Seafood, Then Civilization | Analyzing Autism | Cloaking Time, Not Space

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 13, 2011

Charismatic Carbon

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Adding Up Global Temperatures

Quantum Theory Gets Axiomatic

Stress for Bigwig Baboons

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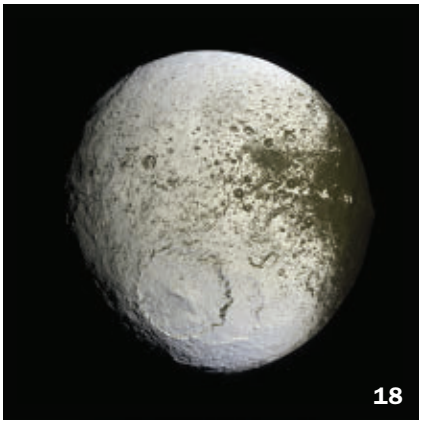

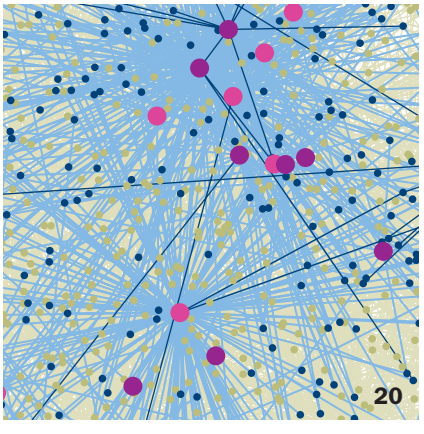

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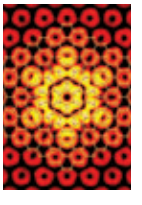

COVER During the fabrication of superthin sheets of carbon known as graphene, flowerlike defects can develop, as shown in this computer simulation. *E. Cockayne and J. Stroscio/NIST*

ScienceNews
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Science News (ISSN 0036-8423) is published biweekly, for $54.50 for 1 year or $98 for 2 years (international rate $80.50 for 1 year or $161 for 2 years) by Society for Science & the Public, 1719 N Street NW Washington, D.C. 20036.
Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Subscription Department: PO Box 1205, Williamsport, PA 17703-1205. For new subscriptions and customer service, call 1-800-552-4412.
Postmaster: Send address changes to *Science News*, PO Box 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

FROM THE EDITOR

Quantum physics axioms back Wheeler's 'it from bit'

John Archibald Wheeler, the late physicist most famous for coining the term "black hole," was fond of another phrase of his invention that captivated the imagination of many quantum physicists: "It from bit."

By "it from bit," Wheeler meant to suggest that physical existence itself (*it*) somehow emerged from information processing (measured, as in computer memory, in *bits*). Wheeler also went around asking anyone who would listen, "How come the quantum?" By that he meant: What is the underlying physical principle (or principles) that would explain why the world is described by the weird rules of quantum theory? He was pretty sure that the two concepts — information and quantum reality — were intimately related.

Beginning in the 1980s, and then especially during the '90s, many physicists worked on understanding information in the quantum sense, building on the standard classical theory of information devised by Claude Shannon several decades earlier. Quantum information theory dealt with quantum bits of information (qubits), quantum coding for secret messages, "teleportation" of qubits from one location to another and the possibility of developing futuristic "quantum computers," with powers (for some problems) far exceeding those of ordinary chips.

Throughout the course of all this work, Wheeler's "it from bit" served as an influential slogan, but remained vague and elusive. It did not really tell anybody how quantum reality emerged from bits of information.

But now, as Devin Powell reports in this issue (Page 12), physicists have given Wheeler's slogan some substance. Using one postulate and five axioms describing information processes in physical terms, Giulio Chiribella and his collaborators have derived the basic mathematical framework of quantum mechanics, the foundation on which modern concepts of matter and energy rest.

"In this approach the rules by which information can be processed determine the physical theory, in accordance with Wheeler's program 'it from bit,'" the physicists write.

It may turn out that this particular approach does not offer the only, or best, way to derive quantum mechanics from information principles. But it surely does suggest that Wheeler's instinct shared certain features in common with the way the universe works. — *Tom Siegfried, Editor in Chief*

JIM WEBB

Technology Simplified

WOW…A Computer Designed For YOU, Not Your Grandchildren!

NEW

…It's easy to read. It's easy to see. It's even easier to understand and use!.
Just plug it in!!!

Have you ever said to yourself "I'd love to get a computer, if only I could figure out how to use it." Well, you're not alone. Computers were supposed to make our lives simpler, but they've gotten so complicated that they are not worth the trouble. With all of the "pointing and clicking" and "dragging and dropping" you're lucky if you can figure out where you are. Plus, you are constantly worrying about viruses, spam and freeze-ups. If this sounds familiar, we have great news for you. There is finally a computer that's designed for simplicity and ease of use. It's the WOW Computer, and it was designed with you in mind.

This computer is easy-to-use, worry-free and literally puts the world at your fingertips. From the moment you open the box, you'll realize how different the WOW computer is. The components are all connected; all you do is plug it into an outlet and your high-speed Internet connection. Then you'll see the screen. This is a completely new operating system, without the cluttered look of the normal computer screen. The "buttons" on the screen are easy to see and easy to understand. All you do is touch one of them, from the Web, Email, Calendar to Games– you name it… and a new screen opens up. It's so easy to use you won't have to ask your children or grandchildren for help.

> "I love this computer! It is easy to read and to use! I get photo updates from my children and grandchildren all the time."
>
> *–From Janet F.*

Until now the very people who could benefit most from Email, and the Internet are the ones that have had the hardest time accessing it. Now, thanks to the WOW Computer, countless older Americans are discovering the wonderful world of the Internet every day. Isn't it time you took part? Call now, and a patient, knowledgeable product expert will tell you how you can try it in your home for 30 days. Call today.

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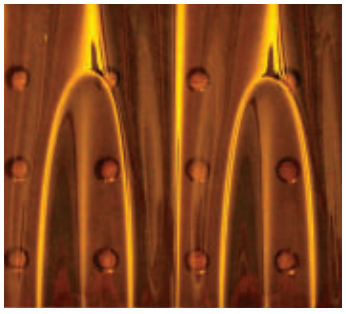


Say What?

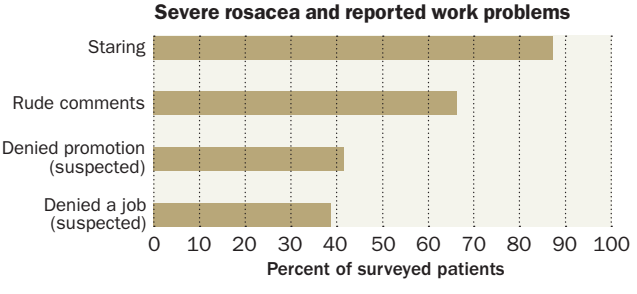
wrinklon ***REENK-lawn***\ ***n.*** The zone between two merging wrinkles. A wrinklon looks like a parabola; it's the U within the wishbone created by the combining wrinkles (shown at left). An international team led by Pascal Damman of the University of Mons in Belgium recently showed that, for a sheet fixed at one end and wrinkled from the other, researchers can describe the pattern of ripples in the sheet by imagining it as made of U-shaped building blocks stacked together, instead of dealing with the wicked math. The wrinklon approach works on a wide range of scales, from nanometers to meters, the team claims in the June 2 *Physical Review Letters*. The approach may help scientists understand wrinkling in techie stuff, like tiny graphene sheets.

Science Past | FROM THE ISSUE OF AUGUST 12, 1961

"CLIMBERS" PRONE TO ILLNESS — "Nonhazardous" occupations can be dangerous for men who work their way up. Eighty-four out of 139 young men between the ages of 22 and 32 who had attained managerial positions showed more illness than 55 co-workers who stepped into the same kind of job right out of college.... The men who had worked their way up displayed both acute and chronic symptoms, including signs indicating eventual high blood pressure and hardening of the arteries.... The men who were sick more often ... had grown up in modest to substandard neighborhoods in low-income families where the fathers generally had a grammar-school education or less. As a result their climb up the ladder of success was full of challenges, threats, demands and other factors of a domestic and financial nature ... unfamiliar to them.

Science Stats | BLUSHING BUSINESSPEOPLE

Rosacea patients suffer professional hurdles as well as skin inflammation and redness, a National Rosacea Society survey found. More than 16 million people in the United States have the chronic condition, the society estimates.



SOURCE: NAT. ROSACEA SOC. 2011

Science Future

August 17–21
Explore antique tractors and other equipment at Columbus, Ohio's Center of Science and Industry. Go to www.cosi.org

August 30
Launch into the sun's cosmic neighborhood in a show at New York City's Hayden Planetarium. See bit.ly/SNsolarnbhd

August 31
In Portland, learn about the technology behind iPhone games. Ages 21 and up. Go to www.omsi.edu/afterdark

SN Online

www.sciencenews.org

ATOM & COSMOS
NASA's Dawn spacecraft enters orbit around the asteroid Vesta. Read "Dawn on Vesta."

MOLECULES
Tasting fat gives rats the munchies. See "Fat stimulates binge eating."

BODY & BRAIN
Armor-clad knights use about twice as much energy to move as non-armored fighters. Read this tale and others in "News in Brief: Body & Brain."

GENES & CELLS
Researchers debate genes' role in autism disorders. See "Environment blamed for autism."

The (-est)

The world record for the strongest man-made magnet was set on June 22 by scientists in Germany. The new record of 91.4 Tesla, which lasted for a couple of milliseconds, tops the previous record of about 89 Tesla. Scientists created the magnetic field by passing current through copper coils (shown). To prevent the field from tearing the magnet itself apart, researchers at the Dresden High Magnetic Field Laboratory wrapped the copper in the same kind of fiber used to make bulletproof vests. The resulting electromagnet, more than 1,800 times stronger than a typical fridge magnet, will be used to test the properties of new materials including superconductors.

CLOCKWISE FROM TOP LEFT: COURTESY OF PASCAL DAMMAN AND MIGUEL PINEIRUA/ESPCI, PARIS; NASA; HZDR; JANEL KILEY

“We’d like to have a set of axioms that give us a little better physical understanding of quantum mechanics.” —MICHAEL WESTMORELAND, PAGE 12

In the News

STORY ONE

Ocean currents and sulfur haze deliver global warming hiatus

But increasing temperatures remain in long-term forecast

By Alexandra Witze

Climate scientists say it’s a puzzle but no surprise that global temperatures haven’t risen as fast since 2000 as in the few decades before that.

Several new studies may solve at least part of that puzzle. The warming slowdown boils down, in part, to several factors: Coal-burning power plants, particularly in Asia, have spewed more light-reflecting particles into the atmosphere and cooled the planet. So too have volcanic eruptions. Meanwhile, natural climate fluctuations have combined with one another to squirrel away heat deep in the oceans.

Together, these observations bolster scientists’ understanding of how different physical processes affect Earth’s temperature.

The bottom line for climate remains the same: The buildup of greenhouse gases is causing more of the sun’s energy to be trapped in the atmosphere instead of radiated back into space. Global temperatures have been rising as a result.

Yet the 2000s, even though they were the warmest decade on record, did not warm as fast as the three decades before.

NASA

Active since 1995, Soufrière Hills in Montserrat is one of several small volcanoes that have spit cooling sulfur particles high into the atmosphere in the last decade.

“After around 2001 the temperatures seem to flatten out a bit compared to the ’80s and ’90s,” says John Daniel, an atmospheric physicist with the National Oceanic and Atmospheric Administration in Boulder, Colo.

Many researchers have wondered if tiny particles called aerosols could be partly responsible. Aerosols come from both man-made sources, like coal-burning power plants and biomass burning, and natural sources like sea spray, dust and volcanoes.

Daniel and his colleagues, led by recently retired NOAA atmospheric scientist Susan Solomon, looked at aerosol measurements taken from satellites and from the Mauna Loa observing station in Hawaii. The team found more aerosols than expected in the stratosphere, or upper atmosphere, between 2000 and 2010. Some of those extra particles probably came from power plants, but some had to have come from relatively small volcanic eruptions like those of Soufrière Hills in Montserrat and Tavurvur in Papua New Guinea. Both erupted in 2006.

The last really big eruption that spewed aerosols high into the stratosphere was

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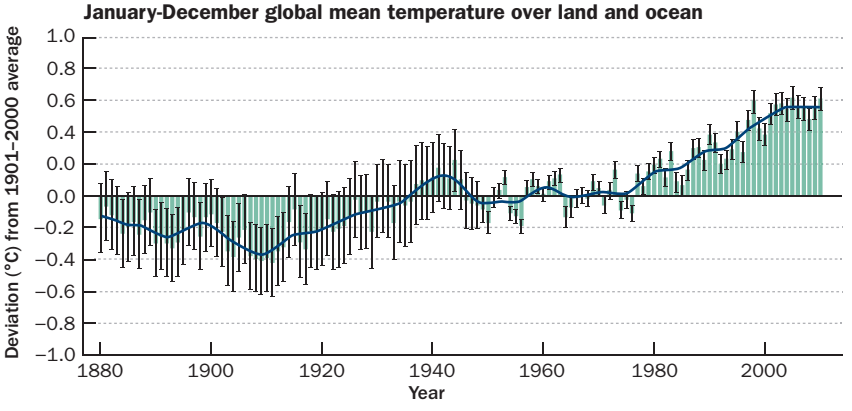
Temporary relief

After warming dramatically during the last quarter of the 20th century, global temperatures rose much more slowly in the first decade of the 21st. Several new studies show that natural and man-made factors can explain that temporary pause.



Mount Pinatubo in the Philippines in 1991. Many scientists assumed that stratospheric aerosols coming from volcanoes had dropped essentially to zero once the Pinatubo particles fell out of the atmosphere several years later.

But small eruptions can have a discernible influence on climate, Solomon's team reports online in *Science* on July 21. Using computer models, the researchers calculated how much those extra aerosols cooled things: about 20 percent more than would be expected without them, Daniel says.

Factors that warm or cool the atmosphere, such as aerosols or greenhouse gases, are known as forcings. The new work "again points out that if we actually do have all the forcings correct, then our ability to reproduce and anticipate the resulting climate responses is actually very good," says Caspar Ammann, a climate scientist at the National Center for Atmospheric Research in Boulder.

Daniel's paper ties into recent work by Robert Kaufmann of Boston University and his colleagues, published July 19 in the *Proceedings of the National Academy of Sciences* (*SN: 7/30/11, p. 17*). That group statistically analyzed why global temperatures didn't rise as much as expected between 1998 and 2008, and concluded that sulfur from coal-burning power plants in Asia was mainly to blame. The NOAA work "gives additional support to the conclusion that increased sulfur emissions can explain the recent hiatus in warming," Kaufmann says.

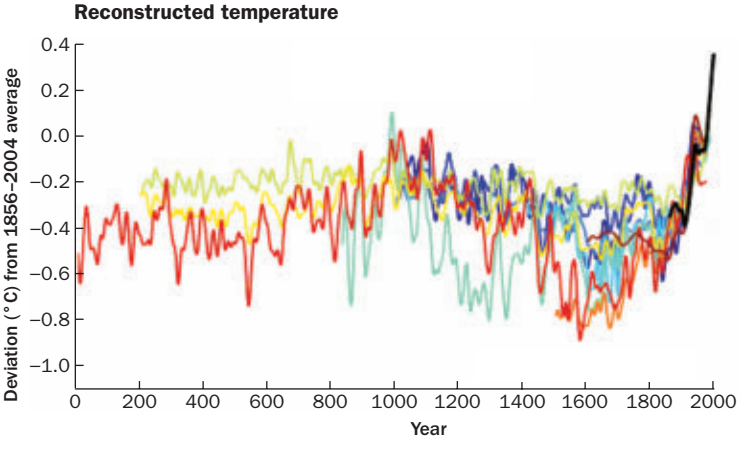
Solomon and Kaufmann both looked at global surface temperature, which includes data from land and sea. But most of the extra greenhouse warming goes into the ocean, which is why a third team recently studied the upper layers of the ocean. Temperatures in the ocean's upper 700 meters rose over the last two decades of the 20th century before flattening out in 2003.

Caroline Katsman and Geert Jan van Oldenborgh of the Royal Netherlands Meteorological Institute in De Bilt used a computer model to probe natural influences on ocean temperatures, such as El Niño (which releases heat from the oceans back into the atmosphere) and deep circulation in the North Atlantic (which can bury heat at greater depths). The model suggested that these two factors happened to combine starting in 2003, keeping excess heat out of the upper ocean. Much of that energy has been released back into space, the team found, while another large chunk was tucked away deeper than 700 meters.

Yet even with such cooling influences, scientists say, global warming will win in the end. Eventually the thickening blanket of greenhouse gases will start global temperatures rocketing up again. ■

Back Story | THE BIG PICTURE

Someone looking at a graph of global temperature since worldwide instrumental records began in 1880 might reasonably conclude that the recent upward trend is not terribly extreme. But longer records are available. The ones shown here use a number of "proxy" records: tree ring thicknesses, the chemical composition of lake and ocean sediment cores, rates of coral growth and other natural phenomena that vary with temperature. Each colored line represents a slightly different interpretation of the data, but they all clearly point to the same conclusion: The past few decades have been the warmest in centuries.



NCDC/NESDIS/NOAA. ADAPTED BY E. FELICIANO; R. ROHDE/WIKIMEDIA COMMONS. ADAPTED BY E. FELICIANO

Is This the Secret Love Child of Ruby and Sapphire?

Rare pink stone inherits the brilliance of the world's most precious parents

Scandal rocks the gem world. It turns out that two of the world's most valuable precious stones have been carrying on behind closed doors. We heard the rumors. Somehow we always suspected that ruby and sapphire had a thing for each other. But our ***Zola Pink Sapphire Ring*** provides the definitive, dazzling proof.

Nature is picky about pink. These are some of the only naturally-occuring pink gems on the planet. Genuine mined pink sapphires are truly something special. Chemically identical to red rubies and blue sapphires, the flirty pink is much more rarely seen than its famous relatives. And larger pinks are exceptionally hard to find. That's why we jumped at the chance to secure a small cache of gem-quality stones. Our designers were delighted by the chance to work with the elusive gem, but frankly shocked that we would offer 2 carats of genuine pink sapphires in gleaming sterling silver for under $200.

One look at the fancy color and fire in this stunning 2-carat cluster was all it took to make us believe in the power of pink. The shimmering sapphire ovals and rounds are prong-set in genuine .925 sterling silver. An open-backed, raised setting lets light ricochet from every angle. It's hypnotic. Seductive. Yes, pink may be famous as the official color of pretty. But behind that ballerina exterior, pink isn't half as innocent as you'd think.

Bask in the shade. Right now there's nothing hotter than pink. Check the headlines. Not long ago, pink diamonds stole the spotlight by shattering world records and fetching millions per carat at auction. But today, pink sapphire is stealing it back. Much of the appeal comes from its rarity, which is due to a complex and delicate chemical balance of trace elements. Mother Nature doesn't prepare the pink sapphire recipe often, but when she does, the results are truly spectacular.

You can find similar rings that sell for as much as $2000. But today the ***Zola Pink Sapphire Ring*** is yours for only $196.

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Damage to lungs seen in some vets

Breathing problems traced to deposits in tiny air passages

By Nathan Seppa

Some soldiers serving in the Middle East who develop difficulty breathing — but whose chest X-rays show nothing out of the ordinary — have constrictive bronchiolitis, a kind of lung damage virtually unknown in young adults.

Reporting in the July 21 *New England Journal of Medicine*, physician Robert Miller of Vanderbilt University in Nashville and his colleagues documented the condition in 38 of 49 soldiers who served in Iraq or Afghanistan and came down with lung problems. Constrictive bronchiolitis, in which tiny airways become narrowed, has rendered some soldiers unfit for active duty.

"Most of them say they can't seem to catch their breath when exerting themselves," says coauthor Matthew King, a pulmonologist at Meharry Medical College, also in Nashville. While anti-inflammatory medicine and inhaled steroids can help symptoms, he says, the soldiers with bronchiolitis don't improve. "We have seen no reversibility."

The researchers discovered the condition by removing and analyzing small bits of lung tissue from the soldiers, who turned up ill between 2004 and 2009. All 49 biopsies showed abnormal tissue despite normal X-rays, and inflammation in 38 of the soldiers indicated constrictive bronchiolitis. Scarring and thickening of tissues was common in this group, and all but one soldier harbored grayish-black deposits in their lungs.

The origin and composition of the lung deposits remain unclear, King says. But the blackened nature of the deposits signals carbon, suggesting fires as a source.

Evidence of bad air in Iraq and Afghanistan is accumulating. A 2009 study of medical records found higher rates of respiratory problems in personnel deployed there than in those stationed elsewhere. In March, researchers reported high levels of airborne aluminum and lead in dust storms in Iraq.

Anthony Szema, a physician and engineer at Stony Brook University in New York, has examined a soldier and found tiny complexes of titanium and iron in the man's lungs, where metals can cause scarring and inflammation. Mined separately, the two metals could not have gotten together naturally, only through a manufacturing process, Szema reported in Denver in May at a meeting of the American Thoracic Society, where he presented the case study. While the metals' origin is unclear, he suspects that garbage-burning pits or exploding devices sent them airborne.

Miller and colleagues "have been very aggressive in figuring out what's going on" in these soldiers' lungs, says Andrew Shorr, a pulmonologist at Georgetown University in Washington, D.C.

Mirror system gets an assist

Brain module gets help when actions can't be mimicked

By Laura Sanders

When a woman born without limbs watches someone else sew, copycat regions in her brain activate even though she can't hold a needle herself. Activity in additional brain regions also demonstrates how flexible the brain is when it comes to observing and understanding the actions of others.

Scientists have known for more than a decade about the mirror system, a network of brain regions usually activated by watching or performing an action. But it has been unclear just how the brain smoothly and quickly intuits what other people are doing, particularly when the action isn't something the observer can do, says study coauthor Lisa Aziz-Zadeh of the University of Southern California in Los Angeles.

In the study, a middle-aged, healthy woman born with no arms and legs underwent brain scans as she watched videos of people performing actions such as biting into an apple slice, sewing with a needle or tapping a finger. Actions that the woman was capable of performing herself activated the mirror system, including parts of the brain that control movement. Mirror areas kicked in even for tasks the woman accomplishes in a different way, such as picking up food using her mouth instead of hands. (The woman had prosthetics briefly as a teenager but hadn't used them in the last 40 years.)

When the woman witnessed actions that were impossible for her, such as using scissors, her brain's mirror system still kicked in, but additional brain regions were recruited to help. These extra regions aren't normally needed when people watch a task they're able to perform, the researchers write in an upcoming *Cerebral Cortex*. These regions are thought to be involved in a process called "mentalizing," in which a person tries to understand what someone else is thinking.

"What's interesting is that even when she can't do it, when it's impossible for her, she still recruits her mirror system, but she additionally recruits these mentalizing regions," Aziz-Zadeh says.

By suggesting that the mentalizing system kicks in for this woman when she cannot copy an action, the new study helps clarify how these two brain systems work together, says cognitive neuroscientist Marcel Brass of Ghent University in Belgium. ■

Why some HIV cocktails pack a bigger punch

Steep dose-response curves explain drugs' characteristics

By Rachel Ehrenberg

A new mathematical analysis of HIV-fighting drugs may reveal why some combinations work better than others.

Infection with HIV was a death sentence until the introduction of multidrug cocktails, yet the differential effectiveness of the combinations has remained a puzzle. The research, published in the July 13 *Science Translational Medicine*, could help refine therapies for HIV and other viruses, such as hepatitis C.

Slightly boosting the dose of some HIV drugs has a profound effect if those drugs are attacking multiple targets, the new mathematical model reveals. Finding that more bullets can kill more targets may seem obvious, says AIDS researcher and Howard Hughes Medical Institute investigator Robert Siliciano of Johns Hopkins University. But the realization required a shift in thinking about a very old idea: the relationship between a drug's dose and its effect.

For the last century, drug effectiveness has been visualized with what's called the dose-response curve. This relationship often takes on a stretched-out "S" shape when graphed.

In 2008, Siliciano's then–graduate student Lin Shen realized that the steepness of the incline of the "S" — its slope — varied with different classes of HIV drugs. A gradual climb means that increases in drug concentration gradually improve the response. But a very steep slope means that tiny increases in a drug's concentration could wipe out significantly more target molecules.

Slightly boosting the dose of some HIV drugs has a profound effect. Now researchers know why.

That the steepness of this slope mattered for HIV drugs was puzzling, Siliciano says. "The differences were huge — orders of magnitude."

For example, increasing the dose of the most effective protease inhibitors, drugs that block an HIV protein that snips up virus parts for assembly, can make those drugs billions of times more powerful against the virus, he says. But increasing the amount of the drug AZT, which attacks virus machinery that translates genetic material, might yield an effect only 10 times greater than the lesser dose.

Incremental dose increases usually yield a vastly improved response when drugs attack a target molecule at multiple sites, an effect known as cooperative binding. Yet HIV drugs target molecules with only one binding site, so more of a drug shouldn't necessarily be much more effective.

But the researchers realized that at certain times in the HIV life cycle the virus makes a huge number of copies of itself or other viral molecules, such as enzymes that help the virus to replicate. With so much virus or viral machinery to attack, some drugs are able to cooperatively bind — not to many sites on one target molecule but to many, many targets.

"It wasn't obvious," says Siliciano. The standard dose-response curve is a very linear approach, he says, "but the virus replicates exponentially. Each infected cell releases enough virus to infect 10 more cells. So we had to think in those kinds of terms."

The new model explains the effectiveness of certain drugs that attack HIV during parts of the virus's life cycle when infection is halted only if a critical number of targets are killed.

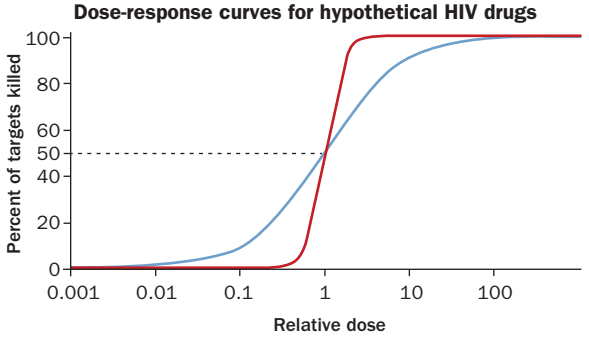
The team tested the model by creating viruses that would offer a different number of targets than usual, such as viruses that didn't crank out their usual number of protease enzymes. When the team infected kidney cells with these altered viruses and calculated the dose-response curves with the new model, the slopes were different than those for normal HIV. If the altered virus had fewer working enzymes for the drug to disable, the virus was inhibited with a lower dose, the team found.

The concepts outlined in the new model not only shed light on fighting HIV but also could inform efforts to attack viruses such as hepatitis C, says HIV researcher and clinician Steven Deeks of the AIDS Research Institute at the University of California, San Francisco, who coauthored a commentary on the new work in the same issue of *Science Translational Medicine*.

"HIV is a replicating machine," says Deeks. "It mutates constantly, and the immune system is ineffective at controlling it. We've never understood, given how effective the virus is at doing what it does, why these drug combinations have worked for so long."

Now that math has revealed the secret of these drugs' success, the word needs to get out, says Deeks. "The math is so dense," he says. "I finally understand it." ■

Halting HIV For two hypothetical HIV drugs, the dose that kills half the target cells (dotted line) is defined as 1. The steep slope of the red drug indicates that for it, a small increase in dose has a big effect on response. Drugs that effectively attack HIV at certain points in the virus's life cycle have these steep slopes.



C. BICKEL/SCIENCE 2011

Life

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A tryst, then the power to resist

Crossbreeding has enabled some mice to tolerate poison

By Susan Milius

Mighty Mouse may have gotten a very important superpower — resistance to widespread rodent poisons — through some mistaken-identity sex.

Since the rat poison warfarin and others in its class of rodenticides went into use in the middle of the last century, various populations of mice and rats have turned up with the ability to survive exposure to it, says evolutionary biologist Michael Kohn of Rice University in Houston. He and a U.S.-German research group have now found that some house mice (*Mus musculus domesticus*) in Germany and Spain take their resistance from an alternate version of a key gene that came from a completely different species.

In the history of house mice, at least one "desperate, lonely mouse," as Kohn puts it, mated with an Algerian mouse (*Mus spretus*), a species whose range extends into Iberia and southern France. This interspecies pairing doesn't produce many reproductively successful offspring. Yet the strong selective force of widespread poison drove borrowed resistance genetics to spread among house mice, the researchers report in the Aug. 9 *Current Biology*.

The borrowed version of this gene, *vkorc1*, isn't the only genetic shield against warfarin that *Mus musculus domesticus* can employ. Other poison-proof versions arose from mutations that occurred over generations within house mice. The two sources for possible protection makes this tale of evolution in action even more interesting, Kohn says. It's the first occasion he can think of where scientists have a chance to study the same basic trait evolving by two different paths in the same species.

In mice, that trait depends on the enzyme that *vkorc1* encodes, which helps recycle vitamin K for blood clotting. Warfarin works by disrupting the clotting process; it is prescribed in gentler formulations as a blood thinner for people. Some of the mutations that arise in *vkorc1* protect animals from fatally excessive blood thinning.

Just how the Algerian mouse acquired its protection is not clear, but Kohn cites older research showing that rodents from arid areas often have evolved unusual clotting, possibly driven by shortages of vitamin K.

Crossbreeding within species has been at the heart of farming and gardening for centuries, but hybridization of different species to create fertile offspring is more problematic. Genetic barriers tend to slow or block abundant mixing — or else the two species wouldn't stay separate.

Yet different species do hybridize. Kinds of bacteria mix and swap important genes for resisting antibiotics, and botanists have come to recognize important crosses between plant species. "Though over the past 15 years or so there has been a growing appreciation for the evolutionary significance of hybridization, there are still those who hold on to a paradigm that denies such a role for genetic exchange," says evolutionary biologist Michael Arnold of the University of Georgia in Athens. Zoologists have been particularly hard to convince, he says, so he's especially pleased to see such an example in mice.

Hybridizing might actually be fairly common among animal species, comments evolutionary geneticist Nick Barton of the Institute of Science and Technology Austria near Vienna. But it's certainly rare for scientists to know what version of a gene such hybridization has moved between species and what evolutionary forces drove the gene's spread.

C. PACKER

The lion eats tonight...

As a full moon fades, hungry lions emerge to prowl for human flesh. A study led by Craig Packer of the University of Minnesota, Twin Cities found that attack rates are two to four times higher in the 10 days after a full moon than during the 10 days before. That's because lions hunt best in darkness, the scientists report, and are hungry after nights of blazing, brilliant moonlight. Researchers used records of more than 1,000 lion attacks on Tanzanian villagers that occurred from 1988 to 2009. Of these, more than two-thirds were fatal, with victims consumed. Researchers were able to pinpoint a precise time for 474 attacks, and found that lions tend to pounce between 6 p.m. and 9:45 p.m., just after dark. "The full moon is not dangerous in itself," they conclude in the July 20 issue of *PLoS ONE*, "but is instead a portent of the darkness to come." —*Nadia Drake*

"These guys are smarter than people say." — **MANUEL LEAL**

Baboon bosses face high stress

In the wild, alpha males reign with surprising level of tension

By Bruce Bower

Baboon males fight ferociously for power, only to have that power bite back.

Top-ranking males generate surprisingly high levels of stress hormones, a sign that these primates pay a cost to be the boss, evolutionary biologist Laurence Gesquiere of Princeton University and her colleagues report in the July 15 *Science*.

Two male baboons face off in a fight. Male group leaders display stress hormone levels about as high as those of their lowest-ranking peers.

Stress-hormone levels in alpha males are on par with those of low-ranking males scuffling to survive, the study shows. Baboon bosses are burdened by having to fight off rivals and guard fertile mates from others' advances, the scientists propose. At the opposite end of the social spectrum, indignities such as not getting enough to eat and enduring harassment by higher-ranking males stress out bottom dwellers.

"Alpha males have higher reproductive success than other male baboons, but those benefits come at a significant cost," Gesquiere says.

The new findings indicate that "life is considerably more stressful" for alpha males than for baboons one rung lower in status, writes Stanford University biologist Robert Sapolsky in a commentary published in the same issue of *Science*.

Sapolsky and other baboon researchers have found that low-status males collectively have higher stress-hormone levels than high-ranking males. Stress-hormone spikes appear in groups of high-ranking males only during occasional periods of social turmoil, when their hold on status is in jeopardy.

Gesquiere and her colleagues find that these previously reported differences between groups mask the tendency of alpha males in particular to have stress-hormone levels as high as those of their lowest-ranking comrades. Her team tracked the social rankings of 125 adult male baboons living in five communities in Kenya's Amboseli National Park from 2000 through 2008. Monthly status rankings were calculated from the number of wins and losses for each animal in fights and confrontations. The scientists also measured hormone concentrations in each baboon's feces monthly.

Learnin' lizards will flip for food

Clever reptiles still get snacks when the rules are changed

By Susan Milius

Lizards everywhere may be scampering a little taller now that an *Anolis* species from tropical tree canopies has passed tests for behavioral flexibility.

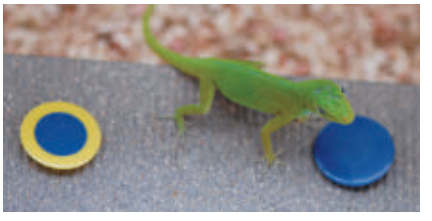
"These guys are smarter than people say," says behavioral ecologist Manuel Leal of Duke University. Cognitive scientists have studied birds' and mammals' powers to solve unexpected problems and learn new rules, but research on lizard cognition has been limited.

Yet several *Anolis evermanni* lizards collected from Puerto Rico and brought into the lab coped with devices not seen in nature, Leal and Brian Powell, also of Duke, report online July 13 in *Biology Letters*. In a series of tests, four out of six lizards figured out how to remove plastic lids firmly stuck on a food box and to ignore a differently colored lid introduced as a possible distracter. Two lizards eventually were able to undo their previous training and switch to an alternative color after researchers reversed the rules.

"I agree with the authors that reptiles, and amphibians for that matter, are generally dismissed as being incapable of the simplest cognitive task," says Walter Wilczynski of Georgia State University in Atlanta, "despite the fact that whenever researchers do a careful study like this one, it turns out that in fact they do learn, often in a sophisticated way."

Wilczynski's lab has demonstrated that whiptail lizards can learn and unlearn tasks.

Alex Kacelnik of Oxford University in England, who studies cognition in New Caledonian crows, was not exactly wowed by the *Anolis* lizards, though. The ability to discriminate among options, and reverse that learning, is also known in fish, flies and bees, among other animals, he says. "It may well be that lizards do have the same flexibility shown by other taxa," Kacelnik says, "but the results shown here are nowhere near what we know in birds and mammals."



In one test of mental ability, an Anolis lizard must select the lid of the correct color and then move it to get a treat of freshly killed fly larvae.

FROM TOP: JEANNE ALTMANN; M. LEAL/DUKE UNIV.

Matter & Energy

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Quantum mechanics gets physical

Theory derived from fundamental information principles

By Devin Powell

Physicists in Canada and Italy have derived quantum mechanics from physical principles related to the storage, manipulation and retrieval of information. The new work is a step in a long, ongoing effort to find fundamental physical motivation for the math of quantum physics, which describes processes in the atomic and subatomic realms with unerring accuracy but defies commonsense understanding.

"We'd like to have a set of axioms that give us a little better physical understanding of quantum mechanics," says Michael Westmoreland, a mathematician at Denison University in Granville, Ohio.

Quantum theory's foundations currently rest on abstract mathematical formulations known as Hilbert spaces and C* algebras. These abstractions work well for calculating the probability of a particular outcome in an experiment. But they lack the intuitive physical meaning that physicists crave — the elegance of Einstein's special theory of relativity, for instance, which says that the speed of light is constant and that laws of physics don't change from one reference frame to the next.

Giulio Chiribella, a theoretical physicist at the Perimeter Institute for Theoretical Physics in Waterloo, Canada, and colleagues based their approach on a postulate called "purification." A system with uncertain properties (a "mixed state") is always part of a larger "pure state" that can, in principle, be completely known, the team proposes in the July *Physical Review A*.

Consider the pion. This particle, which has a spin of zero, can decay into two spinning photons. Each single photon is in a mixed state — it has an equal chance of spinning up or down. The pair of photons together, though, make up a pure state in which the photons must always spin in opposite directions.

"We can be ignorant of the part, but we can have maximal knowledge of the whole," says Chiribella.

This purification principle requires the existence of the quantum phenomenon known as entanglement, which connects the parts to the whole. It also explains why quantum information can't be copied without destroying it but can be "teleported" — replicated at a distant location after being destroyed at its point of origin.

Building on this principle, Chiribella and colleagues reproduced the mathematical structure of quantum mechanics with the aid of five additional axioms related to information processing. Their axioms include causality — the idea that a measurement now can't be influenced by future measurements — and "ideal compression," meaning that information can be encoded in a physical system and then decoded without error. Other axioms involve the ability to distinguish states from each other and the ability of measurements to create pure states.

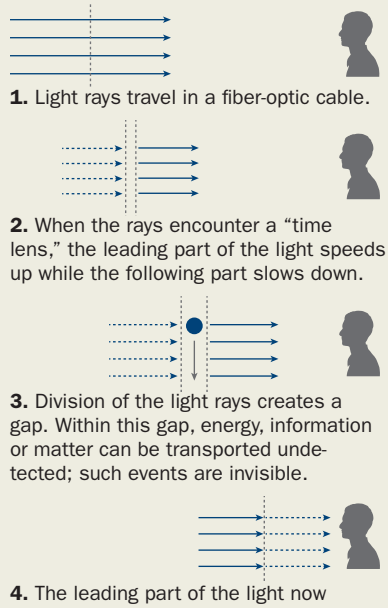
"This now approaches something that I think is along the lines of trying to find a crisp physical principle," says Christopher Fuchs, also of the Perimeter Institute.

Whether this new derivation of quantum theory will prove to be the simplest and most physically meaningful remains to be seen.

"What is simple or physically plausible is a matter of taste," says Časlav Brukner, a physicist at the University of Vienna in Austria who has developed an alternative set of axioms.

Some speculate that recasting quantum theory in terms of information could help to solve outstanding problems in physics, such as how to unify quantum mechanics and gravity.

How a time cloak works



1. Light rays travel in a fiber-optic cable.

2. When the rays encounter a "time lens," the leading part of the light speeds up while the following part slows down.

3. Division of the light rays creates a gap. Within this gap, energy, information or matter can be transported undetected; such events are invisible.

4. The leading part of the light now slows down and the trailing part speeds up. The gap closes, leaving no sign of the event. An observer sees only an apparently continuous flow of light.

SOURCE: IMPERIAL COLLEGE LONDON

A cloak in time conceals events

Physicists hide events in the lab for trillionths of a second

By Devin Powell

In his final battle against evil on the big screen, Harry Potter could have used a newfound type of cloak: one that hides not objects in space, but events in time.

Like filmmakers cutting together a movie, physicists have found a way to temporarily tear a hole in a beam of light. Events that occur in the beam's path during a brief period of time remain unseen, as does the hole itself.

Moti Fridman and colleagues at Cornell University report the first experimental demonstration of such "temporal cloaking" online July 11 at arXiv.org.

While this trick won't be hiding bank robbers from security cameras anytime

T. DUBÉ

15 trillionths | Fraction of a second cloaked by lab experiment

1.25 microseconds | Time theoretically cloakable with fiber optics

8 minutes | Time cloakable by a theoretically perfect solar system–sized device

soon, it could find its way into optical and electronic devices.

Invisibility cloaks hide objects from view by bending light. Just as water flows around a rock in the middle of a river, light waves curve around a cloak and rejoin perfectly on the other side, leaving no trace of their detour.

A time cloak conceals an event by changing light's speed, not its direction. With the speed of light capped at 299,792,458 meters per second, this trick works only when light travels slower than it would in a vacuum — such as through fiber-optic cables.

The Cornell researchers, who declined to discuss their work while the paper is under review for publication, manipulated light in a fiber-optic cable using a time lens, a silicon device originally developed to speed up data transfer. Some of the light passing through this lens speeds up, and some slows down. The waves divide, Moses-style, creating a gap of darkness. A second lens farther along the cable then stitches the light back together so that it arrives at its destination intact, with no record of a hole — or of anything that happened during this brief window of opportunity.

This hole lasted for 15 trillionths of a second, long enough to conceal pulses of light created inside the cloak, the researchers write. A longer cable could, in theory, increase this time gap to more than a microsecond. Longer than that, imperfections in the technique would grow large enough to reveal the presence of the gap.

"This is a much bigger time gap than we were thinking would be possible," says Paul Kinsler, a physicist at Imperial College London.

Kinsler and his colleagues first described the idea of a time cloak in a paper published in the February *Journal of Optics*. Building their perfectly undetectable time cloak would require exotic metamaterials, man-made structures used in traditional invisibility cloaks.

"You would need metamaterials that change their properties in time as well as space," says team member Martin McCall, also at Imperial College London. "It's currently beyond metamaterial technology to produce that ideal situation."

The imperfect Cornell cloak, which is not made of metamaterials, may be useful for signal processing. It could, in theory, interrupt one data stream, allow another to be processed and then reconstitute the original signal for a detector that would be unaware of the interruption.

Larger time gaps on everyday scales, though, are unlikely. Even with a theoretically perfect metamaterial cloak, a mere eight-minute gap would require a device the size of the solar system. ■

Earth

1,080 fish | Catch rate per kilometer in northern Gulf of Mexico, 2006–2009

1,989 fish | Catch rate per kilometer in northern Gulf of Mexico, 2010

Deep sea rich in valuable metals

Cost would be high to mine Pacific rare earth elements

By Devin Powell

Mud at the bottom of the Pacific Ocean contains surprising levels of rare earth elements, 17 chemicals with exotic names like neodymium and europium that are crucial to technologies ranging from cell phones and televisions to fluorescent lightbulbs and wind turbines.

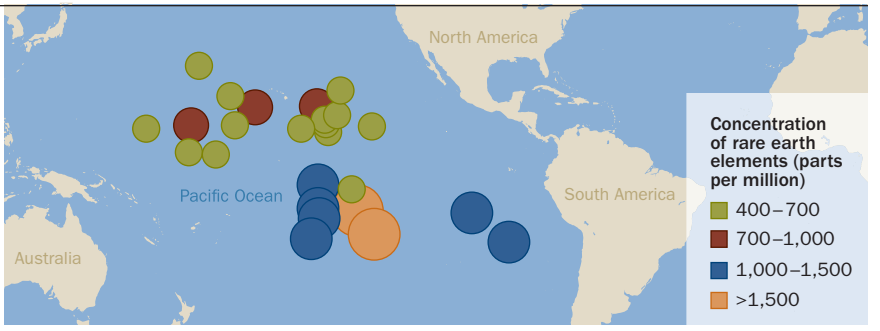
Hot plumes from hydrothermal vents pulled these materials out of seawater and deposited them on the seafloor, bit by bit, over tens of millions of years. One square patch of metal-rich mud 2.3 kilometers wide might contain enough rare earths to meet most of the global demand for a year, Japanese geologists report online July 3 in *Nature Geoscience*.

"I believe that rare earth resources undersea are much more promising than on-land resources," says Yasuhiro Kato, a University of Tokyo geologist who led the study.

About 97 percent of the world's rare earth elements come from China, which has restricted exports in recent years. With prices skyrocketing, shortages are feared — especially in Japan, which lacks minable deposits of these elements.

Kato's team analyzed seafloor cores taken from 78 sites throughout the Pacific Ocean. Near Hawaii and in the southeast Pacific, concentrations of rare earths were comparable to those found in clays mined in China. Some deposits of heavy rare earths such as dysprosium, a component of magnets in hybrid car motors, contained twice as much as in the clays.

Deep-sea mining is an old idea, but one that has yet to prove itself in the face of high costs and environmental concerns. Discovered decades ago, chunks of manganese on the ocean floor and deposits of metals such as zinc and copper in the Red Sea have proven impractical to mine.



Sunken treasure Geologists measured concentrations of rare earth elements in ocean sediments at 78 Pacific sites. In some places (shown), concentrations were comparable to those in clays in China, which produces most of the world's supply. SOURCE: Y. KATO *ET AL*/*NATURE GEOSCIENCE* 2011

Some fish thrived despite oil spill

BP blowout didn't dent populations in Gulf's seagrass beds

By Janet Raloff

Young fish remained abundant last summer and fall in some areas of the Gulf of Mexico that were slammed by the catastrophic BP oil spill. The finding runs counter to expectations of huge losses, especially among fish born during or shortly after the April 20 well blowout.

F. Joel Fodrie of the University of North Carolina at Chapel Hill and Kenneth Heck Jr. of the University of South Alabama Dauphin Island Sea Lab tallied juvenile fish retrieved by research vessels between mid-July and late October over five years ending in 2010. The abundance of youngsters offered one gauge of whether eggs and larval fish had taken a big hit from exposure to the spill.

Among 20 different fish types (some species, some larger groups) commonly found in seagrass meadows in the northern Gulf, juveniles of a dozen types were present in numbers notably higher than during the previous four years. For the remaining eight kinds of fish, Fodrie and Heck found that 2010 catch rates were "statistically indistinguishable" from previous years. The pair detailed their findings online July 6 in *PLoS ONE*.

Large trawl yields following the spill probably reflect a reduction in fishing resulting from a broad postspill ban on commercial harvests, Heck says. Initial fishery closures began 12 days after the blowout and continued in some places through April 19, 2011, just over nine months after the well was capped.

"Our initial results don't show cause for concern," Heck says. "But we don't know what we're going to see in a few years in terms of their growth or survival." Indeed, he notes, "there's reason to believe from some prior work that there may be delayed effects."

Seagrass-dwelling pipefish of the genus *Syngnathus* (left), were as abundant during and after the 2010 *Deepwater Horizon* spill as in previous years.

FROM TOP: GEOATLAS/GRAPHI-OGRE; ADAPTED BY E. FELICIANO; KIKE CALVO VWPICS/SUPERSTOCK

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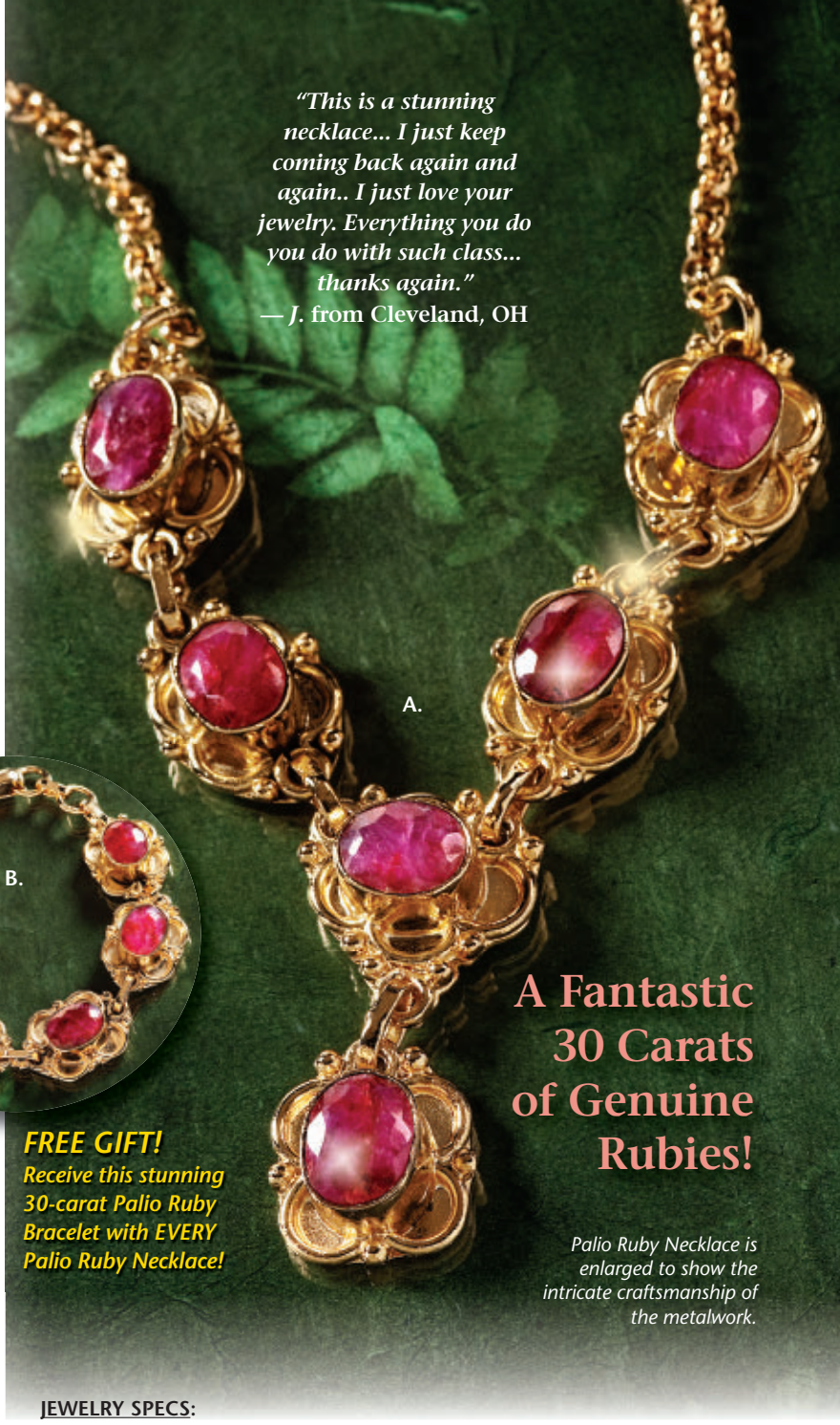

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4 percent Proportion of volunteers with narcissistic traits

Narcissists need no reality check

Despite inflated egos, they see their own vanity clearly

By Bruce Bower

Narcissists make spectacles of their supposedly awesome selves, but they don't see the world entirely through rose-colored glasses.

These sultans of self-regard accurately appraise their own personalities and reputations, say psychologist Erika Carlson of Washington University in St. Louis and her colleagues. The team unexpectedly finds that narcissists acknowledge their own narcissism and assume that their arrogant strut is frowned on by others.

Narcissists also tend to realize that they make good first impressions that rapidly turn sour, the researchers report in the July *Journal of Personality and Social Psychology* (in a paper titled "You probably think this paper's about you").

In contrast, many other researchers think that narcissists sugarcoat how they regard themselves — believing, say, that they're humble team players — and assume others hold them in high regard.

Narcissists' insights into their own personalities and reputations, combined with exaggerated self-regard, suggest that they view arrogance and related characteristics as personality pluses worthy of others' appreciation, comments psychologist Mitja Back of Johannes Gutenberg University Mainz in Germany.

Carlson's team examined college students' perceptions of narcissistic peers upon first meeting them in a class exercise and in weekly group meetings held over the course of a semester. Another experiment probed U.S. Air Force recruits' perceptions of narcissistic peers after six weeks of basic training.

Participants rated their own and others' personality traits, so that the extent to which each person knew his or her reputation could be estimated.

Chimpanzee has an ear for talk

Warped words no obstacle for ape that's hip to speech

By Bruce Bower

Panzee doesn't talk, but she knows a word when she hears one — even if it's emitted by a computer with a synthetic speech impediment.

That's not too shabby for a chimp. Raised to recognize 128 spoken words and to point to corresponding symbols, Panzee perceives acoustically distorted words about as well as people do, say psychology graduate student Lisa Heimbauer of Georgia State University in Atlanta and her colleagues. Panzee thus challenges the argument that only people can recognize highly distorted words, the scientists contend in a paper published online June 30 in *Current Biology*.

Originally, the researchers thought that Panzee would need training to understand artificially distorted words. But after hearing only one such word, the chimp identified the next four synthetically distorted words before making a mistake. "What were supposed to be training sessions became test sessions," Heimbauer says.

Panzee, a chimp at a research facility, uses a portable keyboard to press symbols that stand for spoken words.

CAROLYN RICHARDSON/UNIVERSITY RELATIONS/GEORGIA STATE UNIV.

Panzee's immediate recognition of distorted words "is quite impressive and novel," remarks psychologist Lori Holt of Carnegie Mellon University in Pittsburgh. In experiments conducted over the past 30 years, birds, rodents and other nonhuman animals have been trained to identify acoustically altered words. In contrast, Panzee apparently generalized from past experience hearing caretakers talk to distinguish acoustically transformed words, Holt says.

Heimbauer's group presented Panzee with spoken and synthetically distorted versions of 48 words, such as *apricot*, that the chimp had previously learned to associate with symbols. Some synthetic words sounded fuzzy and noisy, much like what hearing-impaired persons perceive with cochlear implants. Others consisted of three whistlelike tones.

Panzee identified a word by pointing to one of four symbols on a computer screen. The researchers played the same natural and synthetic words for 32 college students, who wrote down what they heard.

Across several sessions, Panzee recognized substantially more words than would be expected if she had guessed — an average of about 80 percent of spoken words, 55 percent of fuzzy words and 40 percent of tone words.

Human participants recognized all spoken words and an average of about 70 percent of fuzzy words and 40 percent of tone words.

Genes & Cells

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African genes get shuffled faster

Increased gene recombination explained by protein variant

By Tina Hesman Saey

Two new genetic maps of African-Americans reveal that people of West African descent have more hot spots where chromosomes mix and match genes than people of European heritage.

Until recently scientists knew next to nothing about the process in humans that mixes and matches parents' genes to create a unique combination in a child, says Chris Spencer, a population geneticist at the Wellcome Trust Centre for Human Genetics at Oxford University in England. This process, known as recombination, also helps chromosomes stick together in pairs until it is time to separate during egg and sperm production.

Previously, scientists could trace recombination only in families and thought that the exchange of genetic information happened at random. These new studies are the first to describe a way to use unrelated people to map genetic shuffling in populations. The studies also demonstrate that the genetic handover actually takes place at predetermined locations on chromosomes. "They make real contributions to methodology, and they really tell you something about biology," says Spencer, who was not involved in either study.

People of West African ancestry have about 2,500 recombination hot spots that are inactive in people of European ancestry, David Reich of Harvard Medical School, Simon Myers of Oxford and a large team of collaborators report online July 20 in *Nature*.

A variant of a protein called PRDM9 is responsible for creating the extra recombination hot spots, the team shows. PRDM9 works a bit like a mail carrier delivering mail to certain addresses: Where it stops along a chromosome, recombination can happen. The variant of the protein more common in people of West African descent can read more addresses, so it makes more stops than the version of the protein usually found in Europeans.

A second new map similarly found that West Africans have a higher recombination rate than people of European heritage. African-American and African-Caribbean people have an intermediate rate, researchers at UCLA and collaborators report online July 20 in *Nature Genetics*.

People of West African ancestry have about 2,500 recombination hot spots that are inactive in people of European ancestry.

The intermediate level is consistent with the idea that PRDM9 is in charge of recombination, says John Novembre, a population geneticist at UCLA and a coauthor of the *Nature Genetics* study. "It's not that the recombination factors from one ancestry overwhelm the other," he says. But the amount of a person's West African or European ancestry does influence the recombination rate.

Both maps were created to improve studies aimed at finding genes that contribute to common diseases. The results indicate that maps for many more ethnic groups should be made, Novembre says.

The findings might also help explain why Africa has so much human genetic diversity. Researchers thought it was because people who stayed in Africa never had their diversity reduced through genetic bottlenecks the way people whose ancestors migrated out of Africa did, Reich says. The new studies suggest that more recombination, due to the hot spots, may also have contributed to greater diversity, he says. ■

NEWS BRIEFS

Centenarian genetics study retracted

Scientists still can't predict who will live to be 100. A study published online in *Science* last year claimed to have found a genetic signature of longevity. But other researchers protested that technical problems invalidated the data (*SN: 7/31/10, p. 10*). Researchers at Boston University and colleagues removed the suspect data and reanalyzed the results. The corrected findings were not strong enough for publication in *Science*, peer reviewers determined. The journal says there was no misconduct on the part of the researchers, but asked the team to retract the publication. The researchers agreed but stand by their results and say they will seek publication elsewhere. The retraction appears in the July 22 *Science*.

—Tina Hesman Saey

Eye of newt regenerates

Shakespeare's witches might be happy to learn that one of their favorite ingredients is a renewable resource. Newts' ability to regenerate the lenses of their eyes is not hampered by aging or repeated injury, an international team of researchers reports online July 12 in *Nature Communications*. Mammals, including humans, lose the ability to renew body parts with age, but newts don't seem to have that problem. In the new study, newts regrew lenses 18 times in 16 years, with no loss of lens quality. Figuring out how newts regenerate body parts may help improve antiaging therapies for people.

—Tina Hesman Saey

Atom & Cosmos

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Big Bang's glow maps early mass

Cosmic radiation confirms existence of dark energy

By Alexandra Witze

In a cosmic feat of observation, astronomers have used the distortions of ancient light left over from the Big Bang to explore how clumps of matter were distributed in the early universe.

The work also independently confirms the existence of dark energy, an enigmatic force that appears to be pushing the cosmos apart faster and faster.

Researchers using the Atacama Cosmology Telescope in the Chilean Andes reported the discoveries July 5 in two papers in *Physical Review Letters*. The new work "will be a really powerful probe for figuring out dark energy and a lot of other interesting things," says team member Blake Sherwin of Princeton University.

Several scientists have won Nobel Prizes for studying the cosmic microwave background radiation, the afterglow left from the fireball that accompanied the creation of the universe 13.7 billion years ago. In the 2000s, a satellite called the Wilkinson Microwave Anisotropy Probe mapped how that radiation is spread across the entire sky. But seeing the distortions now being studied required a telescope with more precise vision.

Using the 6-meter Atacama telescope, astronomers analyzed the temperature of the afterglow in a narrow strip of sky along the celestial equator. They used complex statistical analyses to tease out how temperature fluctuations — essentially, hot and cold spots on the ancient sky map — had been distorted by intervening matter.

Astronomers regularly see such "gravitational lensing" with individual galaxies or galaxy clusters, when another massive clump of matter gets in the way. Just as a piece of broken glass distorts light passing through it, gravity from the foreground clump distorts the light coming from the more distant one, making it appear as a smeared-out arc.

Scientists first reported seeing gravitational lensing in the cosmic microwave background in 2007. Now the Atacama scientists have taken that work further. Their high-resolution data on gravitational distortions provided more statistical information about how mass, including invisible "dark matter," was distributed in the early universe. The new work is also the first to discern the lensing without using other sources of data.

"What's nice about being able to detect lensing using just the cosmic microwave background is that you don't have to make an assumption about knowing where the dark matter already is," says team member Sudeep Das of the University of California, Berkeley.

The team also verified that dark energy exists, as previous studies of distant exploded stars have suggested. "It's arguably the most important measurement in physics in the last couple of decades, so it's definitely worth confirming," says Sherwin.

Together, the new studies open a window to studying where matter lies in the distant universe, says Wayne Hu, a cosmologist at the University of Chicago.

Other experiments will soon start hunting for lensing in polarized light coming from the Big Bang afterglow.

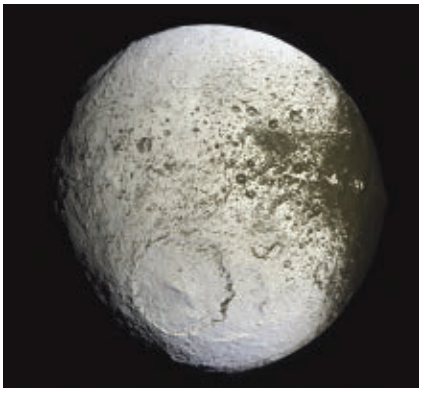
Iapetus splattered in orbital dustup

Black layer is from another Saturn moon's wrong-way motion

By Nadia Drake

Imagine a powdered-sugar doughnut hole plowing through a cloud of dark-chocolate dust. The resulting two-colored treat would resemble one of Saturn's weirder moons, Iapetus — an icy world with a coal black face and a bright white backside.

For centuries astronomers have puzzled over the source of this yin-yang color pattern. Now a team led by Daniel Tamayo of Cornell University offers an explanation: Dust flung from another of Saturn's moons is coating one side of Iapetus. Because Iapetus doesn't rotate relative to Saturn, the same face continually catches the dark moon flakes.



Dust from another Saturn moon blackens Iapetus, seen in this false-color image taken by NASA's Cassini spacecraft.

NASA, JPL-CALTECH, SPACE SCIENCE INSTITUTE

In a study posted online July 7 in *Icarus*, Tamayo and colleagues mathematically describe the movement of dust particles in the outer Saturnian system. The team focuses on dust coming from Phoebe, a dark and distant moon that circles Saturn in the opposite direction as Iapetus.

Collisions between Phoebe and smaller outer moons produce an enormous, invisible ring of dust lying far beyond Saturn's well-known photogenic ones. Nearly every particle in that ring larger than 10 micrometers across ends up on Iapetus, the team concludes. Smaller particles that miss Iapetus land on the Saturn moons Titan and Hyperion.

"This is a very significant paper," says astronomer Bonnie Buratti of the Jet Propulsion Laboratory in Pasadena, Calif. "It does the math."

Paul Fredrick

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One problem, many paths

Autism's many genetic players may act through common networks

By Laura Sanders

Though the diagnostic code scrawled on a doctor's chart might suggest otherwise, each person who lives with an autism spectrum disorder has a very private disease. An avalanche of new genetic data shows clearly that there is no single culprit in autism. Each case stems from a unique jumble of genetic and environmental triggers, which makes figuring out one clear cause for every person's disorder impossible.

This news may sound grim, but it contains a glimmer of hope. By uncovering huge numbers of genetic aberrations, scientists say, they have the opportunity to begin piecing together all of the disparate threads weaving through autism to find the commonalities.

A suite of new studies have identified numerous genetic changes that may have a role in the disorder, some of which could help scientists understand why boys are more vulnerable than girls, for instance. And some of the genes affected by these changes appear to be players in common networks of molecular activity in the brain. New work shows that many genetic changes impair nerve cell communication. Understanding this process and finding other common cellular activities that go awry may lead to powerful ways to combat autism, regardless of what caused it.

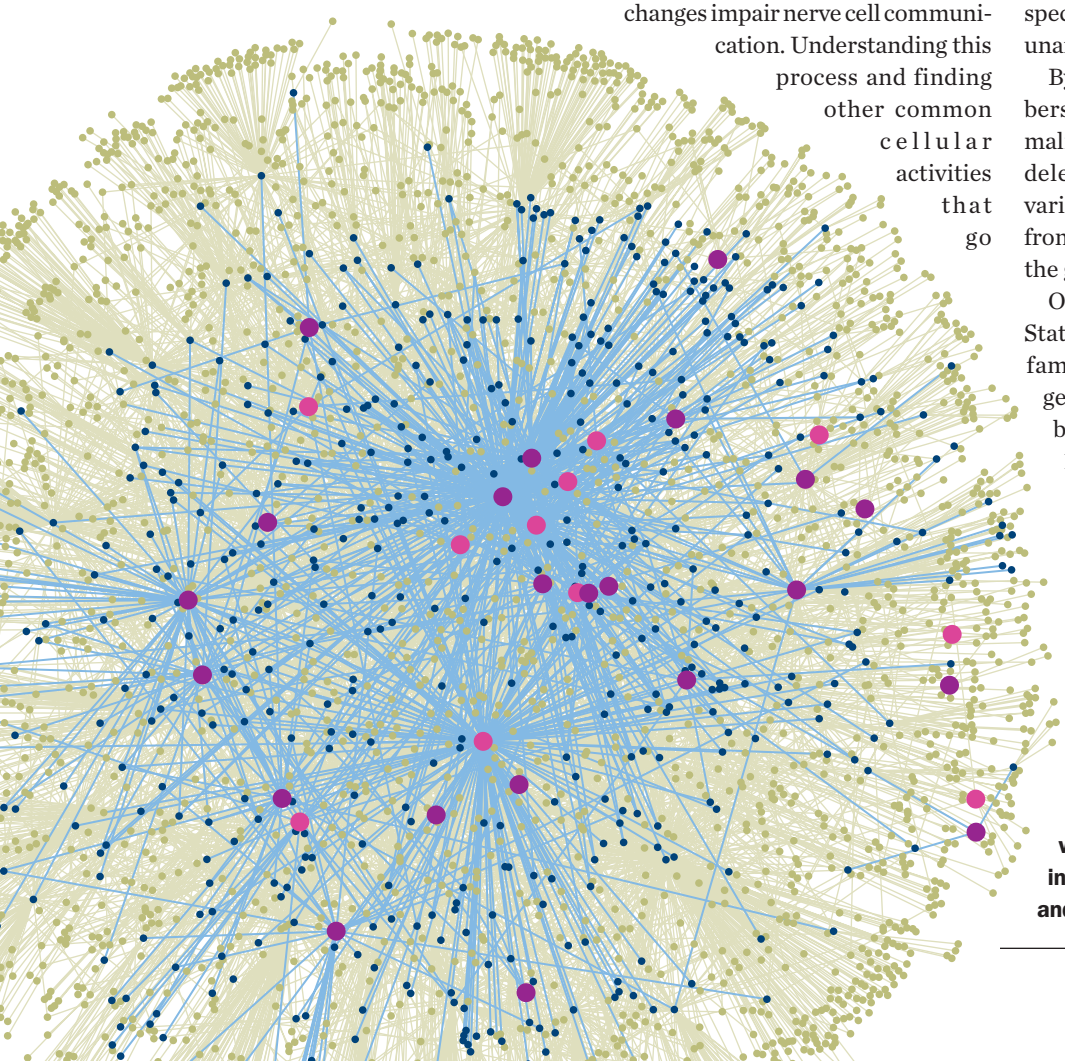
"Parents and families have been tremendously patient," says child psychiatrist and geneticist Matthew State of the Yale University School of Medicine. "They've been promised a lot by geneticists for a long time, and it's been tougher than any of us expected to deliver." But the flood of studies in the last few months reflects tremendous progress, he says. "These are all, in their own way, making a chink in the armor."

Pieces here and there

Two studies in the June 9 *Neuron* identified a host of genetic changes that together account for 5 to 8 percent of autism cases. Both studies examined DNA samples taken from carefully screened families, a roughly 1,000-family cohort called the Simons Simplex Collection. Each family included two unaffected parents and one high-functioning child diagnosed with autism spectrum disorder. For most families, an unaffected sibling was also included.

By including unaffected family members, the researchers could find abnormalities — specifically, duplications and deletions of DNA called copy number variations — that were not passed down from parents but arose spontaneously in the genomes of affected children.

One of the studies, coauthored by State and his colleagues, included 1,124 families and estimated the number of genome regions in which copy number changes were linked to autism at 130 to 234. The other study, done by Michael Wigler of Cold Spring Harbor Laboratory in New York and colleagues, looked at 887 families and put the number at 250 to 300. "This really speaks to the



Maps depicting interactions among neural proteins provide clues to autism's roots. Proteins known to be related to autism (pink and purple) have been linked with over 500 proteins that may be involved, some newly identified (blue) and some already suspected (tan).

CHAD SHAW, BRIAN DAWSON, YASUNARI SAKAI, H. ZOGHBI

immense heterogeneity of autism," says geneticist Huda Zoghbi of Baylor College of Medicine in Houston, who was not involved in the studies. "We suspected it, but these data show it clearly."

Results described by Wigler's team may also help explain why autism spectrum disorders are much more common in boys. Autism strikes four boys for every girl, yet girls' DNA actually harbors more of these rare autism-associated genome duplications and deletions, the researchers found. And these anomalies aren't just more abundant in girls; each change interrupts more genes. For a girl with autism, each duplication or deletion disrupted a median of 15.5 genes, while for a boy, the number disrupted was just two.

300
Genome regions with DNA duplications or deletions linked to autism (upper estimate from one study)

Through some mysterious process, girls are just more resistant than boys to the genetic causes of autism, the results suggested. "Overall, it does look like a girl can have the same genetic insult as a boy, but not be diagnosed with autism," Wigler says.

For the most part, each duplication or deletion was specific to each affected child. Although copy number variations of one particular region of chromosome 16 were observed in multiple children in both studies, changes to this region still accounted for only slightly more than 1 percent of autism cases.

"Some people will see that as glass-is-half-empty, but we see it as glass-is-half-full," State says. "It shows that there are a lot more clues to be had." State and his colleagues are now combing through 1,000 more samples from the Simons Simplex Collection, conducting more targeted studies to find out how some of these genes may contribute to the disorders.

While single, severe abnormalities in parts of the genome are clearly important for certain cases of autism, in some people the disorder could be caused by more numerous mild genetic changes. A new study from Zoghbi and her colleagues finds that children with autism are more likely than unaffected children to have double hits: mutations in two of 21 autism-implicated genes.

Just one of these mutations is not severe enough to completely scramble or eliminate a gene's functions, nor is it strong enough to affect the parent, who oftentimes carried it as well. "Each parent is fine, but those two together now in a child can perhaps increase the possibility of having autism," Zoghbi says. Once a certain mutational threshold is reached, the disorder appears, the researchers suggest in a paper to appear in an upcoming *Human Molecular Genetics*.

Linking up

Other researchers are taking a different tack: Instead of searching for DNA changes to identify related genes, they study how genes behave. For instance, a recent study by neurogeneticist Daniel Geschwind of UCLA focused on gene activity — measured by the amount of RNA molecules shuttling information from a particular gene to the protein-producing parts of cells.

5 to 8%
Cases of autism attributable to such DNA copy number variations

Hundreds of genes behaved differently in the brains of people with autism compared with unaffected people, Geschwind and his colleagues reported online May 25 in *Nature* (*SN: 6/18/11, p. 5*). Many of these genes were involved in maintaining the complex and sensitive links called synapses, the junctions between nerve cells.

Wigler and his colleagues have also found that in children with autism, deletions and duplications tend to strike genes whose products are essential for nerve cell communication. The study, published in the June 9 *Neuron*, adds to a growing body of evidence that nerve cell signaling is profoundly altered in people with autism.

With better ways to uncover the biochemical networks in which genes, RNA and proteins are players, scientists can now study such nerve cell malfunctions with precision. Wigler and his team analyzed how genes in DNA regions that have duplications or deletions associated with autism interact with one another. Among other things, some of the affected genes tell nerve cells how to grow a signal-sending axon and how to find the right partner to send signals to. Others oversee the chemical messages that carry signals across synapses from cell to cell.

Another study from Zoghbi confirms that synapses are key. She and her team turned up an unexpected relationship between two proteins that both work at the junction where nerve cells connect. In a massive undertaking, the researchers tested whether each of 26 autism-related proteins latched on to nearly every other protein a human brain cell produces. This effort, reported online June 8 in *Science Translational Medicine*, identified more than 500 proteins that interacted with the autism-related proteins.

Two of the autism-related proteins, called SHANK3 and TSC1, had a surprisingly cozy relationship. Zoghbi and her colleagues didn't think those two proteins would be related, but it turns out that they share at least 21 protein partners, implicating them as tight coconspirators at the synapse. These proteins probably act together in dendrites, the parts of a nerve cell that pick up messages from other cells, the researchers suggest.

"At the end of the day, we have to remember that features of autism suggest to us that neurons are not functioning well," Zoghbi says.

Understanding this shared problem, and uncovering similar networks, may lead to ways to treat or prevent autism in the future. Figuring out ways to protect vulnerable brain processes may turn out to be more important than knowing exactly how things went wrong. ■

Explore more

- Christian P. Schaaf and Huda Y. Zoghbi. "Solving the autism puzzle a few pieces at a time." *Neuron*. June 9, 2011.

Water's Edge Ancestors

Human evolution's tide may have turned on lake and sea shores

By Bruce Bower

In a cave hugging South Africa's lush southern coastline, Curtis Marean suspects he has cornered a wily Stone Age crew that brought humans back from extinction's brink. These plucky refugees of continent-wide desolation were able to pull off such a stunning evolutionary turnaround because they got lucky. A coastal oasis near the bottom of the world spread its sheltering arms in the nick of time.

Marean proposes that it was there, where the Arizona State University archaeologist now conducts excavations, that humankind's mental tide turned sometime between 164,000 and 120,000 years ago. Seaside survivors learned to read the moon's phases in order to harvest heaps of shellfish — brain food extraordinaire — during a few precious

SACP4

Stone age human ancestors residing near caves at South Africa's Pinnacle Point (shown) may have learned to track the tides in order to harvest shellfish.

days each month when ocean tides safely retreated.

Tantalizing traces of complex thinking and behavior, including lunar literacy, have turned up at South Africa's Pinnacle Point, a cave-specked promontory that juts into the Indian Ocean. Chunks of dark red pigment and strikingly beautiful seashells found by Marean's team in one cave attest to ancient ritual activities. Stone points unearthed in the same cave sport glossy patches, signs that the rock was heated to make it easier to work with. The finds challenge the long-standing view that Stone Age people did not think abstractly and perform complex rituals until about 50,000 years ago.

People chanced upon Pinnacle Point and its dietary bounty, Marean says, only after global cooling had rendered much of Africa barren and uninhabitable. Several genetic studies suggest that modern human numbers throughout Africa plummeted to a few hundred breeding individuals around that difficult time.

"Our excavations may have intercepted ancient people who shadowed the shifting shoreline and are the ancestors of everyone on the planet," Marean says.

Research on Pinnacle Point's mussel-seeking moon trackers exemplifies a growing scientific conviction that fish and shellfish have played a largely unappreciated role in brain and mind evolution throughout the history of the *Homo* genus, which appeared at least 2 million years ago and includes people today. Though several East African savanna sites contain butchered animal bones, signaling carnivorous tastes among human ancestors, some scientists now argue that red meat has been oversold as a dietary staple.

At a meeting of the American Association of Physical Anthropologists, held in Minneapolis in April, researchers argued that ancient menus focused heavily on food from lakes, rivers and oceans. New work presented at the meeting pointed to lakeside fishing in East Africa nearly 2 million years ago, the shoreline shellfish harvesting among *Homo sapiens* at Pinnacle Point starting more than 160,000 years ago and sea voyages to Pacific Ocean islands by an unlikely group of New World settlers around 12,000 years ago.

Food scientists at the meeting emphasized that nutrients essential for brain growth are much more abundant in fish and shellfish than in red meat or any other food. And grabbing catfish out of shallow waters, not to mention scooping up handfuls of shellfish along the shore, may be far easier than hunting land animals or scaring predators away from meaty carcasses, says archaeologist Jon Erlandson of the University of Oregon in Eugene.

Seashells found at a South African cave were probably carried there by early peoples.

Shellfish collecting and fishing probably began early among members of the *Homo* genus, Erlandson says. "These foods later could have provided nutrients that enabled the evolution of fully modern brain size and cognition."

Olduvai gorging

Erlandson suspects that, before *Homo sapiens*' Pinnacle Point pursuits, fishing was a catch-as-catch-can affair. Consider ancient cuisine unearthed on the eastern shore of Kenya's Lake Turkana. Someone there bellied up to an aquatic buffet nearly 2 million years ago, leaving a mess that only an evolutionary scientist could love.

At a site unceremoniously dubbed FwJj20, a team led by anthropologist David Braun of the University of Cape Town in South Africa unearthed butchered remains of fish, turtles and crocodiles. Remains of animals that don't live in the water but often reside nearby, such as tortoises, birds, giraffes, hippos, rhinos and antelope, also turned up. Stone tools lay among scraped and fractured shells of tortoises and water-dwelling turtles. Several catfish bones bore tool marks made by individuals who cut off the heads of their catches. Whatever members of the human evolutionary family once dined at FwJj20, they needed only basic implements to put catfish and other lake animals in hungry mouths.

"A large rock is probably all that ancient hominids would have needed to catch fish," Braun said at the anthropology meeting. Even simpler fishing techniques may extend deep into primate prehistory. Orangutans have been found to snatch catfish from shallow ponds bare-handed and chase the finned snacks out of deeper water with poking sticks (*SN: 5/7/11, p. 16*).

A steady diet of fish would have nutritionally powered brain expansion in early members of the *Homo* genus, such as the untidy Lake Turkana crowd, in Braun's view.

The Lake Turkana finds leave a sweet taste in archaeologist Kathlyn Stewart's mouth. In a 1994 study, Stewart, of the Canadian Museum of Nature in Ottawa, concluded that abundant fish, crocodile and turtle remains at five sites within Tanzania's Olduvai Gorge represented leftovers from hominid meals. Finds at these nearly 2-million-year-old locations, which have yielded fossils of early *Homo* and a related lineage called *Paranthropus*, also include butchered bones of land animals, which have received the lion's share of scientific attention for more than 30 years.

Game hunting occasionally occurred at Olduvai Gorge, Stewart pointed out at the meeting in April, but aquatic foods provided stable, high-quality nutrition. Pollen data and chemical analyses of fossils indicate that hominids began hanging

A. JERARDINO AND C. MAREAN/JOURNAL OF HUMAN EVOLUTION 2010

out in marshy areas, eating grasses and papyrus shoots, more than 3 million years ago, Stewart reported. Papyrus marshes feature a lot of fish, shrimp, snails, mollusks and microalgae, which the gorge residents also dined on. "Lake and river margins provided high-quality food to ancient hominids, especially pregnant and lactating females," Stewart says.

Some researchers argue that a few aquatic munchfests don't confirm that ancient hominids across East and South Africa fancied fish. Doubters and advocates alike await finds from more digs along African lakeshores and riverbanks.

Coast with the most

Marean suspects that such excavations will demonstrate that an increasing taste for catfish and other water creatures accompanied increases in brain size among early *Homo* species. Stone Age people exploited that evolutionary endowment at Pinnacle Point, putting their outsized brains together to solve the puzzle of the tides, Marean says.

Protein-rich shellfish, loaded with omega-3 fatty acids crucial for brain development, led to further social innovations, including a move from eating for now to organizing seaside harvests for later, in his opinion. If so, a sense of time needed to plan for the future characterized the human species almost from its start about 200,000 years ago.

Marean's team previously reported that mounds of brown mussels and local sea snails excavated in one Pinnacle Point cave date to 164,000 years ago, providing the earliest evidence of coastal dwellers scarfing shelled food with relish, if not condiments (*SN: 10/20/07, p. 243*).

The researchers have since found that, by 110,000 years ago, limpets and sand mussels joined the menu. Shellfish foragers face their own brand of perils, Marean explains. Mussels, limpets and sea snails live in treacherous rocks that border the ocean. If the tide is not at its lowest, incoming swells can easily knock collectors onto sharp rocks or into the sea.

The cave excavated by Marean's group sat two to five kilometers inland around 164,000 years ago, when sea levels were lower than today. Early foragers must have scheduled their activities around the best times to go to the coast for shellfish. When tides were high, foragers instead headed inland eight to 12 kilometers to exploit other foods in South Africa's rich Cape Floral Region. This 90,000-square-kilometer strip curves around the bottom of Africa like a half-smile. Many plants in the Cape Floral Region produce edible geophytes, underground energy-storage organs that swell with carbohydrates at certain times of the year.

Coastal residents dug up geophytes and hunted inland game until the moon issued a call to the sea, Marean proposed at the anthropology meeting. When the sun and moon align, their combined gravitational forces cause daily tides to spring back and forth from extremely low to extremely high levels. Such spring tides, a twice-monthly effect that has nothing to do with the seasons, correspond to full and new moons.

During spring tides, low tides advance by 50 minutes each day. Fishers and other coastal devotees today consult printed tide schedules or programmed watches to coordinate activities with daily tidal rhythms. Pinnacle Point's Stone Age crowd informally estimated each day's prime time for shellfish collecting, Marean suggests.

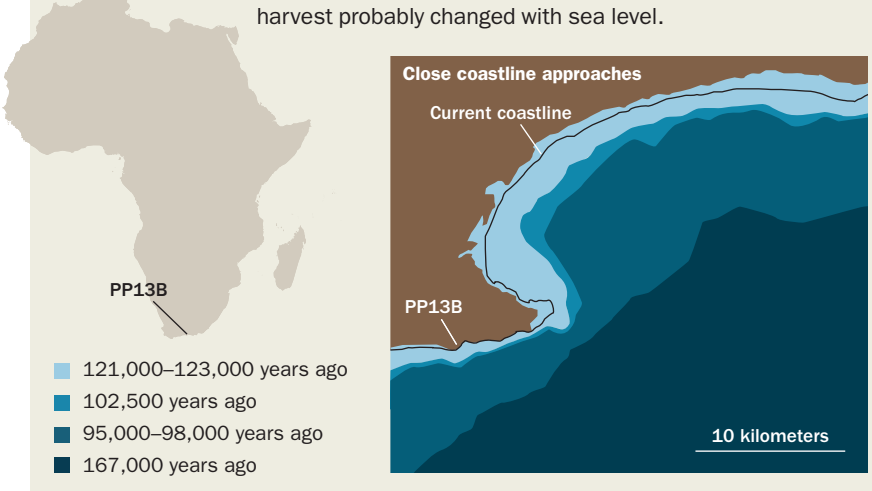
Access to shellfish wasn't always available during the Stone Age, though. Climate and environmental records indicate that South Africa's coastline repeatedly advanced and retreated between 195,000 and 123,000 years ago. Thanks to a gently sloping continental shelf off much of the coast, as much as 95 kilometers of land was exposed when sea levels retreated during that period, Marean and his colleagues estimate.

Pinnacle Point attracted human visitors when its caves lay within about a day's walk of the sea, the scientists assert. This off-and-on shoreline access over tens of thousands of years was enough to trigger big lifestyle changes. "Organizing foraging activities around a complicated system of tidal timing had a trickle-down impact on social life," Marean says.

Abundant shellfish and geophytes made foragers less nomadic, increased birthrates and reduced infant death rates, Marean suggests. Burgeoning Pinnacle Point communities adopted symbolic and ritual behaviors, as well as advanced toolmaking techniques, to express social identities.

Tide tracking's domino effect on mental and social life may have given modern humans a survival advantage when they met European Neandertals after leaving Africa. Caves overlooking the Mediterranean Sea in southwestern Europe contain remains of fish, seals and dolphins,

Southern bounty The distance between a Pinnacle Point cave labeled 13B and the shoreline changed over time. Shellfish collection probably occurred at times when the coast was within 10 kilometers (highlighted below), though the harvest probably changed with sea level.



AFRICA MAP: GEOATLAS/GRAPHI-OGRE, ADAPTED BY JANEL KILEY; RECEDING SHORELINE MAP: A. JERARDINO AND C. MAREAN/*JOURNAL OF HUMAN EVOLUTION* 2010, ADAPTED BY JANEL KILEY

as well as mollusks, eaten by Neandertals toward the end of their evolutionary run around 42,000 years ago (*SN Online: 9/22/08*). But these Neandertal caves contain no huge shell heaps that suggest that coastal visits occurred at tidal low points, when masses of mollusks lay exposed, Marean argues.

It seems that hungry *Homo sapiens* patiently consulted the moon, whereas Neandertals heeded the urgency of their grumbling bellies.

New World sea cruise

Tide tracking at Pinnacle Point led to expanding numbers of people who eventually turned to sea travel to find virgin territory. These seafood-lovers may well have colonized the world.

Starting around 50,000 years ago, ocean voyagers based in Asia fanned out across the Pacific to Australia and points beyond. These mariners have sailed under the radar of many scientists seeking the earliest settlers of the Americas, Oregon's Erlandson asserted at the anthropology meeting.

Inland sites in North America contain stone points and mammoth bones that have nurtured a decades-old idea: The New World was first colonized by Asian big game hunters who crossed a land bridge to Alaska around 13,000 years ago. A corridor through massive ice sheets ushered these intrepid carnivores into what's now the United States, where they founded the Clovis culture, named after a New Mexico site that has yielded stone spear points.

It's now an open question whether the Clovis-first hypothesis will hold up, Erlandson says. In the March 4 *Science*, he and his colleagues reported that people lived on California's Channel Islands by about 12,200 years ago. A sea cruise of nine to 10 kilometers was required to reach these ocean outposts.

Three Channel Island sites — seasonal camps, most likely — yielded narrow-stemmed stone points and crescent-shaped implements, lying among bones of seabirds such as geese and cormorants, seals and other sea mammals, and several types of fish. Piles of shells from red abalone, giant chiton, mussels and other shellfish also turned up.

Stone tools from Channel Island sites dating to 12,200 years ago suggest that the first colonizers to the New World may have come by sea.

Stone tools found on the Channel Islands look nothing like Clovis points. In an upcoming *Quaternary International*, Erlandson and Todd Braje of Humboldt State University in Arcata, Calif., argue that stemmed stone points found on the islands instead resemble those that have been found at coastal sites stretching from Korea, Japan and northeastern Russia to North and South America.

These finds date to between 35,000 and 15,000 years ago in Asia, and to as early as 14,500 years ago in the Pacific Northwest, Erlandson said at the meeting, supporting his suspicion that initial New World colonists used canoes or other vessels to navigate along the coast from Asia to the Americas. Stemmed points found around lakes and marshes in western North America look like Channel Island finds, indicating that coastal people not only cruised the open sea but headed inland, possibly to trade for goods with Clovis people, Erlandson says.

"We have to start creating new models of the peopling of the Americas," he says. "Received wisdom and a good story can inhibit research for decades, as happened with the Clovis hypothesis."

Inundated evidence

Encroaching oceans also inhibit investigations of humankind's water-traveling ancestors. A global sea level rise of about 120 meters between 20,000 and 6,000 years ago flooded shorelines and nearby lowlands where ancient populations presumably camped. "Current evidence for Stone Age coastal occupations represents the tip of the iceberg," Erlandson says.

Yet the patchy evidence available for ancient tide tracking on South Africa's coast leaves some researchers skeptical. A connection between shellfish harvesting at Pinnacle Point and a rapid transformation in human thinking remains questionable, argues Stanford University archaeologist Richard Klein.

Coastal caves bearing stone tools and seafood remains from more than 164,000 years ago may yet be found, he asserts. And shellfish gathering requires no special knowledge, tools or personal risk if the tide happens to be out. Coastal baboons in Africa collect and eat shellfish. Seagulls drop mussels and other tidal treats on hard ground to break open shells, leaving behind what sometimes looks like human garbage, Klein says. Also, abundant archaeological evidence of fish eating by Europeans and Africans dates to no more than 50,000 years ago, long after brain size had ballooned.

"It will take a long time to test my hypothesis about an ancient coastal adaptation in South Africa," Marean acknowledges. Prime shoreline camps from long ago undoubtedly lie underwater, "guarded by great white sharks and dangerous currents," he says.

He and his colleagues are now exploring more caves at Pinnacle Point and have expanded their search to caves on South Africa's eastern coast. Some of these sites are located where the continental shelf drops steeply and the coast was always near, possibly giving researchers access to ancient camps that never got inundated by the ocean.

Marean looks forward to further encounters with long-dead lunar tide trackers. This is, after all, no fishing expedition. ■

Explore more

- S. Cunnane and K. Stewart, eds. *Human Brain Evolution*. John Wiley & Sons, 2010.

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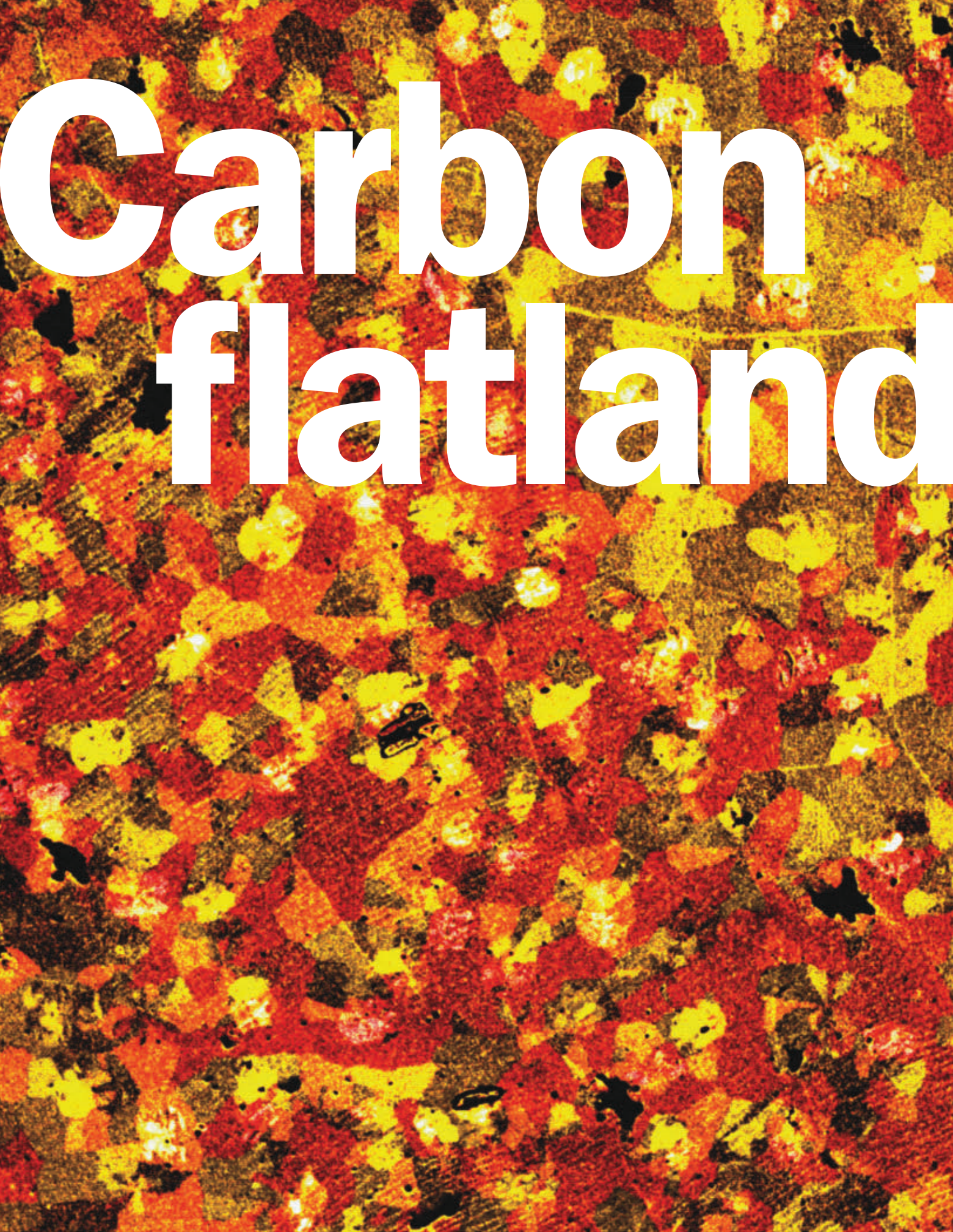

Carbon
flatland

Graphene's two dimensions offer new physics, novel electronics

By Alexandra Witze

Some physicists spend their days exploring the three dimensions of space, the four dimensions of spacetime or even the 11 dimensions of something called M-theory. Other researchers are content with just two.

But fewer dimensions doesn't mean less science. For seven years, researchers have been enjoying a two-dimensional playground of new physics provided by a superflat material called graphene.

This deceptively simple substance — nothing more than a sheet of honeycombed carbon atoms, which you can find within flakes from pencil lead — contains head-slappingly bizarre physics. Unlike almost any other common material, graphene sometimes behaves according to the weird rules of quantum mechanics. And electrons within it assume an otherworldly identity, zipping along as if they have no mass.

"Suddenly graphene came on the scene and it had a completely new physics to it," says Joseph Stroscio, a physicist at the National Institute of Standards and Technology in Gaithersburg, Md. "That got everyone very excited" — even scientists who ordinarily like lots of dimensions.

Discovered in 2004, graphene was quickly recognized as cool enough to warrant a Nobel Prize in physics, awarded in 2010. Now, researchers are shifting from simply being excited about graphene (*SN: 9/27/07, p. 200*) to more deeply understanding and even harnessing the physics at play.

In this false-color microscopy image, a patchwork "quilt" of graphene displays colorful patches where the usual six-member carbon rings grow imperfectly and at different orientations.

OPPOSITE PAGE: MULLER LAB/KAVLI INSTITUTE AT CORNELL FOR NANOSCALE SCIENCE; THIS PAGE: TOP TWO IMAGES: E. FELICIANO; BOTTOM IMAGE: 3DRENDERINGS/SHUTTERSTOCK

For one thing, scientists now understand how stacking one sheet of graphene atop another in just the right way can change the way electrons flow between the layers. Other researchers have found that putting graphene atop a slab of boron nitride lets them manipulate the electron flow far better than before. Some groups are already designing devices for a new graphene age; this spring, IBM researchers reported building the first electronic circuit entirely out of graphene.

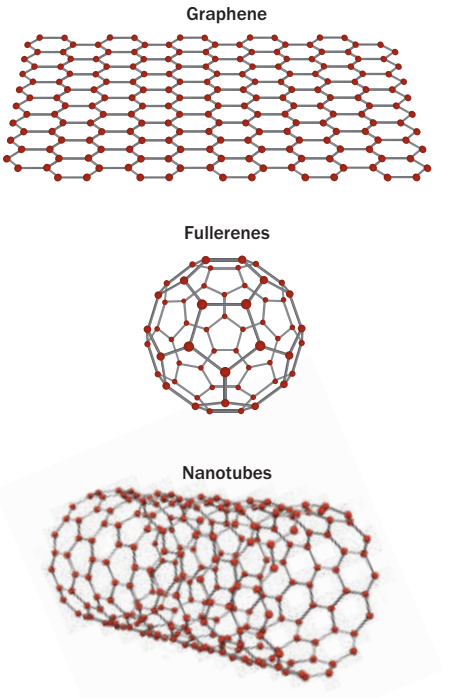
Graphene, the two-dimensional wonder material, seems ready to deliver on some of its early promises for the three-dimensional world.

A simple sheet

Not all of graphene's predecessors have lived up to their original hype. In 1985, Texas and British chemists discovered cages of carbon atoms including the famous "buckyballs," 60-carbon conglomerates that look like miniature soccer balls. These molecules, part of a class called fullerenes, were touted as the next big thing in electronics; yet after a quarter century, nobody has a buckyball running an iPhone. Then, in 1991, a Japanese scientist discovered another carbon curiosity, tiny "nanotubes" made of rolled-up atoms. Although some scientists have developed new electronics based on carbon nanotubes (*SN: 12/4/10, p. 20*), the tubes turned out to be hard to make and arrange cleanly.

Now graphene is having its try at a technology revolution, and many argue it will fare better than the other carbon protégés. "The thing about graphene is that it's a truly two-dimensional crystal," says Antonio Castro Neto, a theoretical physicist at Boston University who is setting up a new graphene research center at the National University of Singapore. "We never had something like that before."

In graphene, electrons can flow far more freely than they can in either buckyballs or nanotubes, in part because it is the simplest of these forms of carbon. The bonds between the atoms also make graphene superstrong and superflat; in theory, a 1-meter-square hammock of graphene could support the weight of a cat despite being lighter than the cat's whisker.



Carbon siblings The single layer of honeycombed carbon atoms that make up graphene forms the basis of two other carbon materials of scientific interest: ball-shaped fullerenes and curled-up nanotubes.

Rather than forming as individual sheets, graphene forms as layer after layer within graphite, the stuff of pencil lead. One millimeter of graphite contains roughly 3 million layers of stacked graphene. "If you write very carefully, it's likely you'll get a few layers of graphene from your pencil," says Sankar Das Sarma, a physicist at the University of Maryland in College Park.

In keeping with the office-supplies theme, the scientists who won the Nobel for graphene used Scotch tape to pull apart flakes of graphite. By repeatedly folding and then opening up a piece of tape with graphite stuck on, Andre Geim and Konstantin Novoselov of the University of Manchester in England managed to peel off single graphene layers.

Each single layer, the scientists later found, behaves in extraordinary ways. In most materials, the speed of electrons changes with their energy. In graphene, though, electrons behave as if they have

no mass; they move at a constant speed no matter their energy, and they cannot be stopped. Only particles in atom smashers and cosmic rays behave this way, and the math that describes graphene electrons is very much like the math that describes neutrinos, those elusive, nearly massless particles that zip through space.

"Boom — all of a sudden we have a system of quasi-neutrinos," says Eva Andrei, a physicist at Rutgers University's campus in Piscataway, N.J. The only difference is that graphene electrons travel at roughly a million meters per second; neutrinos (and light) travel 300 times that fast.

Discovery after discovery has revealed the bizarre things these graphene electrons can do. In April in *Science*, Geim and his colleagues reported that under certain conditions, electrons in graphene can adopt a split personality in which one of their properties (electric charge) behaves according to the rules of the everyday world but another property (spin) behaves according to the otherworld of quantum mechanics. "We are not used to quantum mechanical effects happening in our normal life," says Castro Neto. "When you find a material like that, it's really a treasure."

Stretching graphene also makes its electrons do funny things. At the University of California, Berkeley and the Lawrence Berkeley National Laboratory, scientists accidentally found that if they grew graphene atop platinum, the graphene sheet could sprout tiny bubbles on its surface. Within those bubbles, electrons act as if they are under the influence of a strong magnetic field. Nobody is really sure what this means, says team member Castro Neto, but researchers in Singapore have managed to create similar bubbles at will. "Now we can control at the nanoscale the nature of the electronic states," Castro Neto says. "I think this is going to really generate a revolution in the way in which we deal with graphene."

And all that in just a single layer of graphene. For even more new tricks, scientists are turning to two-layer, or bilayer, graphene.

Doubled up

When it comes to building new electronic devices, single-layer graphene suffers from one huge drawback: It doesn't have a "band gap," or break in the energy levels that its electrons can occupy. Without a band gap, scientists can't turn the flow of electrons on and off — a crucial part of any electronic gadget. But adding a second layer of graphene creates such a band gap, making the bilayer structure more like a semiconductor in which the flow of electrons can be controlled instead of zooming along willy-nilly.

"Unlike single-layer graphene, bilayer has the possibility of shifting charge from one layer to another," says Amir Yacoby, a physicist at Harvard University. And interactions among the electrons cause other weird and wonderful physics, Yacoby says, such as the breaking of fundamental symmetries in how the electrons spin and move. "Several experiments indicate that interesting things are happening, but there is really no good understanding of what is going on there as of yet," he says.

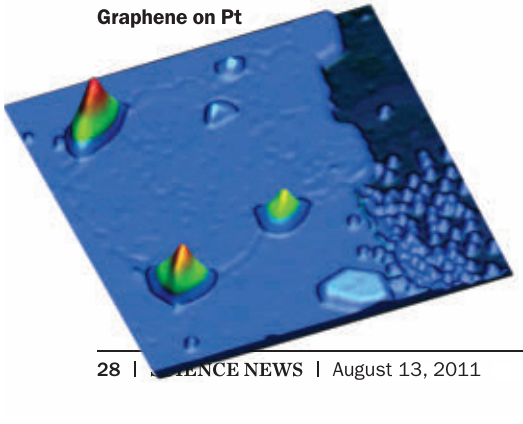
As intriguing as bilayer graphene is, making it isn't as simple as slapping one graphene layer atop another. How the two layers are stacked relative to one another is crucial for electronic applications, Andrei and her colleagues reported in March in *Physical Review Letters*. If the carbon honeycombs of each layer are rotated less than 5 degrees relative to each other, Andrei's team found, then they behave as a true bilayer, and can create the electronic band gap. But if the honeycombs are offset by about 20 degrees or more, then the graphene layers continue to behave electronically as two separate layers.

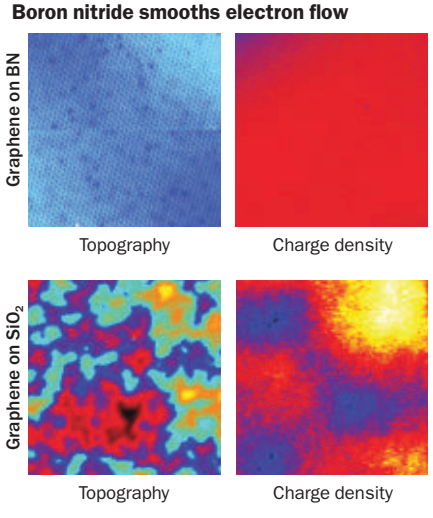
Such research shows how graphene electrons can be coaxed into acting however scientists want them to, Andrei says. "Here we have an external knob to control the electronic properties," she says. "That's quite exciting."

Where two layers are good, three might be even better, and so some researchers are pushing to make trilayer graphene. But as with the bilayer, researchers can't just throw three graphene sheets in a pile; the carbon honeycombs have to line up just so. Usually trilayer graphene comes in what's called the ABA form, in which the honeycombs of the top and bottom layer mirror each other. The ABC form, in contrast, slides that topmost layer over to one side so that the honeycombs climb like stairsteps.

Nobody has ever gotten the ABA version of graphene to do anything very exciting, but a research team led by Tony Heinz of Columbia University has been playing around with the ABCs. In a paper appearing online in May at arXiv.org, Heinz and his colleagues report making an electronic band gap appear in ABC

Graphene on top Putting a graphene sheet atop different substances creates different electronic effects. Atop platinum, the sheet wrinkles to form tiny nanobubbles (colored peaks, below). When graphene is put on boron nitride, the flow of electrons is simplified compared with the flow on silicon dioxide (right).





FROM LEFT: N. LEVY *ET AL./SCIENCE* 2010; R. DECKER *ET AL./NANO LETTERS* 2011

graphene. It's the first time anyone has been able to do this, and opens a new class of materials that scientists can work with.

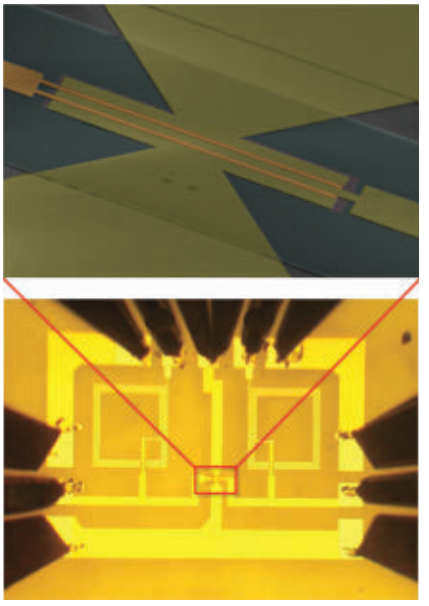
Graphene building

Just as in the construction industry, foundation is everything when it comes to building with graphene. Left to its own devices, a graphene sheet will wrinkle like poorly torn plastic wrap. Some researchers try to get around this by suspending graphene on clips in air, like a piece of laundry hanging out to dry. Even then, though, the edges will ripple or roll themselves up, or the sheet itself will tear. So scientists are investigating new ways to lay graphene flat and keep it that way.

Early on, most research teams plopped some graphene on a slab of silicon dioxide, the stuff of everyday computer chips. But the silicon and oxygen atoms interfered with the way the graphene's electrons zipped along. Instead, scientists have now switched their foundations to boron nitride, the stuff used to add glitter to cosmetics. Like graphene, boron nitride also has its atoms arranged in a single hexagonal sheet, with boron and nitrogen alternating in the spaces where carbon atoms sit in graphene. It's an almost perfect match.

"Once you use a boron nitride substrate and stack it with graphene, a number of things change," says Philip Kim, a physicist at Columbia. Compared with silicon dioxide, boron nitride lets the electrons zip along without interference, Kim and his colleagues showed last year.

To see why boron nitride works so well, scientists at UC Berkeley and the Lawrence Berkeley lab recently took a closer look at what happens when graphene and boron nitride meet. Using a scanning tunneling microscope, which can see at the level of individual atoms, the team compared graphene mounted on silicon dioxide with graphene mounted on boron nitride. The silicon dioxide version turned out to be strewn with "charge puddles," or spots where the electron flow got hung up. In contrast, the boron nitride samples were practically puddle-free. Michael Crommie, Alex Zettl and colleagues reported the findings this year in *Nano Letters*.



The first integrated circuit made fully from graphene (yellow design, bottom; close-up, top) could herald a new age of graphene electronics.

IBM

With this solid foundation and new ways of stacking, researchers can now act as architects, designing devices that take advantage of graphene's protean qualities. Though it probably won't ever replace the industry standard of silicon, graphene could lead to new kinds of gadgets. "It's really about what we can gain by using graphene in different applications," Castro Neto says.

Already, the wonder sheets are making inroads into silicon's traditional territory. In June in *Science*, IBM scientists reported making an integrated circuit whose components, including a transistor, are made completely out of graphene. Other teams have made individual graphene components before, and even linked hundreds of transistors together on a single chip. But the IBM group, led by Phaedon Avouris at IBM's Watson Research Center in Yorktown Heights, N.Y., is the first to make a complete circuit entirely out of graphene. Because graphene is so cheap, these kinds of circuits could prove popular for use in smartphones and other portable devices.

Unlike today's rigid computers, graphene can also be molded over surfaces, like a dust sheet protecting furniture from debris. Last year, for instance, researchers at Samsung in South Korea showed off the world's first graphene touch screen, a flexible sheet that uses the carbon atoms as see-through electrodes. Other industry scientists are developing graphene-based biological sensors and solar cells as cheap, bendable alternatives to ones already on the market. And in a paper published in June in *Physical Review B*, the Berkeley collaborators describe how they gathered up graphene like a bedsheet into folds, ruffles and pleats, creating a never-before-seen material they dub "grafold."

At another research frontier, scientists are taking advantage of graphene's weird electronic properties by interleaving stacks of it with different materials, such as insulators. "It's like making a big sandwich with tomato, lettuce, meat, bread and so on," says Castro Neto. "Each material gives a different taste, and at the end of the day you can have a very juicy sandwich that doesn't look at all like the piece of bread you started with."

Scientists are just starting to test the various combinations available, and it's clear the graphene delicatessen won't run out of possibilities anytime soon. In early 2005, at the first major American Physical Society meeting after Geim and Novoselov's Nobel-winning discovery, attendees at the only graphene session didn't even fill a small conference room. In spring 2011, Novoselov headlined the same physical society meeting while dozens of breakout sessions delved into the new possibilities offered by graphene.

With this amount of intellectual firepower, the discovery that started with some Scotch tape and pencil lead is sure to meet a much higher-tech end. ■

Explore more

- More info on graphene from the Nobel Prize committee: bit.ly/nFOHdu

Eruptions That Shook the World

Clive Oppenheimer

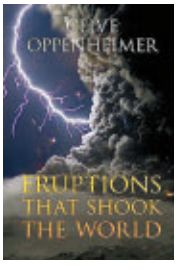
Megadisasters sell, and megavolcanoes sell more than most: Turn on any documentary channel to see mountains belching ash clouds across townspeople paralyzed by fear.

Oppenheimer, a volcanologist, has served as consultant on some of these films. But he tops them all with a new book, heavy on scientific detail and light on dramatic froth, chronicling eruptions that really did change the world.

Often, the deadliest eruptions come out of the blue. Few scientists foresaw the 1883 eruption of Krakatoa in Indonesia or the Philippines' climate-changing Mount Pinatubo in 1991. Oppenheimer argues that understanding such past events is key to surviving the future.

That future could hold far greater disasters than last year's eruption of Eyjafjallajökull, the Icelandic volcano that shut down Europe's air space. Take, for example, the 1783–84 eruption of the Laki volcano, whose poisonous fog killed tens of thousands, not just in Iceland but as far away as England and France.

Death tolls are not the only measure of an eruption's influence on society. Consider the little-known Campanian Ignimbrite eruption, which devastated southern Italy some 39,000 years ago just as Europeans were developing stone tools. And in early Mesoamerica, leaders at the city of Teotihuacán may have exploited the fear and uncertainty following an eruption of nearby Popocatépetl to consolidate power. These are stories that don't make the Discovery Channel.



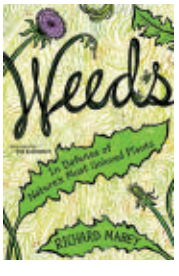
Oppenheimer wisely avoids the trap of environmental determinism for explaining the rise or fall of a particular civilization. Rather, he thoughtfully makes his case that volcanoes and humankind have been intertwined throughout history, and will continue to be long after the next unpronounceable Icelandic volcano erupts. —*Alexandra Witze*

Cambridge Univ. Press, 2011, 449 p., $30

Weeds: In Defense of Nature's Most Unloved Plants

Richard Mabey

Weeds, according to one definition, are simply plants that are growing in the wrong place. Some have invaded gardens from the surrounding countryside, and others escaped cultivation to infest the landscape. But in almost every case, weeds — whether you think of them as adaptable opportunists or as botanical thugs — thrive in human company.



In a charming paean to plants sometimes ignored and often detested, nature writer Mabey points out that weeds are evolutionarily primed for success: They tend to grow quickly and produce prodigious numbers of seeds. Those seeds are dispersed by winds or carried far and wide by creatures, on fur and feathers or hitching a ride in stomachs — in which case the plants-to-be are deposited at their destination amid a dollop of fertilizer. And if growing conditions aren't quite right, so be it — some seeds can lie dormant for decades before sprouting in profusion.

Regardless of common perception, weeds can be useful, Mabey argues. The first crops were essentially domesticated weeds. Kentucky bluegrass, a symbol of the American South, was considered a weed in Britain before it was planted as forage for livestock in the colonies. And burdock burrs, covered with thin spines ending in tiny flexible hooks, inspired the invention of Velcro.

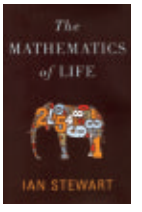
Plants unwelcome in some places are beloved in others, from cornflowers and fuchsia to the exuberant yet fragile poppy — a reminder, the author says, that plants become weeds only when people label them as such. —*Sid Perkins*

HarperCollins, 2011, 324 p., $25.99

Avian Architecture

Peter Goodfellow

A browsable, amply illustrated overview of avian construction from mere scrapes in the sand to edible structures people prize for soup. *Princeton Univ. Press, 2011, 160 p., $27.95*



The Mathematics of Life

Ian Stewart

In this engaging overview, a mathematician describes how the field of biomathematics is answering key questions about the natural world and the origins of life. *Basic Books, 2011, 358 p., $27.99*

Falling to Earth

Al Worden with Francis French

An astronaut offers a candid look at his trip to the moon, including the scandal that ended his spacefaring days. *Smithsonian Books, 2011, 304 p., $29.95*

The Sun's Heartbeat

Bob Berman

Light-hearted tales trace human understanding of Earth's nearest star and of the sun's effects on Earth. *Little, Brown and Co., 2011, 304 p., $25.99*

War's Waste

Beth Linker

An account of how World War I influenced veteran medical treatment delves into the rise of rehabilitation therapy and the costs of supporting wounded veterans. *Univ. of Chicago Press, 2011, 291 p., $35*

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Prescient sci-fi

It took the *Science News* editor in chief to recognize the most prescient science "fiction" movie of all time, *Forbidden Planet* ("Science brings real life to the technologies of fiction," *SN: 7/2/11, p. 2*). Beyond civilization without instrumentalities, the film also brought us lasers before there were masers, Robby [the Robot] analyzing molecular structure to duplicate anything and multiple concepts that have come to fruition in my and Tom Siegfried's lifetime. If only those handsets hadn't had wires....
Tony Witlin, St. Petersburg, Fla.

Attraction and gender

Thank you for a great publication! The meeting note entitled "Familiarity breeds congeniality" (*SN: 6/18/11, p. 17*) raises the question as to why "men showed no signs of especially liking women who resembled a romantic partner" while women did. One possible answer is that the ancient male genetic dictum said to spread his DNA as far and as often as possible; therefore, unfamiliar looks equaled difference and perhaps distance. On the other hand, the ancient female genetic dictum said to rear offspring in a safe environment; therefore, familiar looks equaled more of what she already knew. Just a thought.
Mike Kletzly, via e-mail

Spatial lessons

"Geometry comes naturally to the unschooled mind" (*SN: 6/18/11, p. 16*), states: "such as lines that extend forever or perfect right angles." I think an old-growth timber forest is the perfect place to visualize parallel lines going on forever, as the trees are perpendicular to the ground and extend virtually till they go out of sight.
Irvin Hentzel, Ames, Iowa

It might be interesting to compare Amazonian villagers' limited experience with respect to geometric principles with that of adults and children blind from birth. This might shed some light on the innate/acquired question.
Bill Britton, via e-mail

Catching the vibrations

A note about "What it means to 'feel the noise'" (*SN: 6/18/11, p. 11*): When I worked as a complementary therapist at a hospice, patients who were said to be hard of hearing frequently responded to the sounds of the Native American flute, a particularly mellow instrument which I would place close to the sternum of these patients. One morning a 100-year-old, profoundly deaf woman turned to me at the completion of an old hymn and said simply: "That was beautiful. I wish I could hear it."
Pat Edmunds, Six Mile, S.C.

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Marketplace

From the Archive

To read the full 1963 article, visit
www.sciencenews.org/archive_mohole

During the first and only completed phase of the U.S. Project Mohole, scientists drilled more than 180 meters beneath the Pacific Ocean's floor.

Russians Dig to Reach Below Earth's Crust

THE RUSSIANS are digging through land to reach down just below the earth's crust to the mantle and expect to dig from six to nine miles down within three to five years.

The digging is being done at five locations in the USSR, Prof. Vladimir V. Beloussov of the Soviet Academy of Sciences said in Berkeley, Calif. He is president of the International Union of Geodesy and Geophysics, which held a two-week meeting in Berkeley, Calif. Scientists from 60 nations attended.

The United States is planning to dig to the mantle through the ocean floor in a program called Project Mohole. Prof. Beloussov pointed out that since the two countries are approaching the exploration of the earth from two different angles, they are not competing with each other.

Prof. Beloussov noted that man now knows quite a bit about cosmic space, but that his knowledge of the earth reaches only a few miles into the ground and much of this knowledge is based on shaky theories.

Nuclear explosions for exploring the earth's crust are not recommended by the Soviet seismologist. The upper mantle has a different composition and construction than the crust itself, Prof. Beloussov noted.

UPDATE

By land or by sea in the earth sciences' 'space race'

While many had their sights on space in the 1960s, earth scientists were looking inward to the Moho — the Mohorovicic discontinuity, that is. Reaching the boundary between the Earth's crust and mantle, named for Croatian seismologist Andrija Mohorovicic, would allow scientists to peer directly into the Earth's innards, providing new insight into the planet's makeup and history and informing controversial ideas about continental drift.

In 1961 Americans began drilling a series of experimental holes through the seafloor off the coast of Guadalupe, Mexico. The Russians countered: They'd dig deep as well, but rather than go through the seafloor, they'd go straight through dry land. Though scientists tried to emphasize that the two countries were not in competition, the tone at the time was clear: Collecting mantle rock was akin to bringing home bits of the moon.

One of the experimental holes dug by the Americans reached more than 180 meters below the seafloor, but plans to dig a larger Pacific hole down to the discontinuity, perhaps six kilometers or more, were called off in 1966 because of increasing costs. The Russians, who didn't begin drilling until 1970, had reached a depth of more than 12 kilometers at a site on the Kola Peninsula by 1989, creating the record-setting Kola Superdeep Borehole. The 14- to 15-kilometer target depth was never achieved.

Today, half a century after the first attempts to reach it, the boundary remains elusive. In *Nature* in March, two researchers described renewed interest in a Mohole campaign, driven largely by the Integrated Ocean Drilling Program (www.iodp.org) and the Deep Carbon Observatory. — *Elizabeth Quill*

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Thank-you.
– G. Austin, MA

For thousands of folks like this satisfied customer, Neutronic Ear is an easy and affordable way to rejoin conversations and get the most out of life. 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.

Neutronic Ear has been designed with the finest micro-digital electronic components available to offer superb performance and years of use. Many years of engineering and development have created a product that's ready to use right out of the box. The patented case design and unique clear tube make it practical and easy to use. The entire unit weighs only 1/10th of an ounce, and it hides comfortably behind either ear. The tube is designed to deliver clear crisp sound while leaving the ear canal open. The electronic components are safe from moisture and wax buildup, and you won't feel like you have a circus peanut jammed in your ear. Thanks to a state-of-the-art manufacturing process and superior design, we can make Neutronic Ear affordable and pass the savings on to you.

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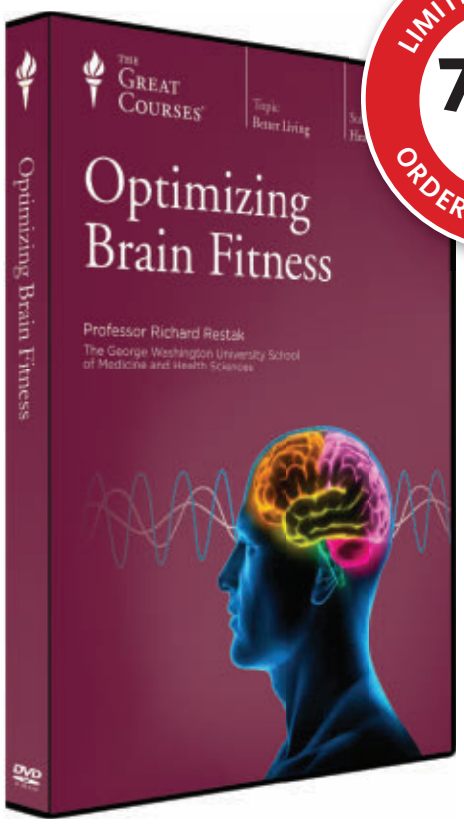

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