rusch, University of Wisconsin professor of oncology, which is the study of tumor growth, and editor of the journal, *Cancer Research*.

The difficult part about applying this preventive measure is that people would have to be hungry most of the time, or as Dr. Rusch puts it:

"In the opinion of the writer, there is no doubt that a drastic reduction in the incidence of almost all forms of cancer would be achieved if the caloric intake were reduced sufficiently to decrease the weight of all people to slightly below the accepted optimum."

Unfortunately, the kind of diet Dr. Rusch prescribes is usually found only in the very poorest regions of the world, or for a short time in other areas right after a war.

The desire to eat is one of the first to be satisfied when more money and more food are at hand, Dr. Rusch reports, and the average person will not give up the joy of eating just to reduce his chances of getting a tumor, especially since it might not happen even if he becomes a glutton.

Evidence that cutting calories improves health continues to mount. But the biology behind the benefits is largely a mystery.

UPDATE

A substitute for cutting calories

A dietary plan that leaves you hungry still has its potential perks. Studies in yeast, flies, worms, fish, rodents and monkeys (*SN: 8/1/09, p. 9*) continue to suggest that restricting food intake helps fend off a host of aging-related diseases.

Whether erasing ailments like cancer, diabetes and dementia would extend the maximum life span in otherwise healthy humans remains unclear. But it's not surprising that large swaths of people aren't eager to sign up for calorie-cutting experiments.

In the last few decades, scientists have set their sights on getting around what could be called the "love-of-food hurdle." Can you get the benefits of calorie restriction without actually restricting calories?

A substance found in grapes and red wine, called resveratrol, has shown some promise. Resveratrol acts on sirtuins, the same age-fighting molecules thought to get a boost when food intake drops. A 2008 study showed that mice treated with resveratrol had better bone health, improved coordination, lower cholesterol and better heart function. But resveratrol didn't appear to fight cancer — what the lab mice in the study typically died of — the way a low-calorie diet did (*SN: 8/2/08, p. 14*).

Resveratrol results have become somewhat controversial recently. In the Feb. 3 *Cell*, researchers report that resveratrol does not activate sirtuin 1 directly. And a study published last year in *Nature* questioned whether the increased levels of sirtuins were really responsible for extending life in worms and flies, anyway. Other potential age-defying pills have faced similar scuffles.

There's a long way to go in unraveling the puzzle of aging. For now, the fountain of youth remains elusive.

—Elizabeth Quill

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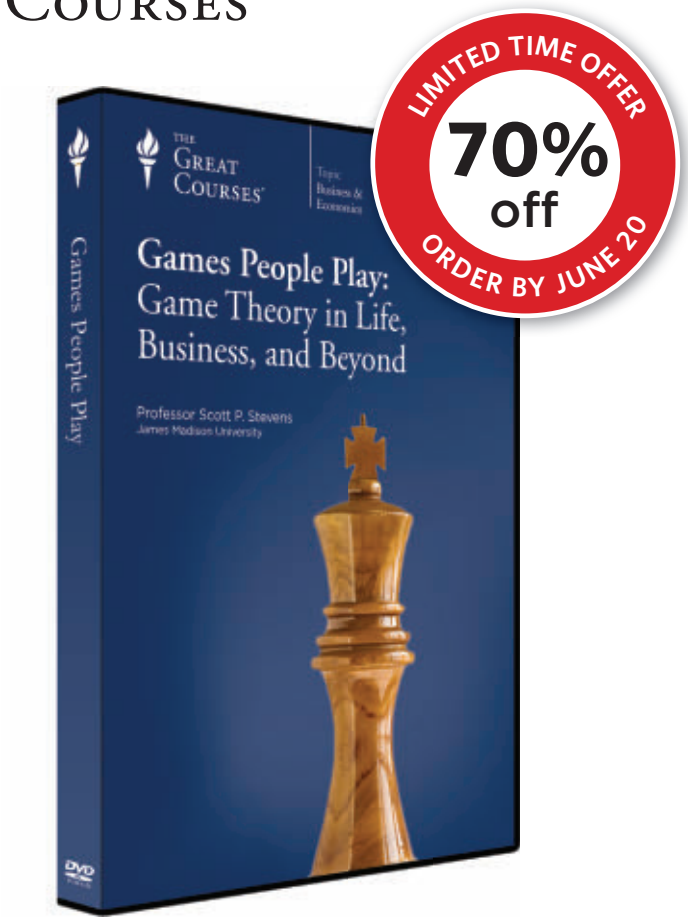

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