Bands Burden Penguins | Inside the Electron | Cold Water on Hot Hand

ScienceNews

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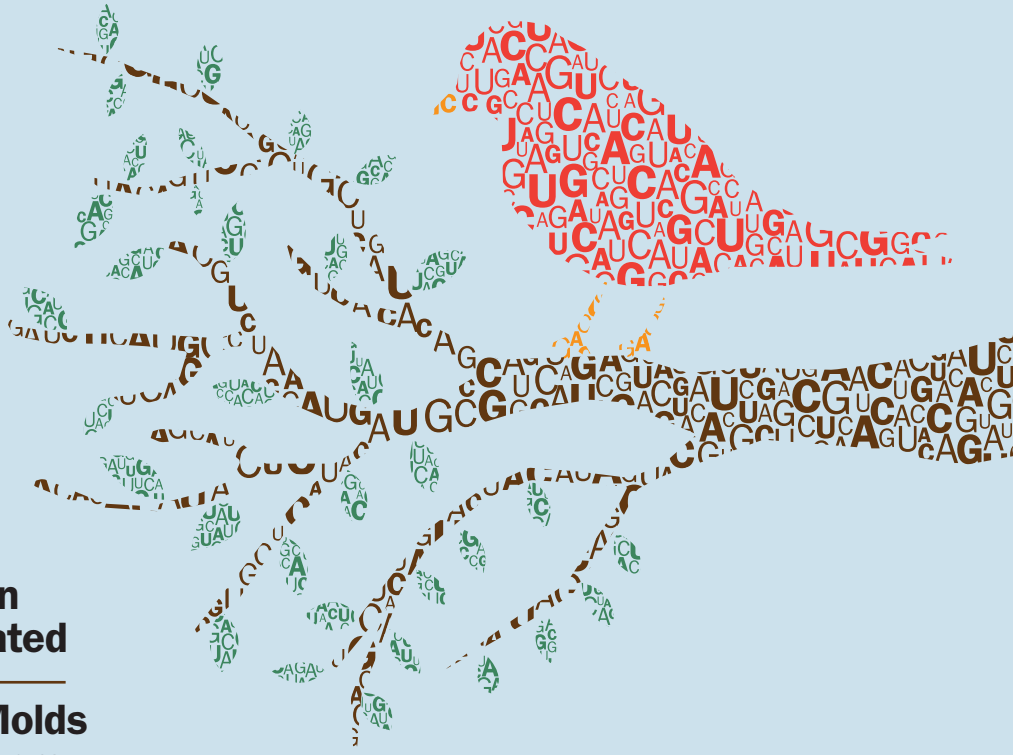
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ FEBRUARY 12, 2011

The Original ABCs

Seeking the source of the genetic code



Tevatron Terminated

Slime Molds as Farmers

Top 40 High School Scientists

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African Gem Cutter Makes $2,689,000 Mistake...Will You?

This story breaks my heart every time. Allegedly, just two years after the discovery of tanzanite in 1967, a Maasai tribesman knocked on the door of a gem cutter's office in Nairobi. The Maasai had brought along an enormous chunk of tanzanite and he was looking to sell. His asking price? Fifty dollars. But the gem cutter was suspicious and assumed that a stone so large could only be glass. The cutter told the tribesman, no thanks, and sent him on his way. Huge mistake. It turns out that the gem was genuine and would have easily dwarfed the world's largest cut tanzanite at the time. Based on common pricing, that "chunk" could have been worth close to $3,000,000!

The tanzanite gem cutter missed his chance to hit the jeweler's jackpot...and make history. Would you have made the same mistake then? Will you make it today?

In the decades since its discovery, tanzanite has become one of the world's most coveted gemstones. Found in only one remote place on Earth (in Tanzania's Merelani Hills, in the shadow of Mount Kilimanjaro), the precious purple stone is 1,000 times rarer than diamonds. Luxury retailers have been quick to sound the alarm, warning that supplies of tanzanite will not last forever. And in this case, they're right. Once the last purple gem is pulled from the Earth, that's it. No more tanzanite. Most believe that we only have a few years supply left, which is why it's so amazing for us to offer this incredible price break. Some retailers along Fifth Avenue are more than happy to charge you outrageous prices for this rarity. Not Stauer. Staying true to our contrarian nature, we've decided to ***lower the price of one of the world's rarest and most popular gemstones.***

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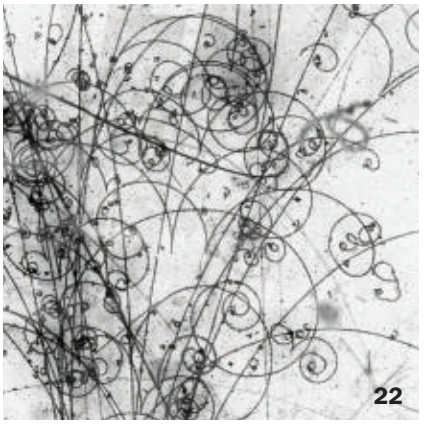

ScienceNews

In The News

Features

Departments

COVER From grazing giraffes to soaring birds and swaying trees, all life on Earth shares a common genetic code whose origin remains mysterious. *Janel Kiley*

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FROM THE EDITOR

Scientists might not know hot hand when they see it

Numbers never tell the whole story, even about sports. Numbers seldom tell the whole story about science, either.

Consider the controversy regarding the hot-hand phenomenon in basketball. As Bruce Bower reports on Page 26 of this issue, humans may have been programmed by evolution to perceive clumps (or streaks) that are actually just statistical fluctuations. So some scientists believe that basketball players never really have a hot hand — any long run of successful shots is just one of those streaks that occasionally happen by chance.

Some scientific studies of the hot-hand effect have been unable to show that it is anything more than randomness in disguise. Fans and players, on the other hand, continue to insist that it exists. Perhaps basketball experts have been fooled by their evolution-based predispositions. Or maybe the scientists don't know what they're talking about.

In hot-hand studies, scientists examine propositions such as "making one shot increases the likelihood of making the next" as a definition of a hot hand. Or data are examined for streaks of consecutive made shots, or for sets of shots where a high percentage are made. A 1985 analysis along those lines found no reason to suspect anything other than chance variations in shooting performance. Hence the widespread belief that the existence of hot hands has been disproved by science.

That's all very nice, but upon further review this conclusion is not confirmed. A subsequent study embedded nonrandom streaks of exceptional shooting in a computer simulation of basketball data. Methods used by the earlier study failed to find most of the embedded streaks. In other words, the method for concluding that hot hands did not exist was not in fact capable of finding hot hands if they did exist.

But apart from that disconfirmation, the whole issue was misposed in the first place. No player would define "hot hand" merely as meaning that making a shot raised the probability of also making the next one. A hot hand reflects a complex, subjective psychological and physiological state of mind and body. Scientists define "hot hand" simply as an excess over chance because that's what they can measure. And sometimes science's methods of measurement don't capture all there is to reality. So it's a good idea to keep in mind when any scientific study reports failure to find something, it could be because that something isn't there — or it could be because the study wasn't capable of finding it. —*Tom Siegfried, Editor in Chief*

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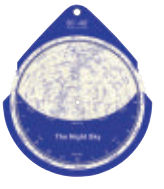

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Scientific Observations

"The process of learning what string theory means has a long way still to go. One of the reasons that it is, I think, an exciting topic for today's students to work on is precisely that so much isn't understood. It's sometimes framed as a criticism, that string theorists don't really understand their theory. That's true, but if we understood it, it might be finished. The fact that so little is understood and that such relatively small pieces are actually such big discoveries in their own right is part of what makes it exciting. And there's a lot still more to do." **—PHYSICIST EDWARD WITTEN OF THE INSTITUTE FOR ADVANCED STUDY IN PRINCETON, N.J., IN HIS ACCEPTANCE LECTURE FOR THE 2010 ISAAC NEWTON MEDAL**

Science Past | FROM THE ISSUE OF FEBRUARY 11, 1961

RELIEVE ARTHRITIC JOINTS — Chronically inflamed arthritic joints can be relieved, but not cured, by injecting cortisone-related steroids, or hormone drugs, directly into the joint. Repeated injections, up to 142 times in one case, had no apparently harmful effect, three doctors report in the Bulletin of Rheumatic Diseases, Jan., 1961. Some 4,000 patients at the University of Pennsylvania Arthritis Clinic, Philadelphia, received more than 100,000 injections during a ten-year period.... Reduction in swelling and relief of pain was found in 90%. The physicians state that relief varies and is often temporary. Because the treatment can be repeated in long-term cases of the most serious types of arthritis ... however, it is especially valuable.

Science Future

February 15
Discuss controversy over non-native species at the University of Minnesota's natural history museum happy hour. See www.bellmuseum.org

February 17
Author Sam Kean regales New York City with tales of the periodic table. Go to www.nyas.org

February 17
Cybersecurity experts address hazards of the digital age at Chicago's Northwestern University. See http://c2st.org

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SCIENCE & THE PUBLIC BLOG
Too much light before sleep could stress the body. Read "Night owls may want to dim their lights."

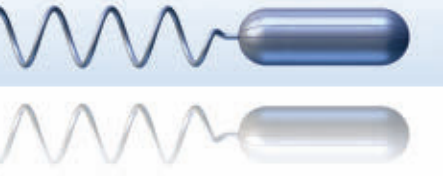
LIFE
Spring thistles may inspire bird courtship. See "Songbird's testosterone surges at sight of thistle blooms."

ATOM & COSMOS
Lightning storms regularly shoot antimatter into space. Read "Today's weather: thunder and antimatter beams."

BODY & BRAIN
Metal tongue studs beget infections and chipped teeth. See "Tongue piercings worse with metal."

How Bizarre

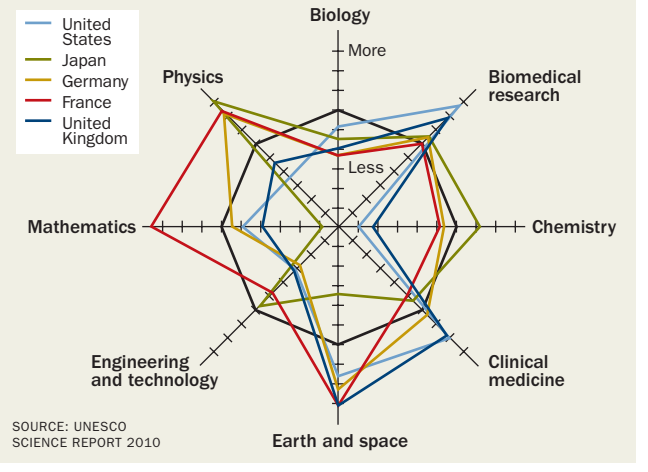
When swimming near an air-liquid boundary, a bacterium moves as if it's cruising alongside a mirror image near no boundaries. A corkscrewlike flagellum propels the microbe, but comes with bad steering. In open water, poor steerage isn't a problem because the spinning flagellum creates a flow in the surrounding fluid that directs a bacterium along a straight line. But near a boundary, such as a solid surface, this flow is distorted and makes the microbe loop-the-loop. Knowing solid surfaces cause clockwise looping, Roberto Di Leonardo of the Sapienza University of Rome and his team tested *E. coli*'s moves near an air-liquid interface. They report online January 19 in *Physical Review Letters* that the bacterium moves counterclockwise, as though navigating a flow created by it *and* a mirror image as they swim through open water.



Science Stats | IT'S WHAT YOU KNOW

Scientific specialties vary, with some nations publishing a larger portion of papers in a given discipline compared with the world average (black).

Specialization by country in 2008, based on publications



CLOCKWISE FROM TOP LEFT: ANDREA KANE; RUNNERJENNY/FLICKR; R. DI LEONARDO *ET AL./PHYSICAL REVIEW LETTERS* 2011

“From 20 feet away you’d do a double-take—will the animal run from you or take your leg off?” —PAUL SERENO, PAGE 10

In the News

STORY ONE

Lack of funds will force Fermilab to shut Tevatron by September’s end

U.S. atom smasher will cede Higgs search to Europe’s LHC

By Ron Cowen

FRED ULLRICH/FERMILAB

In operation since 1985, the Tevatron particle collider at the Fermi National Accelerator Laboratory (shown) in Batavia, Ill., is slated to shut down in September. A proposal to keep the collider running through 2014 failed for lack of funding.

The Fermi National Accelerator Laboratory’s Tevatron will shut down by the end of September, the U.S. Department of Energy has announced, dashing hopes that the 25-year-old atom smasher in Batavia, Ill., might win a transatlantic race to find the most sought-after elementary particle in high-energy physics.

On January 10, Fermilab received the news from the Department of Energy that the agency could not come up with an annual $35 million to keep the Tevatron running until 2014. The department’s advisory panel on high-energy physics had recommended that the Tevatron operate for three additional years after the European consortium CERN announced in early 2010 that its more powerful Large Hadron Collider would close down during all of 2012 for repairs. (It’s now likely that the collider will shut down in 2013 instead, a CERN official says.)

Electrical problems had already postponed by a year the opening of the Large Hadron Collider, until the fall of 2009. That delay, along with the future year-long shutdown, had seemed to give a leg up to the Tevatron in its search for the long-sought Higgs boson, a particle whose existence would explain the origin of mass in subatomic particles.

“The Tevatron has now accumulated enough data to be sensitive to the mass of the Higgs [as predicted] in the standard model” of elementary particle physics, says Stefan Söldner-Rembold, a physicist based at the University of Manchester in England who is a spokesman for one of the Tevatron’s two experiments. “We have reached a threshold and it seems like a waste to turn [the Tevatron] off at such a moment when one is almost there,” he notes. Over the past two years, the U.S. accelerator has narrowed the range of masses that the Higgs could have (*SN: 8/14/10, p 16*).

Söldner-Rembold notes that the Tevatron’s shutdown marks a shift in the frontier of particle physics from the United States to Europe.

“For the next decade, at least, that’s where the action will be,” he says.

The Tevatron smashes protons into antiprotons at energies up to 1.96 trillion electron volts, compared with the 7 TeV energy that the Large Hadron Collider now achieves in colliding twin proton beams, and its eventual maximum energy of 14 TeV. But the intensity—the number of particles in each beam—rather than the energy may be most important if the Higgs boson has a relatively low mass, as many physicists suspect, says Fermilab physicist Dan Green.

The Tevatron and the Large Hadron Collider now have similar beam intensities, but the Fermilab accelerator has

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SN Today at **www.sciencenews.org**

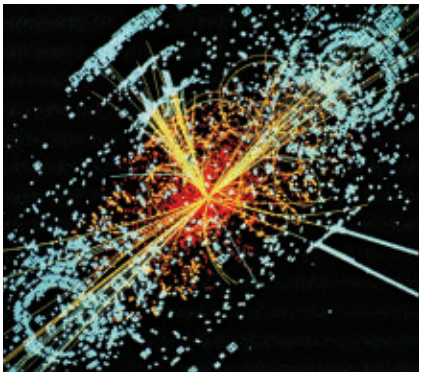
been operating at that level for much longer, since about 2003, and has more data, Green says. The LHC, which CERN expects to roughly triple its beam intensity in 2011, will soon catch up, he adds.

To explore other new physics, such as possible hidden dimensions or supersymmetry — the notion that every known subatomic particle has a heavier, yet-to-be-discovered counterpart — the higher energy of the Large Hadron Collider provides a huge advantage, Green says.

Because the two accelerators hunt for the Higgs in different ways — the Tevatron would detect the proposed particle's most common decay products, a bottom quark and its antiparticle, while the Large Hadron Collider would record a rarer decay mode that produces two photons — the searches are not only competitive but complementary. "It would have been very intriguing to see the Higgs" at both atom smashers and compare results, notes Söldner-Rembold.

Green adds that the lower energy of the Tevatron produces a lower background of extraneous particles, making its Higgs search "a somewhat cleaner" process.

"If we get at the Higgs with the LHC it will be with higher backgrounds,



The Higgs boson, if it exists, would explain the origin of mass. Physicists hope to see a signature of the particle (simulation above) at the LHC when its proton beams reach higher intensity.

meaning that it will take us longer to dig it out," Green says.

Because the Tevatron collides protons with antiprotons, it's also better suited than the LHC to explore ideas about why nature contains so much more matter than antimatter (*SN: 6/19/10, p. 8*). The Tevatron has produced a number of strange hints about nature's asymmetries that might have been confirmed by an extended run.

Theorist Neal Weiner of New York University agrees that "there are some things that may be delayed, or be difficult to study at the LHC." But, he adds, "the field remains extremely exciting, both for the results still to come from the Tevatron and the exciting discoveries that hopefully await us at the LHC."

Cosmologist Rocky Kolb of the University of Chicago is philosophical about the Tevatron's demise. "All great accelerators have an end," he says. "Any disappointment at the closing of the Tevatron is tempered by my wonderful memories of my time at Fermilab, when the Tevatron was cranking out discoveries and it was the center of the high-energy physics world."

Those highlights include the 1995 discovery of the top quark, the sixth and last discovered quark predicted to exist according to current theory. Quarks are a fundamental building block of matter.

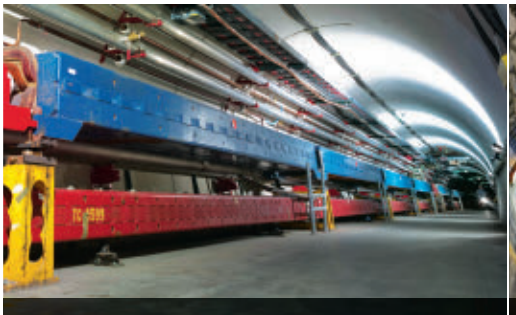
Other Fermilab experiments won't be affected by the shutdown. These include MINOS, in which physicists study the properties of neutrinos, which can morph from one type to another, as they journey between Fermilab and the Soudan Underground Laboratory in northern Minnesota, 724 kilometers away (*SN: 7/17/10, p. 9*). ■

Back Story

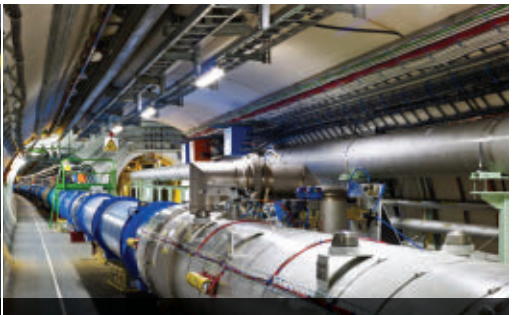
A TALE OF TWO COLLIDERS

A side-by-side comparison of the soon-to-be-shuttered Tevatron and the recently commissioned LHC.

SOURCE: FERMILAB, CERN



Tevatron



LHC

	Tevatron	LHC
Particles collided	Protons vs. antiprotons	Protons vs. protons
Circumference	6.85 kilometers	26.66 kilometers
Maximum energy	1.96 trillion electron volts (TeV)	14 trillion electron volts (TeV)
Peak collision rate	28 million per second	600 million per second
Number of magnets	1,000+	9,300
Magnet operating temperature	–269 Celsius	–271 Celsius

TOP: CERN; BACK STORY: LEFT, FERMILAB; RIGHT, CERN

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It's amazing how technology has changed the way we live. Since the end of the Second World War, more products have been invented than in all of recorded history. After WWII came the invention of the microwave oven, the pocket calculator, and the first wearable hearing aid. While the first two have gotten smaller and more affordable, hearing aids haven't changed much. Now there's an alternative… Neutronic Ear.

First of all, Neutronic Ear is not a hearing aid; it is a PSAP, or Personal Sound Amplification Product. Until PSAPs, everyone was required to see the doctor, have hearing tests, have fitting appointments (numerous visits) and then pay for the instruments without any insurance coverage. These devices can cost up to $5000 each! The high cost and inconvenience drove an innovative scientist to develop the Neutronic Ear PSAP.

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The Evolution of Hearing Products

Invention	Date	Easy to Use?	Invisible?	Affordable?
The Ear Horn	17th Century	No	Hardly	Maybe
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Digital Hearing Aid	1984	No	No	Not for most people
Neutronic Ear	2010	Yes	Yes	Yes

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Humans

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Chimps wear personalities on face

People can gauge dominance from expressionless photos

By Bruce Bower

A study indicates that people can usually tell if a chimp is socially dominant, like the one shown, from a picture of its emotionally neutral face.

In chimpanzees, as in humans, faces are personality billboards, a new study suggests.

People can usually tell whether a chimp acts dominantly and is physically active just by looking at a picture of the ape's expressionless mug, says a team led by psychologist Robert Ward of Bangor University in Wales.

Consistent with earlier evidence from other researchers, Ward and colleagues reported last year that volunteers can also accurately detect whether people are extroverted, emotionally stable, agreeable and imaginative by looking at pictures in which the people have neutral expressions. Extroversion in people and dominance in chimps both relate to assertiveness and sociability, and both partly derive from an individual's genetic makeup.

An ability to discern key personality traits via facial structure evolved more than 7 million years ago in a shared ancestor of people and chimps, the researchers propose online January 18 in *Evolution and Human Behavior*.

"The fact that chimpanzee facial signals can be read by humans suggests that our ability to read others' faces accurately is not solely acquired through culture, but is part of an evolved system," Ward says.

That's an intriguing hypothesis in need of testing with composite images that digitally combine many pictures of the same chimps into single mug shots, remarks psychologist and chimp researcher Lisa Parr of Emory University in Atlanta. Composites minimize slight variations from one photograph to another in lighting, skin hue, head angles and other factors that can create different personality impressions of the same individual.

In previous studies, Ward's team had participants evaluate composite images of people, but technical difficulties have stymied attempts to create composite chimp faces. Anatomical landmarks used to create composite images, such as the jaw's position, are difficult to measure on chimps' hairy faces. Also, composites smooth facial textures, so chimps' faces look blurry rather than hairy.

In the new study, 139 college students viewed pairs of mug shots showing chimps previously identified by researchers as high or low in dominance. Each photographed chimp looked straight ahead or at a slight angle, with no teeth showing and no strong shadowing over the eyes that might impart a menacing look.

Participants distinguished dominant from nondominant chimps more often than would have been expected by chance. Average accuracy rates ranged from about 60 percent to 70 percent, with higher scores for faces of male chimps than of female chimps.

Core facial characteristics of dominant chimps and extroverted people are poorly understood, Ward says. He suspects that chimps can identify dominant chimp faces and plans to explore this possibility.

Kids' friendships not all so mutual

Many grade-schoolers put up with disliked classmates

By Bruce Bower

In the brutal social world of elementary school, friendship can be deceptive. It's relatively common for children to consider as friends classmates who admit disliking them but seem affable on the surface, researchers say.

"The common prevalence of unbalanced relationships, where children believe themselves to be friends with someone who actually dislikes them, is surprising," says James Olsen, a psychologist at the University of Memphis in Tennessee.

Unbalanced relationships comprised 12 percent of third- to sixth-graders' classroom relationships in a university-affiliated elementary school, Olsen and colleagues report online January 13 in *Personal Relationships*. That figure exceeded the percentage of relationships in which each child dislikes the other.

One-quarter of the 2,313 classroom relationships studied consisted of two-way friendships. Remaining pairings mainly included cases in which one child acknowledged another as a friend or as especially disliked, but the second child expressed no opinion about the first.

Not so surprisingly, aggressive and socially troubled third- to sixth-graders often believed they were friends with kids who disliked them, the researchers say. On the other side of the equation, kids who got labeled as buddies by a classmate they disliked got along well with others and had plenty of genuine friends.

Unbalanced friendships have received little attention from researchers, Olsen notes. Previous research has focused on pairs of children who say that they mutually like or dislike each other.

ALESSANDROZOCC/SHUTTERSTOCK

"One bout of writing about test anxiety can substantially increase students' test scores and prevent the dreaded choke." —SIAN BEILOCK

The write stuff for test anxiety

Fearful students score better if they jot down their worries

By Bruce Bower

High school and college students can go from choking to smoking on big tests by writing about their exam fears beforehand, a new study suggests.

In what amounts to a Heimlich maneuver for choking under pressure, writing down test-related worries for 10 minutes before taking a major exam appears to dislodge those concerns and clear the way for higher achievement, say psychologists Gerardo Ramirez and Sian Beilock of the University of Chicago.

Writing about unspoken fears of failure and related anxieties lets students reevaluate such concerns and keeps worries at bay during a test, Ramirez and Beilock propose in the Jan. 14 *Science*.

"One bout of writing about test anxiety can substantially increase students' test scores and prevent the dreaded choke," Beilock says.

Ramirez and Beilock provide the first evidence of people reaping immediate benefits from expressive writing, remarks psychologist James Pennebaker of the University of Texas at Austin. His research has linked writing about personal conflicts and traumas over several days at the start of a college semester to improved physical health and final grades by semester's end.

Researchers have also found that depressed people who write about distressing personal experiences over several months ruminate progressively less about melancholy topics.

Over two consecutive school years at a Midwestern high school, Ramirez and Beilock had teachers randomly assign one of two writing exercises to a total of 106 ninth-graders about to take final exams in biology. Each student had 10 minutes to write either thoughts and feelings about the upcoming exam or a description of a biology topic that they suspected wouldn't be on the exam.

On questionnaires administered six weeks before the final exam, 54 of the students had reported constant worries about taking — and potentially failing — tests.

Among test-anxious students, those who wrote about exam-related feelings scored an average of 6 percent higher on the final than those who wrote about biology topics. Expressive writers received a B+ average on the final, versus a B- for biology writers.

It's unclear whether students plagued by test anxiety can repeatedly raise their test scores via expressive writing, Beilock notes.

Recalling a taste of the Iron Age

Barley grains offer savory insights into ancient Celtic malt

By Bruce Bower

Early rulers of a community in what's now southwestern Germany liked to party, staging elaborate feasts in a ceremonial center. The business side of their revelries was in a nearby brewery capable of turning out large quantities of a beer with a dark, smoky, slightly sour taste, new evidence suggests.

Six ditches at Eberdingen-Hochdorf, a 2,550-year-old Celtic settlement, were used to make high-quality barley malt, a key beer ingredient, says archaeobotanist Hans-Peter Stika of the University of Hohenheim in Stuttgart, Germany. Thousands of charred grains unearthed in the ditches came from a large malt-making enterprise, Stika reports in a paper published online January 4 in *Archaeological and Anthropological Sciences*.

Stika bases that conclusion on a close resemblance of the ancient grains to barley malt that he made by reproducing several methods that Iron Age folk might have used. He also compared the ancient grains with malt produced in modern facilities. Upon confirming the presence of malt at the Celtic site, Stika reconstructed malt-making techniques there to determine how they must have affected beer taste.

"Stika's experiments go a long way toward showing how precisely barley was malted in ancient times," says classics professor Max Nelson of the University of Windsor in Canada, an authority on ancient beer. The oldest known beer residue and brewing facilities date to 5,500 years ago in the Middle East, but archaeological clues to beer's past are rare (*SN: 10/2/04, p. 216*).

These charred barley grains from a site in Germany were the basis of an Iron Age beer.

H.-P. STIKA

At the Celtic site, barley was soaked in the specially constructed ditches until it sprouted, Stika proposes. Grains were then dried by fires at the ends of the ditches, giving the malt a smoky taste and a darkened color. The growth of lactic acid bacteria stimulated by slow drying of grains added sourness to the brew.

Unlike modern beers that are flavored with flowers of the hop plant, the Eberdingen-Hochdorf brew probably contained spices such as mugwort, carrot seeds or henbane, in Stika's opinion. Beer makers are known to have used these additives by medieval times. Excavations at the Celtic site have yielded a few seeds of henbane, a plant that also makes beer more intoxicating.

Life

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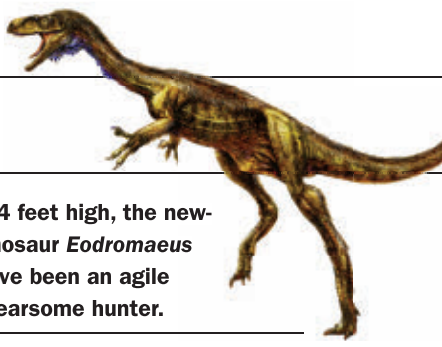


Roughly 4 feet high, the newfound dinosaur *Eodromaeus* would have been an agile but not fearsome hunter.

Lightweight, but also carnivorous

Pint-size biped offers look at dinosaurs' early evolution

By Alexandra Witze

The dinosaur family tree just added a new relative: a small, meat-eating creature dating back to dinosaurs' earliest days.

Unearthed in Argentina in 230-million-year-old rocks, the bipedal *Eodromaeus*, or "dawn runner," would have been as tall as a 7-year-old but as light as a house cat.

Eodromaeus joins its kin *Eoraptor*, a similar-sized dinosaur known to have lived in the same time and place. In fact, when researchers first unearthed *Eodromaeus* they thought that the bones belonged to *Eoraptor*. Despite the two dinosaurs' superficial resemblance, one ate plants while the other ate meat.

"From 20 feet away you'd do a double take — will the animal run from you or take your leg off?" says team member Paul Sereno, a paleontologist at the University of Chicago. Each creature eventually led to a separate branch of dinosaur evolution. "There's no way to look at them and realize that the ultimate descendants of one results in a tyrannosaur, and the other something like [the plant-eating] diplodocus," Sereno says.

The paper describing *Eodromaeus*, in the Jan. 14 *Science*, also reports a wealth of other Argentinean fossils that illuminate how the earliest dinosaurs evolved. "The new dinosaur is special for sure, but we also have the first step of the radiation of the dinosaur story," says the study's lead author, Ricardo Martinez of the National University of San Juan in Argentina.

Fossil evidence shows that the first dinosaurs appeared around 230 million years ago, after a mass extinction 250 million years ago at the end of the Permian period. Many researchers have thought that as dinosaurs rose to prominence they muscled out other animal groups.

But the team analyzed rates of biodiversity in the Argentinean rocks and found the opposite: Other groups of plant-eating creatures underwent a small-scale extinction before dinosaurs began their rise. "Dinosaurs used those empty ecological niches," Martinez says.

Penguins' IDs may impair survival

Metal bands on flippers also shown to reduce reproduction

By Susan Milius

A 10-year project has found that metal identification bands that researchers attach to penguin flippers can cause long-term harm to the birds and possibly to research results, too.

Scientists trying to tell one tuxedoed bird from another — no small task — in some cases wrap metal strips with ID numbers around a part of the flipper near the bird's shoulder. On an island in the southern Indian Ocean, king penguins banded this way had 41 percent fewer chicks and a 44 percent lower survival rate over a decade than did colony mates carrying just an electronic tag, a team reports online January 12 in *Nature*.

A metal identification band on the upper part of a flipper (penguin near center) appears to lower penguin survival rates and reproductive success.

In another worrisome development, the flipper-banded penguins averaged 12.7 days away from home on foraging trips instead of 11.6. "One day or two days is a huge difference," says ecologist and study coauthor Claire Saraux of the University of Strasbourg and France's CNRS research network. Chicks at the breeding site eat only when a parent swims home with food collected hundreds of kilometers, sometimes thousands of kilometers, away. And young chicks have to build up reserves to survive their first winter, when parental food delivery drops off to only a few times during the whole season.

Slower foraging fits with worries that flipper bands may be increasing drag on penguins during swimming, Saraux says. In a swim test in a tank, an Adélie penguin wearing a band expended 24 percent more energy than an unbanded penguin.

"From an ethical point of view, I think we can't continue to band," Saraux says.

P. Dee Boersma, a biologist at the University of Washington in Seattle who has studied various penguin species, notes that all bands are not created equal. "In my view, the main point of the *Nature* paper is that the bands they used were bad for king penguins at their location."

Saraux says flipper bands may also not be good for science. Biologists study penguins to see how climate change impacts life in and around the Antarctic, but the researchers found that environmental conditions affected banded birds more than their unbanded counterparts. During warmer phases of the El Niño climate cycle, when the seafood that penguins eat is scarce, the banded birds showed a greater tendency to arrive late at breeding grounds.

FROM TOP: TODD MARSHALL; BENOÎT GINESTE

"If you're a brown belt, maybe you don't want to challenge a black belt. And you're happy to know it beforehand." —FABRIZIO SERGIO

Plastic doodads deter enemies

Spanish birds adorn nests as a warning sign to rivals

By Susan Milius

Nests built by three black kites of different ages (left to right, ages 3, 11, 22 years) illustrate the abundance of plastic decoration used by birds at their physical peak, possibly as a warning to intruders that the nest's owner is ready to defend it.

Not just any bird can pull off the nest-full-of-shredded-shopping-bags look.

Among black kites nesting in Spain's Doñana National Park, breeding pairs in the prime of life collect an abundance of white plastic and tuck it into their nests, says ecologist Fabrizio Sergio of the CSIC Doñana Biological Station.

Sergio and colleagues report that this conspicuous plastic decor warns rival birds that any attempts to take over a desirable territory will meet fierce resistance. The jumbles of pale, easy-to-see oddments apparently serve as a reliable indicator, the researchers say in the Jan. 21 *Science*, because weaker birds seem loath to display phony warnings.

Fights between black kites (*Milvus migrans*), midsize birds of prey, can get quite violent. Combatants sometimes lock talons in midair, struggling as they plummet to the ground. Signals of strength might be valuable in picking which fights to start, Sergio says. "If you're a brown belt, maybe you don't want to challenge a black belt. And you're happy to know it beforehand," Sergio says.

The potential of bird nests to send signals has been "greatly underrated," comments Michael Taborsky of the University of Bern in Switzerland. Just as feather colors or other body features send messages, so can built structures.

Tracking 127 kite nests, researchers found that extensive nest decoration showed up mainly among birds between 7 and 12 years old, in their physical prime. Younger and older birds displayed little bling or none at all. And decorations were associated with domestic success. Kites with bigger displays were more likely to rear two or three chicks a season instead of just one. Also, nests with a lot of decoration tended to have fewer intruders.

When researchers added plastic, the sudden uptick in finery actually increased the number of attacks (at least for the first couple of hours) on previously unadorned nests. Sergio calls the onslaught "an initial social test," in which intruders check to see whether defenders really can live up to their plastic. Such testing may help keep the signaling system honest.

In another experiment, the team set out shreds of white, green or transparent plastic. Of the 33 pairs that picked up some of the doodads, 29 chose only the white snippets.

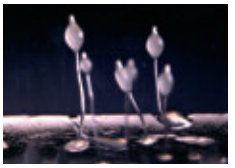
Slime molds adept at agriculture

Some social amoebas engage in farming of bacterial food

By Susan Milius

Birds, bees and educated fleas actually don't do it. But a social amoeba does practice simple agriculture in the form of bacterial husbandry.

Dictyostelium discoideum, aka a slime mold, is the latest member in a small club of species known to practice farming. It's not fancy. But 13 out of 35 wild strains of the tiny soil-dwelling creature routinely stop grazing on their bacterial food while there's still some left, reports Debra A. Brock of Rice University in Houston. The social amoebas then mix uneaten bacteria into reproductive structures that release spores complete with starter kits for planting a new food patch, Brock and colleagues report in the Jan. 20 *Nature*.



Slime mold sporing structures host bacteria for future farmers.

There's no evidence so far that the social amoebas tend a bacterial crop once it starts growing, notes evolutionary geneticist Duur Aanen of Wageningen University in the Netherlands. Yet, he says, "the example described in this paper really fulfills the definition of farming: carrying, seeding and prudent harvesting of food."

The short list of farmer species — including certain ants, termites, beetles, a salt marsh snail and a damselfish — has intrigued scientists searching for shared features. "One such commonality is that farming occurs in societies," Aanen says, a pattern reinforced by the social amoebas.

Dictyostelium farming went undiscovered for decades, Brock says, because biologists focused on a particular strain that's easy to grow in the lab. It happened, Brock now knows, to be one of the non-farmer strains.

FROM TOP: F. SERGIO; OWEN GILBERT

Atom & Cosmos

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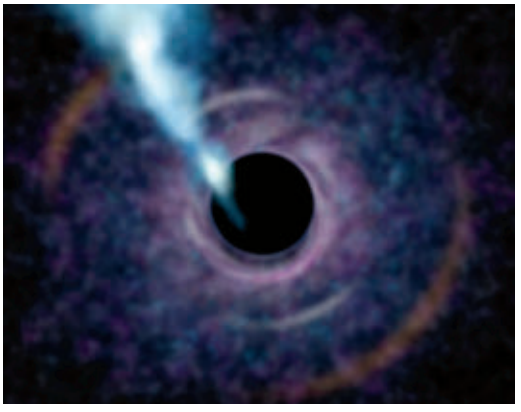
Nearby black hole's heft pinpointed

Galaxy M87's massive heart weighs in at 6.6 billion suns

By Ron Cowen

Astronomers have determined with high precision that the black hole at the heart of the nearby galaxy M87 weighs the equivalent of 6.6 billion suns. The finding makes the monster the most massive known in Earth's cosmic neighborhood and, so far, the heaviest black hole yet measured using the orbits of stars.



New measurements confirm that the nearby M87's black hole, shown in an artist's conception, is on par with more distant behemoths.

More than doubling a widely accepted estimate, the new M87 measurement for the first time puts the mass of a nearby supermassive black hole — some 50 million light-years from Earth — on a par with the estimated 10-billion-solar-mass heft of black holes in distant galaxies, said Karl Gebhardt of the University of Texas at Austin. He described the findings on January 12.

Because more massive black holes have larger event horizons — the boundary inside which any incoming particle remains forever trapped — the new result makes it more likely that astronomers will one day glimpse the shadow of this boundary region in M87. Such a feat would clinch the existence of these gravitational beasts (*SN: 10/9/10, p. 22*).

The finding corroborates simulations by Gebhardt and a collaborator that suggest supermassive black holes in other nearby galaxies are also about twice as heavy as had been calculated (*SN: 7/4/09, p. 5*).

Extremely massive black holes are rare "and having one so close to us is extraordinary," commented astronomer Avery Broderick of the Canadian Institute for Theoretical Astrophysics in Toronto. The Milky Way's central black hole weighs the equivalent of a mere 4 million suns.

To weigh M87's black hole, Gebhardt and his team took advantage of precision optics on the Gemini North telescope atop Hawaii's Mauna Kea to measure the speeds of groups of stars orbiting the galaxy's core at different distances. The acceleration of stars closest to the center gave a precise measure of the black hole's pull, which allowed researchers to calculate the central object's mass. The researchers also used data gathered by a telescope at the McDonald Observatory in Fort Davis, Texas.

Now, says Gebhardt, "it's time to push the limit" and use Gemini to measure the supermassive black holes in more distant galaxies. If astronomers can show that those black holes have a maximum mass, the find may put a cap on how heavy galaxies can become.

MEETING NOTES

Rocky body beyond solar system

A newly discovered extrasolar planet is not only the smallest yet found, but also the first confirmed to be made entirely of rocky material, Natalie Batalha of San José State University in California reported January 10. Discovered by NASA's Kepler spacecraft and dubbed Kepler-10b, the rocky body has a diameter 40 percent larger than Earth's.

Probably partially molten, the planet is too hot to contain liquid water or support Earthlike life. But rocky planets interest scientists because chemical reactions that form the building blocks of life may happen most readily on solid surfaces. "The more rocky planets we can find, the better placed we will be to understand the subset that are in the habitable zone," says Rory Barnes of the University of Washington in Seattle. —*Ron Cowen*

Massive clusters and cold clumps

The European Space Agency's Planck spacecraft has identified some of the most massive galaxy clusters ever measured and the coldest clumps of material in the Milky Way.

Some of the galaxy clusters detected by Planck weigh the equivalent of a million billion suns. Some of the clumps are the coldest places known, with temperatures as low as 7 degrees Celsius above absolute zero.

The roughly 10,000 cold cores, many previously unknown, will help astronomers study the very beginnings of star formation, said Planck researcher Charles Lawrence of NASA's Jet Propulsion Laboratory in Pasadena, Calif. Although Planck's main mission is to examine the faint microwave glow left over from the Big Bang, astronomers must painstakingly identify and subtract confounding emissions from foreground objects. The new findings, reported January 11, are among the first fruits of those labors. —*Ron Cowen*

GEMINI OBSERVATORY, AURA ILLUSTRATION BY LYNETTE COOK

Technology

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Computers learn trick from fruit fly

Insect's nerve cells use timing, not census, to choose leaders

By Rachel Ehrenberg

Fruit flies have solved a computing problem that has vexed computer scientists for decades. Mimicking how some developing nerve cells in flies pick a leader to make decisions has led to a computer algorithm that could make wireless sensor networks — such as those used to control swarms of robots — more efficient, researchers report in the Jan. 14 *Science*.

In such smart networks, some sensors act as leaders to alert headquarters if, for example, a certain number of them detect the first rumblings of an active volcano. The new approach achieves the same leader-follower relationships but eliminates a lot of cross talk among sensors, saving energy and computing power.

How fly nerve cells decide to take on different jobs parallels an issue in distributed computing, in which many processors work together toward a common goal with minimal leadership. A handful of processors — typically ones with many neighboring processors — are designated leaders; they receive information from nearby processors and pass it on. Yet fly nerve cells set up their networks without knowing much about their neighbors and still come up with solutions.

As fruit fly larvae develop, some cells take on particular tasks, such as becoming precursors to the sensory bristles that the flies use to read the air around them. Each bristle ends up surrounded by non-bristle cells. This layout, where there are enough specialized cells, or leaders, but no two are right next to each other, is very similar to how tasks are divvied up in distributed networks, says Ziv Bar-Joseph of Carnegie Mellon University in Pittsburgh, who led the new work.

For 30 years, computer scientists thought that each processor had to take stock of its local neighborhood to most efficiently designate the leaders. The new algorithm shows that networks of sensors that use timing in the selection process are more efficient.

Young fruit fly nerve cells don't necessarily know how many cells are in their neighborhood, yet manage to develop into properly distributed sensory bristles. The trick lies in using timing instead of a neighborhood census. As time passes, if a cell hasn't received a don't-become-a-bristle directive, it becomes a bristle. Once a cell elects itself as a bristle, it sends out a protein signal that inhibits neighboring cells from becoming bristles.

National Center for Agricultural Utilization Research
Peoria, Illinois

Supervisory Research Chemist/Physical Scientist/Chemical Engineer

The National Center for Agricultural Utilization Research (NCAUR), Plant Polymer Research Unit (PPL), Peoria, IL, is seeking a permanent full-time Research Leader.

The mission of PPL is to conduct research to convert agricultural products into novel, value-added materials, thus creating expanded markets for agricultural commodities. Research emphasis is on chemicalor enzymatic modification of polysaccharides and proteins, bio-based materials, and structure-property relationships of the modified materials. In addition, as Research Leader the incumbent exercises leadership and line authority over scientists and support personnel assigned to the Unit. In this capacity, the incumbent is responsible for maintaining and enhancing the creativity and productivity of the Unit, hiring personnel and managing the human, fiscal, and physical resources assigned to the Unit, serving as the Unit fund holder, providing technical information and consultation both internal and external to ARS, and ensuring the proper interpretation and reporting of scientific research results and information.

A degree in one of the following fields; chemistry, physical science or chemical engineering is required; in addition to professional knowledge of materials science, polymer extrusion and processing, polymer chemistry and physics, chemical engineering and organic chemistry. Familiarity with instrumental analysis techniques necessary for polymer characterization is required. The ability to plan, conduct and report a personal research program is required. An ability to effectively communicate with stakeholders, cooperators and the general public is required. For details and application directions, visit the website - http://www.afm.ars.usda.gov/divisions/hrd/index.html and refer to announcement ARS-X11W-0051. U.S. citizenship and pre-employment background investigation required. Application must be received by February 28, 2011. USDA/ARS is an equal opportunity employer and provider.

USDA ars Agricultural Research Service
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Genes & Cells

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Putting a worm on a laser leash

Scientists use light signals to control nematode actions

By Laura Sanders

Satirist Stephen Colbert envisions his "Colbert Nation" mentally marching in lockstep with his special brand of patriotism. But researchers have done him one better, by creating tiny worm-bots completely under the scientists' control.

Rather than comedic persuasion, a laser light can make a live worm turn left, freeze or lay an egg, scientists report online January 16 in *Nature Methods*.

The new system, named COLBERT for "Controlling Locomotion and Behavior in Real Time," doesn't just create a mindless zombie-worm, though. It gives scientists the ability to pick apart complicated behaviors on a cell-by-cell basis.

"This system is really remarkable," comments biological physicist William Ryu of the University of Toronto. "It's a very important advance in pursuit of the goal of understanding behavior."

Transparent and small, the nematode *C. elegans* is particularly amenable to light-based mind control. And while researchers already knew the precise locations of all 302 of the worm's nerve cells, or neurons, until now there wasn't a good way to study each cell by itself, especially in a wriggling animal.

"This tool allows us to go in and poke and prod at those neurons in an animal as it's moving, and see exactly what each neuron does," says study coauthor Andrew Leifer of Harvard University.

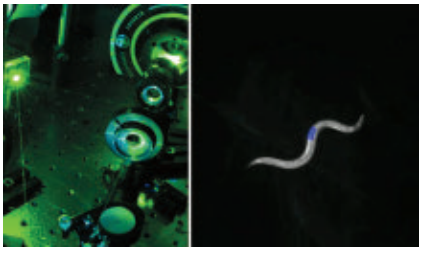
The system is based on the emerging field of optogenetics, in which light is used to control cells. Leifer and colleagues genetically engineered light-responsive molecules into groups of cells in the worm.

A computer program figures out where in the microscope's field of view a target cell is. Once the cell is pinpointed, the program directs lasers so that a tiny beam of light hits the cell. The whole process, from finding the cell to light hitting its target, takes about 20 milliseconds.

As the worm's position changes, that information is fed back to the computer, and the laser is adjusted. If the worm crawls too far, a motorized microscope stage brings it back.

One benefit of the new method is that it works in a roving animal. "The worms are not held down in any way — they're freely moving," Ryu says.

The team used the method to study two nerve cells that help the worm respond to touch. A gentle tickle on the head causes worms to move backward, but after too many touches, the worms grow desensitized and stop responding. By mimicking touches with light, the researchers found that a cell that has been touched too many times can also tire out its partner cell that hasn't been touched, suggesting that these cells don't act alone.



A computer-guided laser (left) directs the behavior of a worm (right), using light to take control of nerve cells.

Another group, led by Jeffrey Stirman of Georgia Tech in Atlanta, reports a similar technique for worm mind-control, also online in *Nature Methods*. The COLBERT method appears to be a little faster, Ryu says, but if the worm is crawling slowly, the Stirman group's approach may offer more precise laser targeting.

Microbes stole metabolic third way

Salt-loving bugs exploit tinkering, thievery to build molecules

By Rachel Ehrenberg

A group of salt-loving microbes cobbled together machinery for making cellular building blocks millions of years ago by stealing the parts, researchers report.

Cells convert food into useful compounds using metabolic assembly lines that produce many molecular middlemen, much to the chagrin of biochemistry students forced to recite them. One such middleman is acetyl coenzyme A, a fundamental component of the glyoxylate cycle used by plants, some fungi and some bacteria. A few years ago, researchers found that some microbes have a second way of using the compound to build new molecules. The newly discovered methylaspartate cycle, reported in the Jan. 21 *Science*, represents a third approach and is further testament to the ingenuity of life, says study leader Ivan Berg of the University of Freiburg in Germany.

Some of the enzymes in the new cycle look so much like those used by distantly related bacteria that the researchers say the salt-loving microbes stole the genes for the enzymes from other life-forms deep in the evolutionary past.

"This exciting result showcases how different organisms communicate in ecosystems and pass information and metabolic capabilities onto each other," says microbial biochemist Scott Ensign of Utah State University in Logan.

Preliminary analysis suggests the cycle is used by about half the species in Haloarchaea, a branch of the Archaea family tree whose members thrive in extreme conditions. Many of the microbes subsist in salty lakes on rare, ephemeral blooms of nutrients. In the lean times between blooms, the methylaspartate cycle might help these microbes survive by tapping stored nitrogen, allowing them to continue to construct things like proteins.

SAMUEL GROUP/HARVARD UNIV.

Science & Society

For more about this year's Intel Science Talent Search finalists, visit **www.societyforscience.org/sts**

Intel Science Talent Search's top 40

High school researchers to present work in Washington, D.C.

By Laura Sanders

Forty young, limber brains have made it to the final phase of the nation's oldest science competition for high school seniors, the Intel Science Talent Search. In March, the finalists will travel to Washington, D.C., where they will spend a week presenting their original research to national leaders, top scientists and the public. Intel and Society for Science & the Public will announce the top award winner, who will take home $100,000, on March 15 during a black-tie gala held at the National Building Museum. Finalists will vie for a total of $630,000 in awards.

This year's competitors hail from 15 states. For the first time in the history of the event, more of them come from California than New York.

Finalists' research topics cover a wide range of disciplines. This year's student projects include a new kind of highly efficient solar cell, a therapy that relies on ultraviolet light to fight autoimmune disease, a study of how air pollution can cause lung inflammation and robots that incorporate emotion to smooth interactions with humans.

The finalists "exemplify the promise of young people to bring creativity and innovation to bear to create a better world," says Elizabeth Marincola, publisher of *Science News* and president of Society for Science & the Public, which has operated the Science Talent Search since 1942. "We applaud their hard work and creativity, and look forward to their continued contributions to human advancement."

The 40 students selected were winnowed from 300 semifinalists, who were chosen from a pool of 1,744 entrants. These math, engineering and science achievers join a select group of scientific luminaries: Past finalists have earned seven Nobel Prizes and four National Medals of Science. Physicist and Nobel laureate Sheldon Glashow was a finalist in 1950; in 1980 Harvard University string theorist Lisa Randall was selected. Actress Natalie Portman was a semifinalist in 1999.

Last year, Erika DeBenedictis of Albuquerque, N.M., nabbed the Intel Science Talent Search's top award for her research on spacecraft navigation. DeBenedictis' study pointed out transit routes through the solar system that would reduce a spacecraft's fuel consumption. ■

THE FINALISTS

ARIZONA **Scott Boisvert,** Chandler, Basha High School

CALIFORNIA **Amol Aggarwal,** Saratoga, Saratoga High School; **Xiaoyu Cao,** San Diego, Torrey Pines High School; **Bonnie Lei,** Walnut, Walnut High School; **Jonathan Li,** Laguna Niguel, St. Margaret's Episcopal School; **Selena Li,** Fair Oaks, Mira Loma High School; **Andrew Liu,** Palo Alto, Henry M. Gunn Senior High School; **Rohan Mahajan,** Cupertino, The Harker School; **Evan O'Dorney,** Danville, Venture School; **Nikhil Parthasarathy,** Mountain View, The Harker School; **David Tang-Quan,** Rancho Palos Verdes, Palos Verdes Peninsula High School; **Chelsea Voss,** Santa Clara, Cupertino High School

CONNECTICUT **Jenny Liu,** Orange, Amity Regional High School; **Shubhro Saha,** Avon, Choate Rosemary Hall

FLORIDA **Eta Atolia,** Tallahassee, Rickards High School; **Elaine Zhou,** Winter Park, Lake Highland Preparatory School

ILLINOIS **Krystle Leung,** Naperville, Naperville Central High School

MASSACHUSETTS **Sung Won Cho,** Lexington, Groton School

MICHIGAN **Shubhangi Arora,** Novi, Novi High School

MINNESOTA **Prithwis Mukhopadhyay,** Woodbury, Woodbury High School

NORTH CAROLINA **Si-Yi Lee,** Charlotte, North Carolina School of Science and Mathematics; **Matthew Miller,** Elon, Western Alamance High School

NEBRASKA **Emily Chen,** Omaha, Brownell-Talbot School

NEW JERSEY **Alison Bick,** Short Hills, Millburn High School; **Joshua Bocarsly,** Plainsboro, The Lawrenceville School; **Wenyu Cao,** Belle Mead, Phillips Academy

NEW YORK **Jonathan Aaron Goldman,** Plainview, Plainview-Old Bethpage John F. Kennedy High School; **Jan Gong,** Garden City, Garden City High School; **Michelle Hackman,** Great Neck, John L. Miller Great Neck North High School; **Bryan He,** Williamsville, Williamsville East High School; **Matthew Lam,** Old Westbury, Jericho High School; **Grace Phillips,** Larchmont, Mamaroneck High School; **Alydaar Rangwala,** Loudonville, The Albany Academies

OREGON **Laurie Rumker,** Portland, Oregon Episcopal School; **Yushi Wang,** Portland, Sunset High School

PENNSYLVANIA **Benjamin Clark,** Lancaster, Penn Manor High School; **Keenan Monks,** Hazleton, Hazleton Area High School

TEXAS **Madeleine Ball,** Dallas, Ursuline Academy of Dallas; **Rounok Joardar,** Plano, Plano West Senior High School; **Sunil Pai,** Houston, The Kinkaid School

Finalists are listed by state, name, hometown and high school.

Body & Brain

40 mg/dL | HDL below this level linked to more heart disease in men

50 mg/dL | HDL below this level linked to disease in women

60 mg/dL | HDL above this level is considered protective

Quality may trump quantity in HDL

Good cholesterol's effectiveness at clearing fats is crucial

By Tina Hesman Saey

How much good cholesterol a person has is not as important as how well the beneficial substance works to stop heart disease, a new study suggests.

High-density lipoprotein — also known as HDL, or "good" cholesterol — is healthy for the heart, previous studies have indicated. Higher blood levels of the molecule tend to decrease risk of developing heart disease.

But a new study indicates that HDL levels may not be the most important factor in protecting against clogged arteries and cardiovascular disease. The study, published January 13 in the *New England Journal of Medicine*, shows that HDL's efficiency at removing fats from arteries is a better predictor of who will develop heart disease than its levels in the blood.

"Just measuring HDL levels isn't enough to figure out what's going on," says Jay Heinecke, an endocrinologist at the University of Washington in Seattle.

Some people's HDL was more efficient than other people's, found researchers led by Daniel Rader of the University of Pennsylvania School of Medicine in Philadelphia. Healthy people with this trait had less thickening of the carotid arteries than people with less efficient cholesterol-clearing HDL. In a separate group of people, HDL functioning was a better indicator than HDL levels of whether the person had heart disease, the team found.

Doctors won't be able to test their patients' HDL efficiency anytime soon. "We don't yet have an assay or a test that can be used in a clinical setting," Rader says. But the work does shed light on questions about how good cholesterol might fight heart disease.

Cocaine vaccine looks promising

Injections raise antibodies to limit drug's effects in mice

By Nathan Seppa

Antibodies generated in response to a new vaccine can capture cocaine molecules in the seconds before the drug reaches the brain, a study in mice shows. Although the antibody brigade doesn't snag all the cocaine, it seems to collar enough to greatly subdue the agitation that mice usually exhibit when given the drug.

With these findings in hand, researchers are moving on to studies in rats and monkeys in hopes of testing the vaccine in people. The new report will appear in the March *Molecular Therapy*.

"When someone takes cocaine ... you don't have much time," says study coauthor Ronald Crystal, a pulmonary physician at Weill Cornell Medical College in New York City. "It takes about six seconds to pass from the lungs to the blood to the brain."

A vaccine would need to elicit a standing army poised to intercede. In the new study, Crystal and his colleagues gave mice three injections over six weeks. Some of the animals received a placebo while the others got the experimental vaccine, which combines a cocainelike substance with noninfectious portions of an adenovirus that stimulate an immune response but don't cause disease. Four weeks later, all the mice were exposed to cocaine by injection.

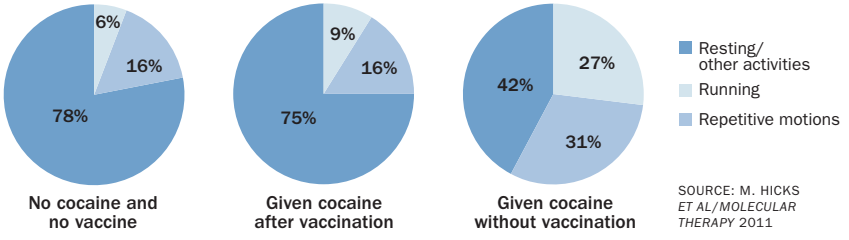
Antibodies elicited by the vaccine kept about two-fifths of the cocaine from reaching the brain in vaccinated animals, according to examinations of the mice. This effect translated into behavioral changes: Cocaine makes mice hyperactive, Crystal says, and in this study the unvaccinated mice spent a good portion of their time running around. In contrast, vaccinated mice ran one-third as much and performed repetitive motions half as much, behavior similar to that of mice that were not given cocaine at all.

Crystal says the vaccine might be ready to test in people in a year or two. "The most obvious strategy is to use it in people who are addicted but who want to stop and have enrolled in a program," he says. "This would help them."

About 40 percent of cocaine users are in denial about their addiction, and another 40 percent are not yet willing to take on the challenge of quitting, says Stephen Ross, an addiction psychiatrist at New York University. "The other 20 percent are ready to make a change," he says. Such people need behavioral therapy and all available support. "The more tools we have, the better," Ross says. "A vaccine could be part of that arsenal."

Calming influence Mice vaccinated against cocaine exhibit less agitated behavior when exposed to the drug than do unvaccinated mice on the drug, as shown by the average time the animals spend on various activities.

Anticocaine vaccine's effect on mouse behavior



SOURCE: M. HICKS *ET AL/MOLECULAR THERAPY* 2011

T. DUBÉ

Earth

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2010 ties record for warmest year

20th century's global average exceeded for 34th year in row

By Alexandra Witze

In the race for hottest year on record, 2010 has joined 2005 and 1998 in a dead heat.

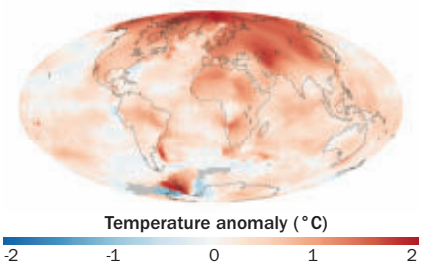
On January 12, NASA and the National Oceanic and Atmospheric Administration released independent analyses of global surface temperature data for last year. Both found that 2010 was statistically tied with 2005 for the title of hottest year, followed closely by 1998 in third place.

An analysis by the United Kingdom's Met Office and the University of East Anglia ranks 2010 as the second-hottest year, just slightly behind 1998. (2005 was third in their estimation.) Looking at all three analyses, the World Meteorological Organization noted that 2010, 2005 and 1998 are effectively neck and neck.

The warmth of 2010 is "not surprising, considering that global surface temperatures have been climbing," says Deke Arndt of NOAA's National Climatic Data Center in Asheville, N.C. The last decade has been the warmest since record-keeping began in 1880.

Combined land and ocean surface temperatures across the globe in 2010 were 0.62 degrees Celsius higher than the 20th century average, NOAA reports. In the contiguous United States, temperatures were 0.6 degrees above normal, making it the 23rd warmest U.S. year on record. The Northern Hemisphere had its warmest year on record, while the Southern Hemisphere saw its sixth warmest, NOAA says.

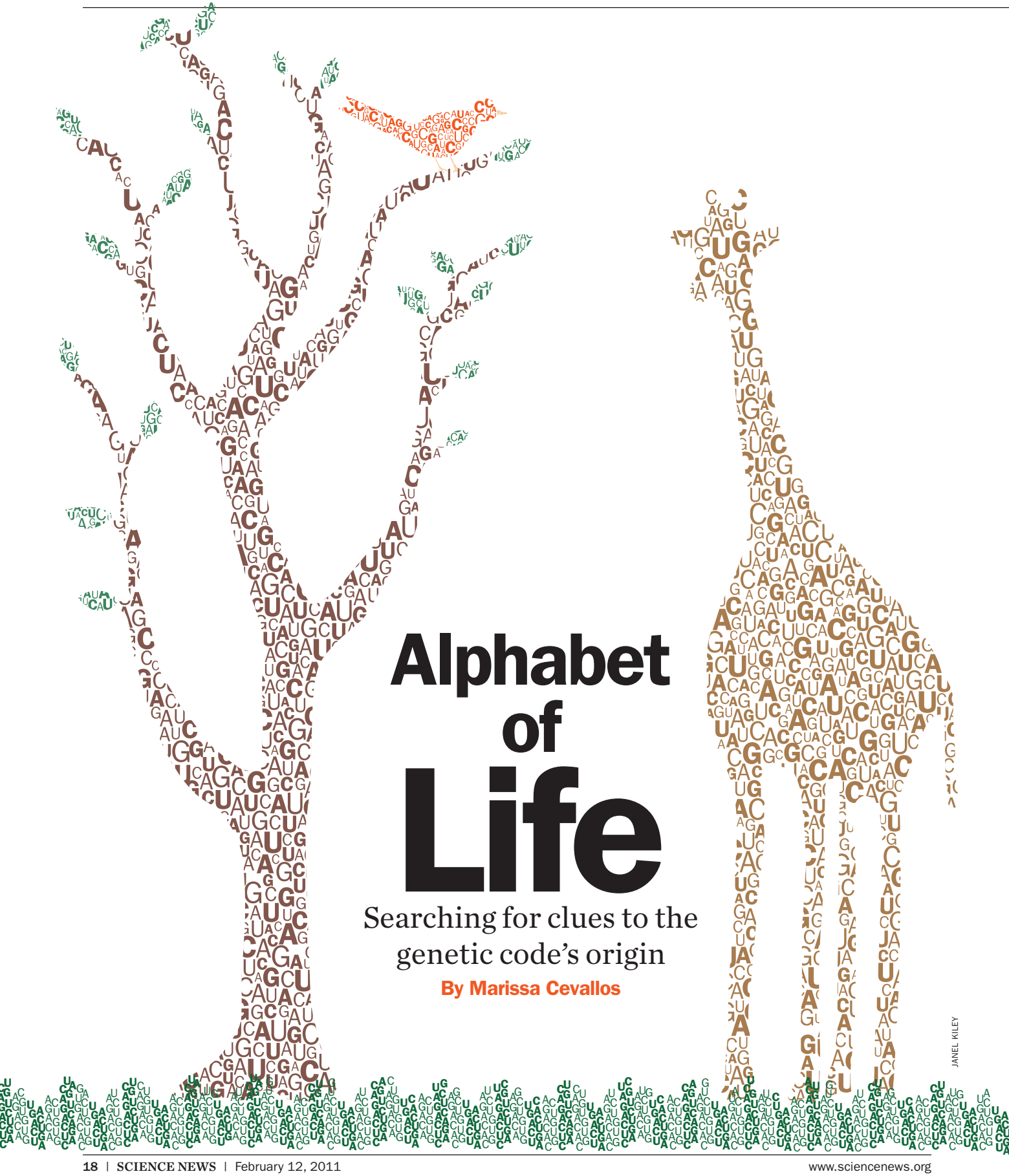
The NASA analysis, produced by its Goddard Institute for Space Studies in New York City, found that, on a global scale, 2010 was about 0.74 degrees warmer than the average for 1951 to 1980.



Between 2000 and 2009, more of the globe warmed (red) than cooled (blue) compared with the 1951–1980 average.

All the bean counting about which year was hottest obscures a deeper point, says Gavin Schmidt, a climatologist at the Goddard Institute who wasn't involved in the new analysis. "The baseline is getting warmer and warmer every year," he says. Indeed, 2010 was the 34th year in a row in which global temperatures were higher than the 20th century average.

ROBERT SIMMON, NASA GISS



Alphabet of Life

Searching for clues to the genetic code's origin

By Marissa Cevallos

JANEL KILEY

"Omg. u no how 2 do the bio hw?"

Texting uses a peculiar alphabet. It keeps messages brief but still encodes enough meaning for students to communicate about homework, coffee dates and crushes — all while accommodating the occasional typo.

The genetic alphabet, the letters used as the blueprint for all life, balances brevity and clarity in a similar way. Just four letters combine to spell out the more than five dozen three-letter words that encrypt the information needed to make all the cells in the human body, and any other body as well.

Figuring out how life's code came to be is nature's original homework problem, and it isn't easy: It's like studying how people in Paris talk today to determine what the first Latin alphabet must have been. Attempts at deciphering the code's origins are also complicated by the fact that, unless another iteration of life turns up, say on a distant planet, scientists have only one version to study.

"We only have one experiment, and it's extremely hard to repeat this experiment," says physicist Tsvi Tlusty of the Weizmann Institute of Science in Rehovot, Israel.

Without a way to replicate life's earliest days, coming up with a theory to explain the code is like interpreting a Rorschach test. But that doesn't stop scientists from trying. Some are now finding that outside pressures, such as a need to minimize error, may have driven the code to evolve the same way as texting — through en masse trial and error. Chemical attractions between molecules, others report, could have set the code's destiny.

"These discoveries make the whole field legitimate rather than a matter of pure speculation," says molecular biologist Eugene Koonin of the National Center for Biotechnology Information in Bethesda, Md.

A shared code

All life on Earth — people, pandas, tulips and slime molds — uses the same genetic letters in its DNA. These letters — A, C, T and G — stand for DNA's four bases (adenine, cytosine, thymine and guanine). With sugar and a phosphate, these molecules form the basic units of DNA, called nucleotides. And the letters provide instructions for making proteins, essential cellular players that kick-start chemical reactions, serve as scaffolding and act as messengers.

To make a protein, the two strands of the double helix–shaped DNA unwind, and a complementary strand called messenger RNA forms alongside one of the exposed arms of the helix. Messenger RNA is a copy of DNA with chemically similar letters (though messenger RNA has a U for uracil instead of thymine). This RNA is moved to a cellular factory called a ribosome where, through a process called translation, the RNA gets decoded and proteins are constructed.

Every three nucleotides in the messenger RNA spell a genetic word, called a codon, that codes for a specific amino acid. In the ribosome, amino acids are linked to form protein molecules, the way words come together into sentences. The codon for the amino acid methionine often serves as a start signal, while three other codons serve as punctuation marks, telling protein construction to "stop."

With an alphabet of four letters, 64 three-letter codons are possible. Yet cells make their proteins from only 20 amino acids.

Francis Crick, codiscoverer of the DNA double helix, proposed in 1968 that the code for these 20 amino acids was a "frozen accident," working well enough to get passed down through generations like an old tradition. If so, on a second go-round life could look completely different, and any life found elsewhere in the universe would probably be unfamiliar as well. But some of the alphabet's features seem too good to be an accident, so scientists have tried to find logic beyond pure luck.

Some of the words, for example, act like synonyms. Three or four codons, usually identical except for one letter, can stand for the same amino acid, just like *hi* and *hey* both mean "hello." This feature can protect cells from errors: If messenger RNA's CGA mistakenly becomes CGU, for example, the cell still selects the same amino acid (in this case, arginine).

But even if a mistranslation leads to the wrong amino acid, the code is arranged so that the product will be chemically similar to the intended one. This logic isn't generally a rule in English: You'd have trouble doing your homework with a "hen" if you really needed a "pen."

Related neighbors The genetic code used by all life on Earth maps 64 three-letter words to 20 corresponding amino acids and a stop signal, which serves as a punctuation mark. Since similar amino acids are coded by similar three-letter words (degree of shading represents similarity, with "stop" signals in brown), some researchers think a pressure to reduce the havoc brought about by errors may have been an important driving force during the code's early development.

UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine
UUC	Phenylalanine	UCC	Serine	UAC	Tyrosine	UGC	Cysteine
UUA	Leucine	UCA	Serine	UAA	Terminate	UGA	Terminate
UUG	Leucine	UCG	Serine	UAG	Terminate	UGG	Tryptophan
CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine
CUC	Leucine	CCC	Proline	CAC	Histidine	CGC	Arginine
CUA	Leucine	CCA	Proline	CAA	Glutamine	CGA	Arginine
CUG	Leucine	CCG	Proline	CAG	Glutamine	CGG	Arginine
AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine
AUC	Isoleucine	ACC	Threonine	AAC	Asparagine	AGC	Serine
AUA	Isoleucine	ACA	Threonine	AAA	Lysine	AGA	Arginine
AUG	Methionine	ACG	Threonine	AAG	Lysine	AGG	Arginine
GUU	Valine	GCU	Alanine	GAU	Aspartic acid	GGU	Glycine
GUC	Valine	GCC	Alanine	GAC	Aspartic acid	GGC	Glycine
GUA	Valine	GCA	Alanine	GAA	Glutamic acid	GGA	Glycine
GUG	Valine	GCG	Alanine	GAG	Glutamic acid	GGG	Glycine

SOURCE: E. KOONIN AND A. NOVOZHILOV/*LIFE* 2009

ADAPTED BY JANEL KILEY

At the same time, the 20 words are different enough that combining them can make bats, bees, birds and bacteria. If the amino acids are LEGOs and the task is to build things for 4 billion years, you had better have a diverse set, with rectangular blocks, joints and wheels, says astrobiologist Stephen Freeland of the University of Hawaii at Manoa.

There are plenty of other ways to arrange the code. By the calculations of a team including Peter Clote, now of Boston College but formerly of Ludwig-Maximilians-Universität München in Germany, there are 10^{84} alternate codes that assign at least one codon to each of the 20 amino acids (and "stop"). So it would be weird if, by complete chance, the code had such clever traits.

Dodging errors

Tlusty thinks that if the genetic code is so good at what it does, it's because it adapted under evolutionary pressure, the way the beaks of some of Darwin's finches developed to be hefty seed crackers or long flower probes depending on available food.

Three pressures, Tlusty argues, could have shaped the current genetic code. First, typos can't be disastrous — if a random mutation changes one of the letters, the cell should still infer which spelling was intended. Second, the language must be able to spell words with diverse meanings. Third, the language shouldn't take a lot of resources to write, forcing the cell to make tons of extra molecules.

Assuming an evolving code, and assuming four letters in the alphabet and three-letter words, Tlusty tried to figure out an ideal number of amino acids. He imagined the code as mapping onto a many-dimensioned doughnut of sorts, with all 64 possible codons spaced out so that those that could easily be confused with each other are neighbors. Then he tried to find how many colors, or amino acids, are needed to make a map that obeys his three demands. In this way, Tlusty rephrased a biological question (How many amino acids would a changeable code settle on?) as a classic mathematical one: What is the fewest number of colors necessary to color geographical divisions on a map without any colors touching themselves?

On a two-dimensional map, like a map of the United States, the answer is four colors. In the higher dimensions necessary to map the code, the range of colors is between 20 and 25, Tlusty reported in *Physics of Life Reviews* in September. That's spot on for how many amino acids are in today's code.

Tlusty's findings support his idea that a changing code could have settled on an optimal number of amino acids. Another team suggests that an earlier code, one that preceded today's, could have been a superstar at one of Tlusty's three demands.

If randomly generated codes are placed on a landscape, with higher elevations designated for codes that are better at preventing errors in protein manufacture, life's code would be found on the side of an unassuming hill. But a previous code could have been atop one of the highest peaks, Koonin argues.

Because changing the third letter of a codon doesn't drastically change the amino acid, Koonin and others think that an early genetic code relied on only the first two of its three letters. Such a code could have expressed at most 16 amino acids. Koonin's team backtracked the code to its most plausible two-letter origins, playing with different codon assignments. In *Biology Direct* in 2009, the researchers reported that several such codes were exceptionally robust against translation errors, suggesting that minimizing error drove the code's development early on. When having more than 16 amino acids was advantageous (allowing for more types of proteins), the code started to use the third letter — getting a little worse at avoiding errors.

Chemistry behind the code

While agreeing that there is nothing accidental about the code, other scientists suspect chemistry was a more important driver. They are turning to experiments in modern labs to try to determine which amino acids came first.

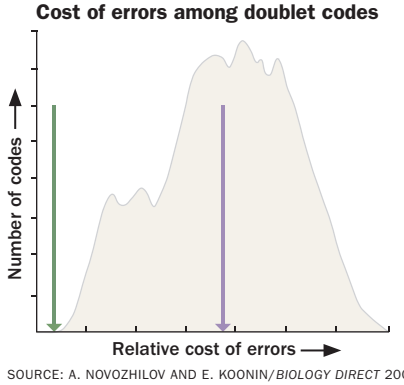
In a legendary spark-tube experiment in 1953, Stanley Miller created a handful of life's amino acids by electrically zapping a chamber filled with hydrogen, water, methane and ammonia gases. And similar follow-up experiments have yielded even more amino acids. A meteorite that crashed in Australia in 1969 contained some of the same amino acids, suggesting that they were forged somewhere in the solar system.

Five amino acids made in spark-tube experiments and found within meteorites — glycine, alanine, aspartic acid, glutamic acid and valine — appear to be related. Each of their codons begins with a G, suggesting that whatever word coded for the first amino acid, G may have grabbed the first position.

"It's sort of a hand-waving argument," says Paul Higgs, a bioinformaticist at McMaster University in Hamilton, Canada. "I don't know if you can really prove that." But in the absence of a detailed chronology, deep hunches have led Higgs and others to create models that begin with these five amino acids. In 2009 in *Biology Direct*, Higgs set out a plan for how the remaining amino acids would be added after the first handful were fixed.

Others argue, though, that the first amino acids weren't the most abundant, but instead were the ones with a natural chemical attraction to RNA, which some scientists think got life off the ground (*SN: 7/3/10, p. 22*).

Error-proof code Early on, the genetic code may have relied on just two letters in its three-letter words. A doublet code proposed to have gotten things going (green) suffered less cost from errors than other possible doublet codes (average error cost for all codes is in purple on a roughly bell curve).



SOURCE: A. NOVOZHILOV AND E. KOONIN/*BIOLOGY DIRECT* 2009

ADAPTED BY JANEL KILEY

Today, every protein found in the cells of every organism has to originate in a DNA or RNA blueprint, as far as biologists can tell. But making DNA and RNA — and proteins — requires proteins. This chicken-and-egg conundrum has flummoxed scientists for decades. In the 1980s, researchers discovered a particular type of RNA called a ribozyme that may be capable of making itself by catalyzing its own synthesis. Many believe the ribozyme could be the chicken *and* the egg — boosting the popularity of what has been known as the "RNA world hypothesis."

Working in this context, biochemist Michael Yarus of the University of Colorado at Boulder imagines different amino acids being chemically attracted to different strands of RNA.

To test the idea, Yarus and colleagues mounted eight amino acids into test tubes and washed the molecules with a solution containing many RNA snippets. Though the interactions in general are weak, Yarus found that many amino acids have natural docking bays for the sequences of three nucleotides that encode them today. He and colleagues estimated in 2009 in the *Journal of Molecular Evolution* that there is a one in 10^{44} chance that the triplets occur at binding sites by pure chance. He suspects that about three-fourths of amino acids currently in the code entered via chemical attraction.

"If you think the triplets were not involved in binding amino acids, then you have to argue that this is all some mistake, some joke nature is playing," Yarus says.

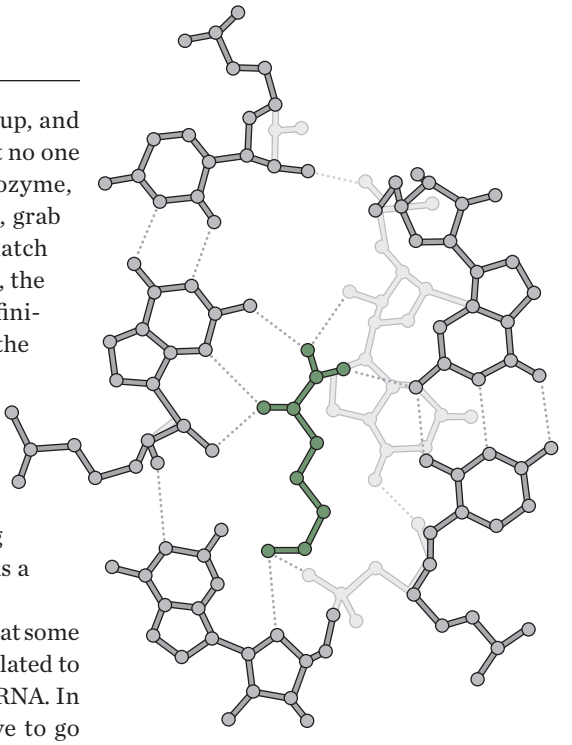
In his chemical theory, it would be inevitable that certain letters end up coding certain amino acids, like how the word for a cow's vocalization is *moo* because that is what the cow sounds like. Any life evolving under similar conditions — say on an extrasolar planet — would thus have a similar code.

"My prediction is if life's out there, it has a similar core," Yarus says. "That will be a great day when we find out."

In November, Wentao Ma of Wuhan University in China proposed a model in *Biology Direct* for how to get from Yarus' simple bonding scheme to today's sophisticated reality. But the proposal now needs evidence to back it up, and some researchers point out that no one has been able to make the ribozyme, a key player in the RNA world, grab the specific amino acids that match up with its nucleotides. Instead, the ribozyme makes up random definitions for genetic words, like in the game Balderdash.

Freeland thinks, because of these major roadblocks, the RNA world may have already passed its prime. "The concept is simply we don't know anything that can make RNA and use it as a living system," Freeland says.

He says it's just as believable that some earlier organism, not directly related to current life on Earth, invented RNA. In that case, scientists would have to go back even farther in time to make sense of the code.



By studying how amino acids (lysine in green) bond with RNA snippets (gray), scientists may uncover chemistry's role in shaping the early genetic code.

M. YARUS *ET AL./JOURNAL OF MOLECULAR EVOLUTION* 2009, ADAPTED BY JANEL KILEY

Paying attention to proteins

Going back in time is exactly what researchers at the Georgia Institute of Technology in Atlanta are trying to do in two new approaches.

Biochemist Loren Williams has turned to the ribosome, that cellular factory where proteins are made. Scientists know that some RNA in the ribosome is very densely connected to other RNA through hydrogen bonds, suggesting those RNAs are among the oldest — the way people who have been on Facebook awhile have more friends than those who just joined. By looking in regions with dense connections, Williams has found what he argues is the oldest protein inside the ribosome. The protein's tail is made of glycine and alanine, Williams and his colleagues recently found, leading them to think that these amino acids may have been the first to join the code.

A second approach, which involves resurrecting ancient proteins, may offer a good test for theories about the code's origins. Astrobiologist Eric Gaucher, also of Georgia Tech, and his colleagues are comparing individual proteins in different living organisms to try to estimate a most likely protein ancestor, going back billions of years. Such ancient molecules can provide clues about which amino acids early life used, and the team's findings agree with those from lab experiments and meteorite evidence.

Such ancestor proteins can also provide a valuable check on theories for the early genetic code, says Freeland. If the earliest proteins are made of five amino acids with codons that start with the letter G, for example, then any proposed earliest code had better be able to make those proteins. If it can't, then that code should be scrapped.

Though not the inkblot it was four decades ago, the code still holds many mysteries. Until they are resolved, some scientists believe, the frozen accident is still a plausible possibility and life on other planets may turn out to be completely different from life on Earth. If texting teenagers could offer any consolation to those in search of answers, it would be "gud luk." ■

Explore more

- For a history of deciphering the genetic code: http://history.nih.gov/exhibits/nirenberg/

Sizing up the elec

Measuring the inner shape of the famous particle could help solve a cosmic mystery

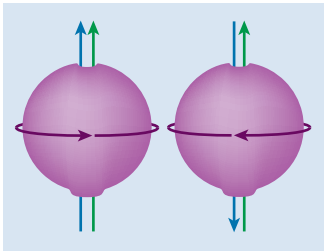
By Alexandra Witze

Long thought to be a simple speck of negative charge, the humble electron may be hiding one more surprise in its depths.

The electron was the first fundamental particle discovered. It was the first to have its charge measured, and it inspired the mathematical equation that first hinted at the existence of antimatter, the exotic, oppositely charged counterpart to ordinary matter.

Now the electron is poised to go one step further, by helping scientists understand why matter triumphed over antimatter in the early universe. In theory, the Big Bang should have created matter and antimatter in equal amounts, but if so they would have annihilated each other and left nothing behind.

Though the standard model of particle physics, the mathematical framework for explaining how stuff is held together, can't quite account for how matter beat out antimatter, some theories that go beyond the standard model do. By carefully measuring the shape of the electron, through a particular property known as the electric dipole moment, scientists think they can narrow those theories down to get at the one that best reflects reality.



Hints in time Reversing time (by switching the direction of a particle's spin) changes the direction of the magnetic dipole (blue) but not the electric dipole (green). This means that possessing an electric dipole moment would give particles a way to violate time-reversal symmetry.

"The electron EDM is one of the places where there should be a good chance of seeing some new phenomena that can't be explained in the standard model, and could in turn help to explain this matter-antimatter imbalance in the universe," says physicist David DeMille of Yale University.

Spotting the dipole moment would mean that the electron has some kind of internal structure, a bizarre concept for a particle that is supposed to buzz around the nuclear hearts of atoms and molecules with its mass concentrated into an essentially sizeless point. Although no one has yet measured the electron's electric dipole moment, researchers think it should exist and could be within reach of today's modern laboratory setups.

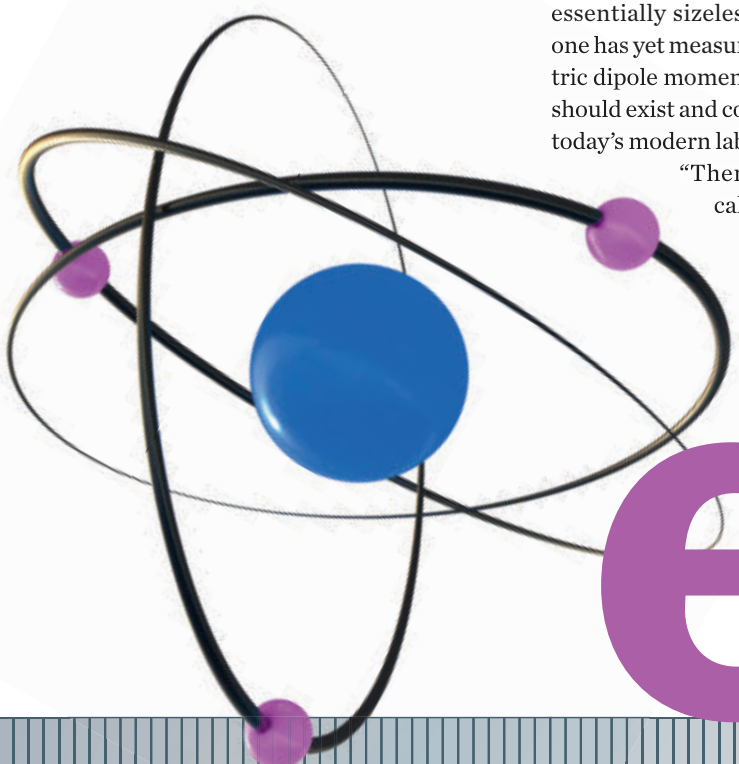
"There are good theoretical reasons to think that it isn't too far away," says physicist Larry Hunter of Amherst College in Massachusetts, who has been hunting the electron's electric dipole moment since the 1980s. "What has made us all dedicate our lives to it is the real good chance that something might emerge soon."

Researchers are now betting on several ways they might succeed, from studying ultracold atoms to lopsided molecules to magnetized ceramics. Within the next few months, scientists at Imperial College London are expected to report the latest limit on the size of the electron electric dipole moment, the first such improvement in a decade.

An actual measurement of that dipole moment "would be a big, big discovery," says Eugene Commins, a physicist now retired from the University of California, Berkeley. "That would be a Nobel Prize."

What lies within

Physicists suspect that electric dipole moments exist because they allow particles to violate what's known as time-reversal symmetry. Although symmetry sounds like a good thing, scientists know that processes involving other particles (such as B mesons) behave differently whether running forward or backward, a violation of time-reversal symmetry. In order for this to happen, the electron (and other fundamental particles) must



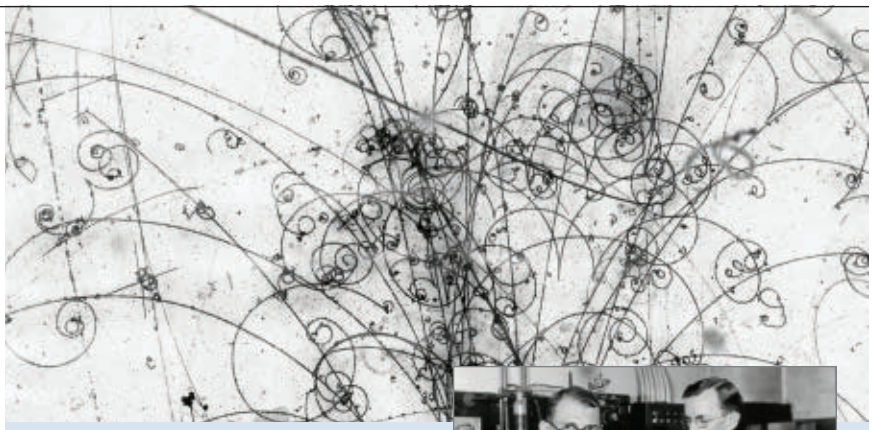
TIME-REVERSAL DIAGRAM: *PHYSICS WORLD* DECEMBER 2009; ATOM: © GALINKA86/DREAMSTIME.COM; RULER: JANGELTUN/ISTOCKPHOTO

have an internal structure, something an electric dipole moment can reveal.

To envision an electron electric dipole moment, imagine that the electron has "a cloud of stuff following it, like the Pig-Pen character in the old Charlie Brown cartoons," says DeMille. Blow that electron cloud up to the size of Earth, and extra positive charge would appear as a tiny dent on the north pole while extra negative charge would be a tiny bulge on the south pole. Given current limits, the size of that dent or bulge would correspond to adding or subtracting no more than about one-thousandth the width of a human hair from either end of the planet.

The standard model predicts that the electron's electric dipole moment is less than 10^{-38} in units of electron charge times centimeters. That's equivalent to separating an electron and a similar charged particle by a distance of 10^{-38} centimeters, or a hundred trillionth of a trillionth of a trillionth of a centimeter. But extensions of the standard model predict the electric dipole moment to be bigger, between 10^{-25} and 10^{-30}. In 2002, Commins' team published the most stringent limit yet: 1.6×10^{-27}. That means researchers are well within the hunting grounds where they might find the beast.

Each time experimentalists fail to detect the dipole moment despite increasing the sensitivity of their tests, they tighten the limit on how big it could be, like lowering the bar in a game of limbo. When the bar drops, theorists have to rule out more of their ideas on how the universe works. "A good theorist can make a model in an hour, but it takes us 20 years to destroy it," Commins says.



FROM TOP: GORONWY TUDOR JONES, UNIV. OF BIRMINGHAM/PHOTO RESEARCHERS; BELL LABORATORIES, COURTESY AIP EMILIO SEGRÈ VISUAL ARCHIVES

Electric past

The electron was at the heart of many scientific discoveries at the turn of the 20th century. Detecting its electric dipole moment could once again put the particle in the spotlight.

1897 J.J. Thomson discovers electrons, calling them "corpuscles," revealing that atoms are divisible.

1900 Henri Becquerel, who discovered radioactivity, finds that beta particles are in fact electrons.

1913 Robert Millikan publishes results of his famous oil-drop experiments, which determine the charge of the electron.

1925 Samuel Goudsmit and George Uhlenbeck propose that an electron has an intrinsic angular momentum, called spin.

1927 Lester Germer and Clinton Davisson (left to right, above) find that electrons scatter from the surface of a crystal the same way X-rays do, proving particles can act like waves.

1928 Paul Dirac formulates his electron equation, which implies the existence of antielectrons—particles with the same mass as electrons but opposite charge.

1932 Carl Anderson discovers the antielectron, or positron, confirming the existence of antimatter (electron-positron pair formation shown above).

The current limit has already ruled out the simplest version of a popular idea known as supersymmetry, which tries to explain the cosmic matter/antimatter imbalance by suggesting that every particle has an as-yet-unseen "superpartner." If researchers can push the limit to 10^{-29}, that would rule out another extension to the standard model that tries to solve the matter problem by postulating multiple kinds of the particle known as the Higgs boson, which Europe's Large Hadron Collider was designed to detect.

To measure the electron electric dipole moment, physicists need to watch an electron closely as they flip on an electric field. They then scrutinize whether a property known as the particle's spin responds differently when the field is switched on in different orientations, which would mean the electron possesses an electric dipole moment. Seeing that difference is the hard part. In particular, because of the deep link between electricity and magnetism (moving

Detecting an electric dipole moment would mean electrons, which buzz about atomic nuclei, have internal structure.

tron

electrons produce a magnetic field), it's easy to accidentally change the magnetic field when the external electric field is applied. If this happens, the electron's spin changes in unwanted ways that mimic how it should respond if it had an electric dipole moment.

Scientists have thus developed a bag of tricks to maximize their chances of detecting an electric dipole moment—by watching the electron for as long as possible, by enhancing its reaction and by removing as many sources of outside error as possible. The work is finicky and frustrating. At Amherst, Hunter spent years fine-tuning an experiment with cesium atoms and published a limit in 1989, only to be overtaken the next year by Commins. That work, at Berkeley, looked for the electric dipole moment in thallium atoms in the wee hours of the morning, when nearby trains that could disturb the measurement weren't running.

Material of choice

Since those days, though, breakthroughs in trapping and cooling atoms using lasers have made atomic studies much more sensitive. One promising atom-based search today is in the lab of David Weiss at Pennsylvania State University in University Park. There he has developed a way to trap cesium atoms in two regions, each with an oppositely oriented electric field. Applying an external electric field to the entire thing should cause electrons in both regions to react equally. And because the fields had opposite orientations to start, any problems that might arise as an artifact of the test should be obvious.

Weiss' team is building equipment now and hopes to start putting atoms into it soon. From there, though, analysis could take years. "The real question is how well you can ultimately control for systematic errors," Weiss says. "You have to be sure that it's right."

Some scientists are taking a different tack by looking for the electron electric dipole moment in molecules. Polar molecules, which have one end with a slightly positive charge and the other with a slightly negative charge, look particularly promising. In polar molecules with one heavy atom and one light atom, electrons zoom around the heavy end quickly, like comets zipping into the solar system and past the sun. This gets the electrons going at nearly the speed of light, which naturally enhances the way the electron responds to an applied electric field, ramping up any dipole moment signal.

Las Vegas gamblers would do well to put their chips on ytterbium fluoride as the molecule most likely to yield a new limit on the electron electric dipole moment. A team led by physicist Edward Hinds, now at Imperial College London, has been using YbF in the hunt since 1993, and has submitted a paper describing its latest limit for publication.

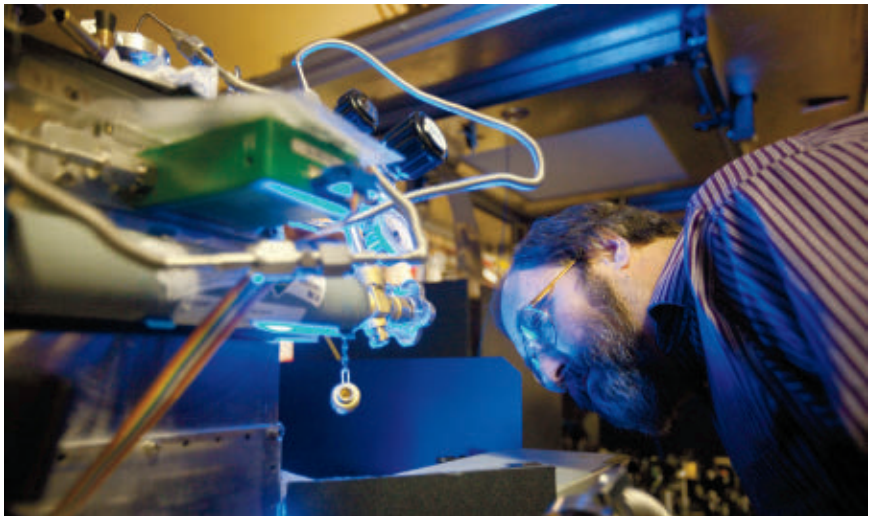
Unlike atoms that can be trapped in one spot for a while, heavy molecules can be studied only in flight: A research team makes a beam of them and looks for the electric dipole moment signal as they fly by. Hinds' group can currently detect only about one in every 100 YbF molecules that zip past, but is working on a new source that sends 10 times more molecules past and sends them at one-third the speed. Because the experiment's sensitivity is proportional to how long researchers can study the molecule, the next generation should be 10 times better at spotting the electric dipole moment, Hinds says.

Even if one team does manage to detect the electric dipole moment, the work could be far from over.

The group plans to have the new source up and running soon and, within the next few years, to lower the limit to 10^{-29}, where the electron electric dipole moment might be detected at last. "It's conceivable that it's just not there," Hinds says. "But there should be a dipole moment unless there is some extraordinary accident."

Hot on Hinds' heels is another molecular experiment. A team led by DeMille along with Gerald Gabrielse and John Doyle of Harvard chose the thorium monoxide molecule because it would naturally enhance the electric dipole moment signal by quite a lot. The team first vaporizes some thorium dioxide with a pulse of laser light, then lines up the resulting thorium monoxide molecules in a beam line so they are all spinning in the same direction. Then, applying an electric field, the researchers try to figure out if the electron spin shifted within the molecule as it would if it had an electric dipole moment.

"These are incredibly tiny signals that we're looking for," says DeMille. "It's not hard to imagine that effects can mimic the tiny thing you're looking for



Gerald Gabrielse of Harvard University (shown) and colleagues are looking for signs of an electron's electric dipole moment in molecules of thorium monoxide. The signal would be incredibly small and so requires very sensitive instruments.

KRIS SNIBBE/HARVARD UNIV.

that have nothing to do with the electric dipole moment.... If you accidentally apply a small magnetic field that changes along with the electric field, it can really be a dangerous type of error."

The way forward

Yet another group is taking a fresh approach to molecules: stripping off one electron so that the molecule has a positive charge. Because they are electrically charged, such molecular ions can be easily confined and studied.

Eric Cornell, a Nobel-winning physicist at JILA in Boulder, Colo., started the molecular ion trend seven years ago, when he wondered how he could design an experiment from scratch to detect the electron electric dipole moment. He walked down the hall and took the elevators to the office of JILA theorist John Bohn. Handing Bohn a thick stack of manila folders, one per candidate molecule, Cornell asked him to calculate which molecular ion had the best chance of being studied for an electron electric dipole moment.

Several detailed papers later, Bohn had a list of candidates. All of them had the peculiar property of having electrons in what's called a "triplet delta" state. That property makes the dipole moment easier to measure because when scientists apply the electric field, they can also simultaneously measure any magnetic field that might result — the very sorts of fields that can trip up the measurements. "There's sort of a built-in way in the molecule to monitor what the magnetic field is doing," says Aaron Leanhardt, a former postdoc in Cornell's lab who now works at the University of Michigan in Ann Arbor.

Cornell is now starting to build an experiment to measure one of the ions, known as hafnium fluoride plus, in this triplet delta state. But so little is known about these molecular ions that his team must first do basic studies on the ions' physical properties. "We're mapping out this terra incognita," Cornell says. Once he gets to measuring the dipole moment, he says, "I think I can do it better."

Some scientists can't be bothered fussing with individual atoms and molecules, and instead are trying big chunks of solids. Such materials contain untold numbers of electrons to measure; the idea is to apply an electric field that would line up a fraction of the electron spins in the same direction as the electric field. The researchers try to detect the resulting magnetization — which in this case is not a problem, but the actual signal they are trying to measure.

At Yale, physicists Steve Lamoreaux and Alex Sushkov think they can succeed with ceramic materials whose electron spins naturally align, a property that enhances the effect of an applied electric field. The researchers apply high voltage to a sample of material, about the size of a quarter, sitting in liquid helium. Using a supersensitive magnetometer, they detect magnetization in the ceramic as the electric field reverses. "We study all the physical effects going on in the sample to make sure that what we detect is from the EDM rather than something else," Sushkov says.

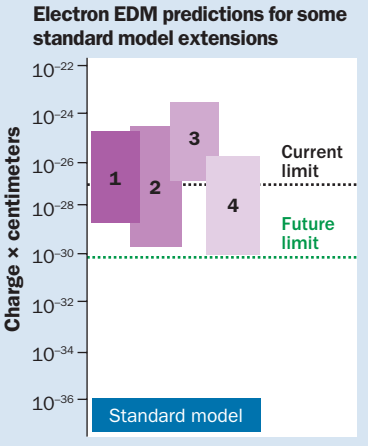
Whether any of these approaches to hunting the electric dipole moment will succeed, and when, remains to be seen. After the Imperial team reports its results, the race will be on to see who can lower the bar next — or even detect the electric dipole moment altogether. Many are betting on DeMille's collaboration using thorium monoxide, though that team, too, has run into unexpected challenges lately.

Even if one team does manage to detect the electric dipole moment, the work could be far from over. At least one other group, preferably working in a totally different system, would need to confirm the result to ensure the dipole moment really had been found. "It's easy to screw up the experiments in subtle ways," Cornell says. "You would really want two very different groups to see it to have any credibility."

Hunter recently shut down another experiment using ceramics because he didn't think it could be competitive. He says he can't wait to see which team manages to cross the finish line first.

"It's a high-risk field," he notes. "You could easily spend your entire life working at it, like I have, and come up fairly empty-handed in the end. On the other hand, if you are the person who manages to improve the sensitivity to the point that you can unambiguously see the electron EDM, that's just really exciting. It kind of shakes the foundation of physics, and that's what we all dream of doing." ■

Beyond the standard Though the electron's electric dipole moment, or EDM, hasn't been detected, experiments keep lowering the bar on how big it could be. Reducing that limit can rule out theories that go beyond physics' standard model. In further experiments, scientists hope to reject some leading ideas. SOURCE: IMPERIAL COLLEGE LONDON



1. The **multi-Higgs model** calls for multiple types of the Higgs particle, the as-yet-undiscovered particle thought to imbue others with mass.

2. In **left-right symmetric models**, particles behave the same way even if their direction of spin (or other qualities that are left-right dependent) is reversed.

3. The **minimal supersymmetric standard model**, or **MSSM**, is a standard model extension that holds that every elementary particle has a "superpartner." One of the simplest versions has been ruled out by the current limit.

4. Another version of **MSSM** that sets a parameter dubbed phi to a different value is still a possibility, but it too may be ruled out when researchers lower the bar further.

Explore more

- Imperial College London site on the electron EDM: http://j.mp/hkkLOn

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in the zone

Evolution may have trained the mind to see scoring streaks — even where they don't exist

By Bruce Bower

Sports fans have cried foul for 25 years as scientists have dumped statistical ice water on basketball players' "hot hands." It seems obvious to even casual spectators that competitors occasionally score a bunch of baskets in a row and need to keep shooting while they're in the zone.

Sorry, b-ball buffs. Researchers have yet to document any chance-defying scoring runs among even the best players. Kobe Bryant may well sink shot after shot, game in and game out, but even this all-star's season-long pattern of hits and misses fits within the mathematical definition of a random sequence, scientists say. Kobe's chances of hitting a shot are no greater following a swish than a miss.

Still, it's perfectly natural to assume that if a sharpshooter sinks one basket — or if a jockey rides a winning horse in the first race of the day, or if a stock goes up in value on Monday, to name a few — it boosts the probability of the same thing happening with the next shot, race or trading session, says psychologist Benjamin Scheibehenne of the University of Basel in Switzerland. In his view, effective thinkers are primed to expect streaks of the same outcome in basketball scoring and other sequences of events — the laws of probability be damned.

A hair-trigger sensitivity for perceiving clumps of events makes sense because most animal species — including people — search for food and other vital resources that are typically found in patches, he asserts. Human ancestors did so. And in the modern world, information foragers on the Internet and snack seekers in the supermarket also find what they want in clusters. So a tendency to look for clumpy patterns in sequences of events pays off when it counts, even if it distorts judgments about basketball scoring and the stock market.

"People seem to be tuned in to detecting streaky patterns," says Scheibehenne. "Detecting actual randomness doesn't buy you much,

BASKET: SHI YALI/SHUTTERSTOCK; PLAYER: YURI ARCURS/SHUTTERSTOCK; BALLS: FENG YU/SHUTTERSTOCK

since there would be nothing to predict anyway."

Evolutionary forces and learned expectations jointly produce streak-seeking minds, proposes psychologist Andreas Wilke of Clarkson University in Potsdam, N.Y. In the distant past and in the present moment, in stands of trees dotting a savanna and in shopping malls punctuating an urban sprawl, desirable stuff clusters together.

A gambler's dilemma

In support of the idea that human thinking — not just brain activity but also how the brain reads the environment — is attuned to streaks, Scheibehenne and his colleagues have found that volunteers prefer betting on the next symbol to appear on a computerized slot machine if they have seen one or both of its two symbols (cherries and a peach, for example) come up several consecutive times on a regular basis, rather than in a random succession that includes a few clusters here and there. That makes sense for gamblers, since a streaky machine is more predictable than a random one.

In contrast, bettors trying to decide whether cherries or a peach would turn up next tended to do poorly and to give up on machines with symbols that frequently alternate, apparently overlooking the predictable back-and-forth pattern, the scientists report in an upcoming *Evolution and Human Behavior*.

Betting patterns of the 238 participants in the slot machine study — who were vying for $50 awards given to the top two gamblers — signaled an intuitive preference for streaky sequences, says Scheibehenne. Slot machines elicited a foraging strategy used by animals that seek food distributed in patches, whether icons were programmed to appear randomly or regularly in long strings. Foraging for slot machine successes in this way worked best on streaky machines and worst on alternating machines.

Finding clumps of anything depends on a simple rule of thumb: Keep searching in the same place after a successful choice, such as finding a berry in a bush, and move to another spot after a failed attempt or two. For alternating sequences, the opposite approach works better: Look elsewhere after a correct choice and stay put after an error, because the situation will reverse quickly.

For random sequences anything goes, because all strategies do equally poorly.

In Scheibehenne's study, volunteers saw two slot machines on a computer screen. Participants didn't know which machine generated a random sequence of icons and which one produced a sequence that alternated icons or clustered them together to varying extents. Overall, players continued to bet on streaky machines 70 percent of the time after making winning choices. And players used the patch-finding strategy on about half of their alternating-machine bets and a bit more often than that when wagering on random machines.

"Participants may have had a general tendency to use the appropriate choice strategy for streaky environments as a default strategy in all cases, which could explain their inferior performance on alternating sequences," Scheibehenne says.

Consistent with that possibility, participants made progressively more losing bets on slightly and moderately alternating sequences over 250 trials, appearing to become increasingly confused, rather than learning to predict back-and-forth swings.

These findings build on evidence of hot-hand thinking across cultures that was reported in 2009 by Wilke and anthropologist Clark Barrett of the University of California, Los Angeles.

Wilke and Barrett developed a computer game that simulates a search for fruit trees in a forest and for modern resources such as parking spaces. In 100 trials, each player decides whether to stay in the same spot or move to a new spot to find what they want. In each case, resources are randomly distributed.

In stands of trees and in shopping malls, desirable stuff clusters together.

Among 32 UCLA students and 32 Shuar hunter-gatherers living in an Amazonian village, most said that they expected fruit trees in the computer game to occur in patches. Both students and villagers usually continued to forage in the same place after finding a piece of fruit, in line with that expectation.

In another exercise, the students and hunter-gatherers tried to predict 100 random coin flips. Half the students, who knew about the concept of randomness, usually assumed incorrectly that getting heads meant that the next flip would yield another heads, and getting tails would lead to another tails. So did nearly all Shuar.

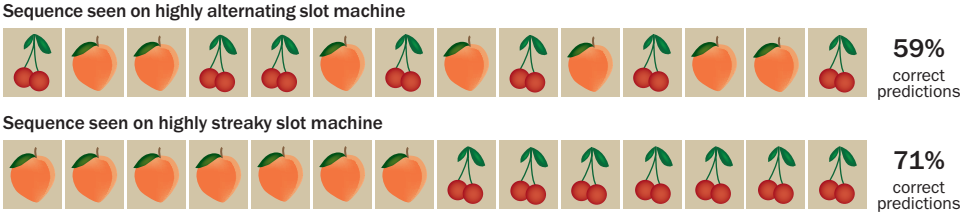
"This supports the idea that hot-hand thinking is an evolved default, which, in cases of true randomness, must be learned out of," Wilke says.

Hunting and gathering

Even in a video game where players roam huge domes searching for chests that contain glowing green spheres, a foraging tactic that evolution has honed for finding patches of berries and other

Picking winners

In a new study, volunteers predicted whether cherries or a peach would next appear on a slot machine programmed to frequently alternate the symbols (top) or to deliver them in clusters (bottom). People appeared to expect streaks in both cases. SOURCE: B. SCHEIBEHENNE *ET AL/EVOL. & HUM. BEH. 2011*



E. FELICIANO

good eats looms large, says biologist Philippe Louâpre of the University of Rennes in France.

With each discovery of a sphere, 92 volunteers reported becoming increasingly motivated to open more chests in the same dome. As empty chests accumulated, the volunteers reported a growing desire to move their search to a new dome. Players reacted more strongly to finding a sphere than to opening an empty chest, enabling them to zero in on clumps of orb-bearing containers but also leading them astray if they found the only orb in one part of a dome first.

Participants searched domes in this way whether spheres were distributed randomly, evenly or in clusters, Louâpre and his colleagues report in a paper published December 8 in *PLoS ONE*.

Other evidence indicates that bumblebees searching for pollen-bearing flowers and parasitic insects seeking host animals take the same simple approach in deciding whether to keep looking in the same place or go elsewhere, Louâpre says.

"There may be an ancient motivational mechanism tailored by natural selection for deciding when to leave a patch," he says.

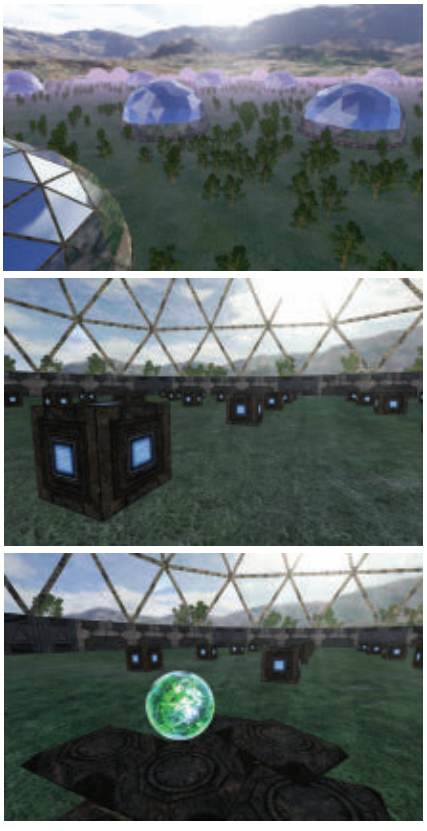
Such findings are intriguing but don't confirm that people have evolved to expect sequences to be streaky, remarks psychologist Thomas Gilovich of Cornell University. Slot machine and video game players may simply reason that clusters of icons or green orbs in a small, random sample represent the pattern that can be expected in a much longer sequence, Gilovich argues. A biased sample could prevent players from recognizing that icon and orb distributions would eventually even out.

Gilovich first proposed this explanation in an influential 1985 paper. Using shooting and free throw records over one to two seasons of play for two professional basketball teams, he and his colleagues found no chance-busting sequences. Yet 91 of 100 basketball fans surveyed by the researchers believed that players get hot hands, defined in the study as a player having a better chance of making a shot after making his last two or three shots than he does after missing his last two or three shots.

Some hot hands do appear to be real. Studies have found hot hands in individual sports — such as golf putting, bowling and horseshoes — in which players largely avoid the influences on one another that affect performance on a team. And a 2000 computer simulation of basketball shots over a season suggests that the statistical tools employed by Gilovich may have missed some genuine hot-hand scoring runs among hoops players, Wilke says.

Just remember: Casino slot machines are called one-armed bandits for a reason. The only streak to expect by feeding them money is a losing one. ■

In a computer game, volunteers tended to use a patch-finding strategy to search domes for chests containing green spheres (game order, top to bottom).



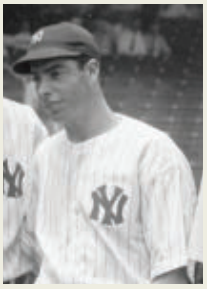
IMAGES AT LEFT: LOUÂPRE *ET AL*/*PLOS ONE* 2010; IMAGES AT RIGHT, FROM TOP: HARRIS & EWING/LIBRARY OF CONGRESS; LENNY IGNELZI/ASSOCIATED PRESS; IRISKAWLING/WIKIMEDIA COMMONS; NFL/ASSOCIATED PRESS

Explore more

- For more resources on streak psychology, visit Andreas Wilke's lab website: http://people.clarkson.edu/~awilke/Home.html

Famous sports streaks

In professional sports, amazing streaks get celebrated as demonstrations of athletic prowess and heroism. Whether these grand acts of sustained achievement surpass mathematical standards of randomness or not, each one inspires new generations of players and fans alike with a story of almost unbelievable achievement.



Joe DiMaggio

56-game hitting streak

Where have you gone, Joe DiMaggio? Look in the record books. Joltin' Joe got at least one base hit in every game from May 15 to July 16 during the 1941 season. During his streak, the Yankee Clipper had a batting average of .408 and added a hit in the All-Star Game. Pete Rose comes in a distant second to DiMaggio, with hits in 44 consecutive games in 1978.

Orel Hershiser

Pitched 59 scoreless innings in a row

The right-handed pitcher, nicknamed Bulldog, finished the 1988 major league season with an amazing streak, leading the Los Angeles Dodgers to a World Series win over the Oakland A's. He bested by one-third of an inning a record set in 1968 by the Dodgers' Don Drysdale. During Hershiser's streak, he allowed 30 hits, walked nine batters and struck out 34.

Wayne Gretzky

51 consecutive games with a point

Known as The Great One, Gretzky tallied either a goal or an assist in each of the Edmonton Oilers' first 51 games in the 1983–84 hockey season. In doing so, Gretzky broke his own record from the previous season of 30 straight games with a goal or assist. The streak, which included 61 goals and 92 assists, set a record that has lasted more than a quarter century.

Johnny Unitas

47 consecutive games with a touchdown pass

From 1956 to 1960, the Baltimore Colts quarterback threw a touchdown pass in 47 straight games. Unitas established a streak that has held up even against today's elite quarterbacks, such as Peyton Manning and Tom Brady. Unitas dismissed his record as unimportant and said that he cared only about winning games. — *Bruce Bower*

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Quantum quirkiness

Your special issue on quantum weirdness (*SN: 11/20/10, p. 15*) was certainly the best presentation I have ever seen. You folks are geniuses and what you did was little short of incredible. It will be difficult (probably impossible) to top it, but keep up the good work. As an aside, could you include more book reviews? They are my favorite part of the issue.
Ken Lawrence, Highland, Mich.

Your articles on quantum mechanics and entanglement were much appreciated, and I hope to see more articles on quantum mechanics in future issues. As Gerard 't Hooft (who is quoted in one article) stresses on his website, physics amateurs such as myself cannot hope to contribute anything of significance to quantum mechanics. Nevertheless, we amateurs can appreciate the philosophical issues quantum mechanics raises and engage meaningfully in the discussion, if only on the sidelines, thanks to the ongoing discourse in nontechnical popular venues like *Science News*.

It appears the field may be entering a renaissance. The evidence for entanglement is solid, and some sort of unseen, instantaneous, universal connectedness has now become thinkable and even likely. Yet the underlying mechanisms remain a total mystery. This state of affairs would seem to reopen the field for quantum interpretations that have been out of vogue for decades. One hopes theoretical physicists will take a fresh look at the possibilities of hidden variables and of a substantial "reality," composed of objects with physically real properties not created by observation.
John Day, Santa Barbara, Calif.

Tom Siegfried's article, "Clash of the Quantum Titans," is a beautifully written piece that makes sense of an uncommonly difficult issue: quantum weirdness. I am convinced the central problem with our lack of understanding quantum reality is that electrons, protons, photons, quarks, etc., are neither particles nor waves. The fact that they may "act" as particles or "act" as waves, or act both ways simultaneously, is due to the fact that humans have constructed analogies to things we can see, feel, know and understand. But I suspect those tiny entities will turn out to be — if we ever can go beyond the "particle" or "wave" analogies — something utterly different. When/if we ever uncover the true nature of those tiny entities, our understanding will increase by magnitudes. In the meantime, we're stuck with analogies that make sense at our size scale, analogies which simply fall short when trying to describe things so small, even if the analogies have been good enough to yield mathematically and observationally correct results.
Bruce Barnbaum, Granite Falls, Wash.

"Schrödinger's cat was born 75 years ago. Its date of death remains uncertain." Great opening sentence! Thanks!
Patricia A. Williams, Birmingham, Ala.

The photograph of Einstein and Bohr (*SN: 11/20/10, p. 19*) clearly renders a verdict in favor of Bohr, Bell, Aspect, *et al*. Though the slight blurriness of Einstein's shoes might be dismissed as a lens defect, Bohr's shoes manifestly lack definite position and momentum.
Douglas Lackey, Wayne, N.J.

I thoroughly enjoyed the two long articles on quantum mechanics. A comment and two questions, however. Tom Siegfried writes, "When James Clerk Maxwell developed the idea of electromagnetic fields...." It is worth reminding people of the sorely underappreciated Michael Faraday, who really developed the idea of an electromagnetic field. Even Maxwell gave full credit to Faraday and claimed that all he did was mathematize Faraday's research.

My first question is this: Siegfried's article says in talking about the polarization of two entangled photons that when photon A is horizontal that photon B is horizontal also. The large graphic in Laura Sanders' article says that photon B will be vertical. There's either a subtle distinction lost on me or someone got it wrong.

Finally, Sanders also talks about how entanglement can be lost and reclaimed. If entanglement is lost by the act of measurement, then how does that reclamation recur? If it is lost in some other manner, then how would anyone know without measurement?

Thanks again for the fascinating articles. In my opinion one can never get enough of this topic.
Dennis Summers, Tajique, N.M.

The reader is completely correct about Faraday; the phrasing should have said that Maxwell "developed the mathematics" of the electromagnetic field. Regarding entanglement, in some cases entangled photons will show the same polarization; in other cases, the polarizations will differ. It depends on the details of how the experimental apparatus to entangle them is arranged. And measurement can indeed sometimes destroy entanglement irretrievably, but in some cases can also restore it, depending on the nature of the experiment. — Tom Siegfried and Laura Sanders

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I was surprised to read that double-slit interference patterns have been observed with 70-atom fullerenes. Is there any theoretical or experimental maximum size for particles that show this effect?
Dean Brown, via e-mail

In principle, quantum effects apply to all matter of whatever size. As objects get bigger, however, interactions among their own internal parts or with other particles in the environment usually eliminate the quantum effects so rapidly that their detection is very difficult and at some point becomes technologically infeasible. — Tom Siegfried

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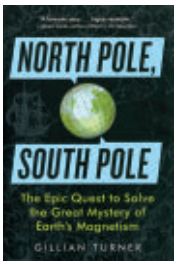
North Pole, South Pole: The Epic Quest to Solve the Great Mystery of Earth's Magnetism

Gillian Turner

Many creatures — birds, bees and butterflies, for example — use the planet's magnetic field to navigate, but humans are the only ones to do so with instruments rather than an innate sense. In her first book, Turner, a geophysicist,



looks at how people came to invent the compass and what has been learned since about the magnetic field that drives it.

Chapter by chapter, the author walks readers through the history of studying Earth's magnetic field, from the ancient Greeks' fascination with natural magnets called lodestones to today's supercomputer simulations of field-generating processes in the planet's core.

The first known compasses were used in China by practitioners of feng shui to auspiciously orient homes, villages, fields and tombs, Turner notes. Only much later were the instruments used by European explorers to help them conquer the seas and expand empires.

As early as the 14th century, European navigators noticed that at many locations the compass didn't point due north. Three centuries later others detected signs that the direction of Earth's magnetic field had changed. Then in the 20th century, researchers came to realize that the field had actually reversed itself many times over the course of Earth's history — which, in turn, led to discoveries that bolstered then-controversial theories of seafloor spreading and continental drift.

By deftly combining threads from science and history, Turner weaves a fascinating geophysical tale that spans several millennia. — *Sid Perkins*

The Experiment, 2011, 272 p., $15.95.

The Great White Bear

Kieran Mulvaney

Starting with the fact that polar bears have black skin, this book offers surprises and up-to-date information about the Arctic's iconic top predator. *Houghton Mifflin Harcourt, 2011, 251 p., $26.*

Geographies of Mars

K. Maria D. Lane

Explore Mars as scientists and the public saw it around the beginning of the 20th century, when canals on the Red Planet seemed a very real possibility. *Univ. of Chicago Press, 2010, 265 p., $45.*

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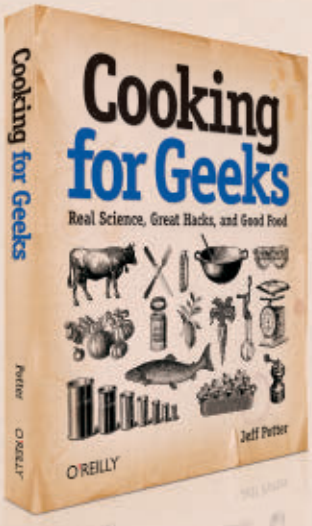

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Robert Langer

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Convergence solves problems that don't fit in one field

In January the American Association for the Advancement of Science hosted a panel in Washington, D.C., on the emerging field of convergence, which integrates engineering, the physical sciences and life sciences to solve problems in health care, energy and other sectors. Speakers described the movement as an integration of disciplines that will require changes to the peer review system, funding mechanisms, the structure of academic departments and the training of science's next generation. Science News *writer Rachel Ehrenberg attended and excerpted comments by Robert Langer, an MIT engineer who develops materials for biomedical applications.*

So how are materials moved into medicine?... Almost always, the way that this happened is medical doctors, clinicians, when they wanted to solve a medical problem, would go to their house and find an object that somehow resembled the organ or tissue they wanted to fix and they'd use it on a person.

So for example, in 1967 the clinicians at the [National Institutes of Health] wanted to make an artificial heart and they asked what object kind of resembles a heart in their house, and they thought of a lady's girdle. And they picked the material in a lady's girdle to make the artificial heart out of. And actually, today, 43 years later, that's still what the artificial heart's made out of. But the artificial heart, as you know, hasn't worked very well. And the biggest reason for that is when blood hits the surface of the artificial heart, the lady's girdle material, it forms a clot. The clot goes to the patient's brain, they get a stroke and they die. But if you think about it, something designed to be a lady's girdle probably isn't the best material to put in contact with blood. And this problem pervades all of medicine. Dialysis was sausage casing, vascular graft — that's artificial blood vessel — was a surgeon in Texas going to a clothes store to see what he could sew well with. Breast implants: One was a lubricant, another actually a mattress stuffing.

When I was a chemical engineer in the early '70s, rather than go into the oil industry — which almost all of my colleagues did — I actually worked with [medical researcher] Judah Folkman. I went to a surgery lab and that's where I learned this. I saw that's how all this would happen. So, some of the things that we started thinking about were, could we bring engineering ... to solve these issues? What we started thinking about was to ask from an engineering, chemistry and biology standpoint, what do you really want? And then, could you just synthesize the material? So one material we created was a new set of biodegradable polymers [for time-release drug delivery and other applications].

What we started thinking about was to ask from an engineering, chemistry and biology standpoint, what do you really want?

A second example might be in the area of minimally invasive surgery. This new example hasn't yet been used clinically, but we've published one paper in *Science* and another in *Nature*.... Let's say somebody had minimally invasive surgery, and you wanted to put a[n] ... object like a medical device in them that was bulky. So what you could do someday, we hope, is you could take a material that might be like a string at room temperature and go through this little hole that you're doing minimally invasive surgery in, and [the material] would convert to a bulky object simply by a temperature change or maybe a fiber-optic–light change.

So that's one approach. The second approach that we started thinking about really is the epitome of convergence, and that's tissue engineering.... The idea is that you could take virtually any cell type, create a polymer scaffold material that could help guide these cells, grow them in what we call bioreactors and make different tissues.... I'll speculate: 30 or 40 years from now somebody wants plastic surgery, and they want a new nose. So my guess is 30 or 40 years from now, you go to a computer screen and any nose you want you can actually pick out.... So let's say somebody wants a regular nose, you could use ... computer-aided design to design a regular nose. But let's say somebody wants an upturned nose. Well, that wouldn't be so hard. We would just take a little bit of this off. Let's say they want a hooked nose. I mean they probably wouldn't, but if they did, we'd give them a little more polymer.

Even though that sounds like science fiction, we're already doing it.... Jay Vacanti, my collaborator, he actually treated this little boy who was 12 years old at the time using these principles.... This little boy doesn't have a chest covering his heart. But like other 12-year-olds, he liked to play baseball. But you could imagine if he ever got hit in the chest with the ball he could die. So we actually made a scaffold for him with his own cells and made him a new chest.

The third example ... and this is still experimental — someday maybe this could even help people with spinal cord damage.... What we did is actually take neuronal stem cells, put them on a polymer scaffold and implant these in rats ... and they are doing better.... This is now actually in primate trials as we hope to someday move it to humans. ■

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