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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JANUARY 29, 2011

New Brain Cells, Better Memories

Recalculating Atomic Weights

How Sun's Corona Heats Up

A New Breed of ROBOT

Social machines learn as they go

Tourist "Borrows" World Famous Diamond

"This is a stunning necklace... I just keep coming back again and again.. I just love your jewelry. Everything you do you do with such class... thanks again."
— J. from Cleveland, OH

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Stauer exclusive **Better Than Free Offer** See details below.

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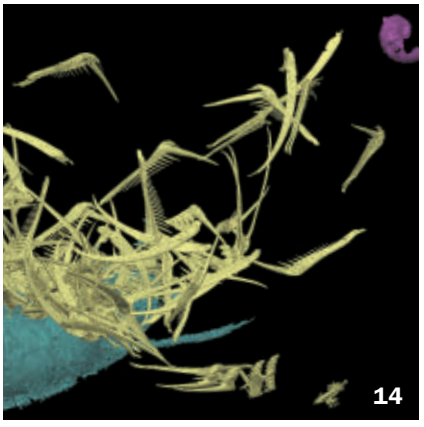

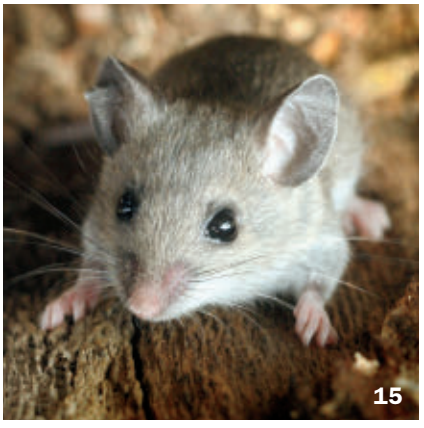

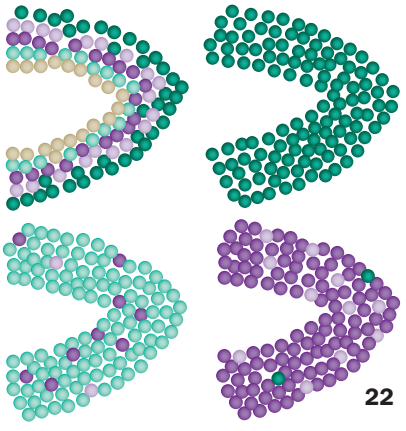

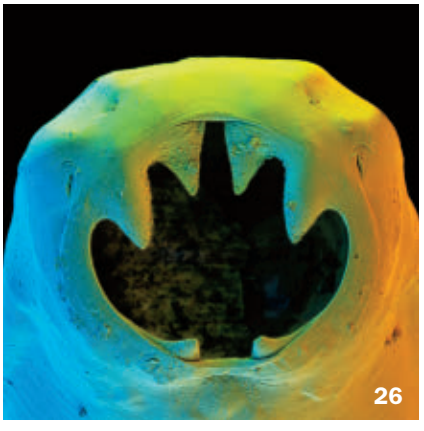

ScienceNews

In The News

Features

Departments

COVER Studies with children are helping roboticists build machines that can learn from social and environmental interactions. This iCub grasps and rolls balls in a lab playground. *Massimo Brega*

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FROM THE EDITOR

Measuring atoms' weights gave science grip on reality

In his famous *Lectures on Physics*, Richard Feynman composed a sentence designed to condense the most information about nature into the fewest possible words. "All things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another," Feynman wrote. It's a deep idea, he averred, containing "an enormous amount of information about the world" that could be extracted with the aid of a little imagination and thinking.

Curiously, the idea itself had been around for at least two and a half millennia before Feynman articulated it so clearly. But only in the last 200 years have scientists taken it seriously, and it gained universal acceptance only about a century ago. Until the early 1800s, atoms were mainly philosophical concepts that didn't have the heft to claim reality on the same basis as rocks. But a color-blind English schoolteacher named John Dalton changed the world's attitude toward atoms, showing how they really mattered for the scientific understanding of matter. He did that by weighing them.

Dalton's approach was crude and indirect, but he was the first to derive weights for the atoms of various elements, gauging them in relationship to the simplest atom, hydrogen. He calculated relative atomic weights by weighing the amounts of various chemicals that combined to make new chemicals, making assumptions about how many atoms of one element combined with an atom of another. Errant assumptions led to some large errors — Dalton miscalculated oxygen's atomic weight as 7 instead of 16, for example. But the idea was sound.

Nowadays, chemists are still making corrections to their atomic weight measurements, as Rachel Ehrenberg reports in this issue (Page 5). An element's atomic weight is an average weighted by the different abundances of its various isotopes. If the mix of isotopes is everywhere the same, an atomic weight is easy to calculate. But in recent decades chemists have realized that relative abundances can vary for samples of elements from different sources. Consequently some atomic weights ought to be reported as ranges, rather than the deceivingly exact numbers commonly printed on periodic tables.

These adjustments may seem trivial, but they reflect a valuable recognition of the importance of atomic weight in chemistry — and reveal some of the nuances hiding within Feynman's concise sentence. —*Tom Siegfried, Editor in Chief*

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Scientific Observations

"We've got a real problem with math education right now. Basically, no one's very happy. Those learning it think it's disconnected, uninteresting and hard. Those trying to employ them think they don't know enough.... I think the answer is staring us right in the face. Use computers. I believe that correctly using computers is the silver bullet for making math education work.... In the real world math isn't necessarily done by mathematicians. It's done by geologists, engineers, biologists, all sorts of different people—modeling and simulation. It's actually very popular. But in education it looks very different—dumbed-down problems, lots of calculating.... I estimated that, just today across the world, we spent about 106 average world lifetimes teaching people how to calculate by hand.... [And] they didn't even have fun doing it." **—STRATEGIC DIRECTOR CONRAD WOLFRAM OF WOLFRAM RESEARCH, IN HIS TEDGLOBAL 2010 TALK "TEACHING KIDS REAL MATH WITH COMPUTERS"**

Science Past | FROM THE ISSUE OF JANUARY 28, 1961

SEE ATOMIC WASTE USE IN SALT WATER CONVERSION — Radioactive waste products from atomic plants may soon be a source of energy for converting salt water to fresh water. This use could help solve the problem of disposing of highly radioactive material, and also help combat the growing water shortage in the United States.... The energy from the waste products could provide the heat source for a salt water distillation plant. One batch of radioactive material, in powder form, could give off heat for 15 years.... The powder is left as a residue when highly radioactive liquid waste material is heated at high temperature, driving off all the gases. The powder remaining is easier to transport and safer to handle than the bulky liquids.

Science Future

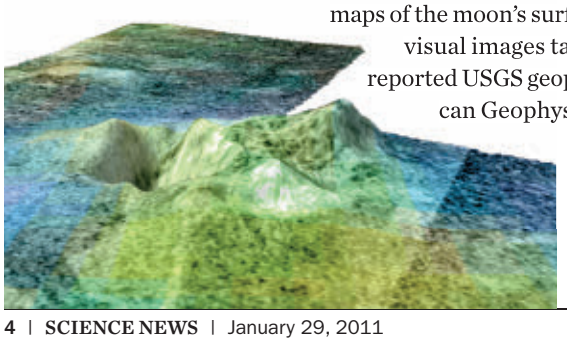
February 11–13
Explore geology at the 60th Annual Agate and Mineral Show at Portland, Oregon's science museum. See www.omsi.edu

February 13
Boston's Museum of Science officially reopens its planetarium with a show about exoplanets. Go to www.mos.org

February 14
Savor a "miracle fruit" berry that deceives taste buds, in a butterfly rain forest in Houston. See www.hmns.org

The (-est)

Scientists have discovered the best case yet for ice volcanoes on Saturn's moon Titan. The region, called Sotra Facula, includes a 1,000-meter-high peak and a 1,500-meter-deep pit, both shown in this false-color image (green highlights possible volcanic areas, blue marks sand dunes). Flows radiate outward from the pit. The features came to light in 3-D topographic maps of the moon's surface created from radar, infrared and visual images taken by NASA's Cassini spacecraft, reported USGS geophysicist Randolph Kirk at the American Geophysical Union's fall meeting. Erupted water, ammonia and methane could explain the features. It's not clear if tectonic activity could inject enough methane into Titan's atmosphere to explain current levels there.



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DELETED SCENES BLOG
Thousands of blackbirds fall from the sky on New Year's Eve. Read "Arkansas birds died of trauma."

BODY & BRAIN
People may use repetition in learning to distinguish sounds from noise. See "How to hear above the cocktail party din."

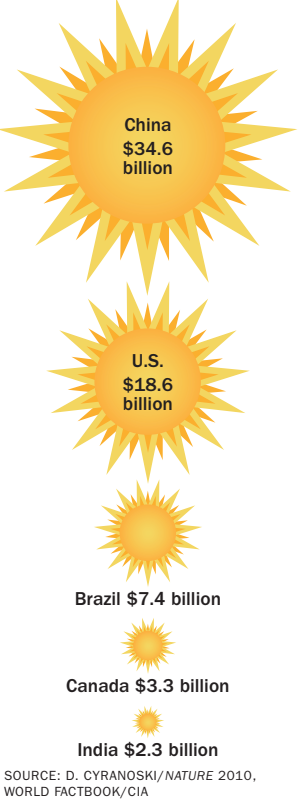
LIFE
New civic duty: recognizing a bedbug's mug. See "Google a bedbug today."

Science Stats

CLEAR THE SMOG

In 2009, China invested nearly double the amount of money the United States did in clean energy, even though China's GDP was about half as high.

Clean energy investment



SOURCE: D. CYRANOSKI/*NATURE* 2010, WORLD FACTBOOK/CIA

CLOCKWISE, FROM TOP LEFT: MEGAN BEARDER; E. FELICIANO; NASA, JPL-CALTECH, USGS, UNIV. OF ARIZONA

“It’s the first example, to our knowledge, of a parasite manipulating its host to avoid being eaten.” —ANDY FENTON, PAGE 14

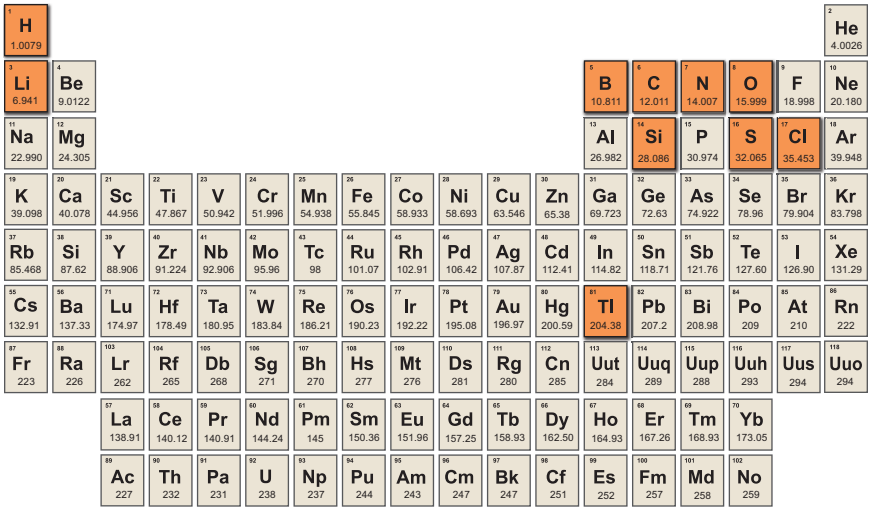
In the News

STORY ONE

Chemists want you to know that atomic weights aren’t constant

Revisions reflect variations in abundances of isotopes

By Rachel Ehrenberg



Currently, the periodic table typically displays only a single value for each element’s atomic weight. In the first of a series of proposed modifications, a committee recommends that atomic weights for 10 elements (orange) should appear as a range.

Just as the weight listed on your driver’s license doesn’t necessarily reflect your actual poundage, the official atomic weights of most chemical elements are actually more like ballpark estimates than precise constants. To better reflect reality, the weights of 10 chemical elements will no longer be expressed as single numbers, but as ranges.

The atomic weights of oxygen, hydrogen, lithium, boron, carbon, nitrogen, silicon, sulfur, chlorine and thallium will now be noted as intervals with upper and lower bounds, rather than as specific values. The adjustments, published online December 12 in *Pure and Applied Chemistry*, come as the first phase in an overhaul of the atomic weight of almost every element on the periodic table.

“It should have been done a decade ago,” says Tyler Coplen, head of the U.S. Geological Survey’s Reston Stable Isotope Laboratory in Virginia and coauthor of several of the reports that led to the current overhaul.

Many elements exist in more than one stable form — atoms of the variants have different numbers of neutrons in their nuclei. For example oxygen, the most abundant element in the Earth’s crust, typically comes with eight protons in its nucleus (which defines it as oxygen) and eight neutrons. But oxygen can gain an extra neutron or two, changing the element’s weight. (Electrons are so light that their weight isn’t taken into account.) The different versions of such elements are known as isotopes, from *iso*, Greek for same, and *topos*, meaning place, because they share the same square on the periodic table.

Until now, determining the atomic weight of an element with more than one stable isotope entailed averaging the relative amounts of the different versions, boosting the uncertainty around each number. While most elements do have a preferred, energetically stable form that dominates in nature, an ocean of data over the last 50 years or so has made it clear that the abundance of each isotope differs depending on when and where you look.

Elements undergo what’s called physical and chemical fractionation during processes such as going from liquid to solid. For example oxygen-18, or “heavy” oxygen, prefers cold things. So the ice cubes in your freezer will have considerably more oxygen-18 than the liquid water from which they formed, notes Coplen.

Similarly, the intense evaporation experienced by citrus trees leaves their cellular water rich in “heavy” hydrogen, or deuterium, yielding orange juice that may be enriched by as much as 4 percent relative to the environment.

This variation is what makes isotopes such a powerful scientific tool. For example, examining the relative ratios of different isotopes in ivory can tell scientists if a sample came from an elephant that ate shrubby savanna plants or woody jungle trees.

CHAROBNICA/SHUTTERSTOCK, ADAPTED BY E. FELICIANO

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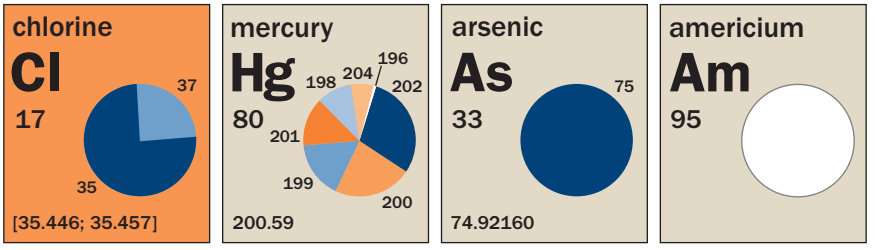
Probing isotopic abundances can also tell scientists about ancient climates, the early solar system and much more. Testosterone supplements are plant-derived and have a different isotopic carbon signature than testosterone made by the body (to Tour de France cyclist Floyd Landis' chagrin).

Isotopes even serve as valuable crime-fighting tools. In Austria in the 1990s, for example, a string of pipe bomb explosions that killed several people had authorities stumped — the bombs were built from ordinary, easy-to-find materials. But one bomb was mounted on a plaster of paris pedestal. Investigating the hydrogen isotopes in the plaster provided a link to one suspect, whose living room air was similarly enriched in heavy hydrogen, a team reported in January in the *Journal of Forensic Sciences*.

"Isotope studies extend from studies of previous climates to dating artifacts to weapons programs and biomedical applications," says James Adelstein, a professor at Harvard Medical School in Boston and coeditor of a National Research Council report on isotopes in medicine and the life sciences.



Chemists propose showing abundances of an element's isotopes on a pie chart, with atomic weight variations (when known, as for chlorine) in brackets. Elements with no variation keep the same weights; unstable elements have no standard atomic weight.

While the variation in isotopic abundances is incredibly useful, it made a mess of the official table of standard atomic weights. Numbers kept having to be tweaked and footnotes added. These adjustments implied that the atomic weight of a particular specimen couldn't be pinned down with precision, says Coplen, when in fact the new information was making the picture more precise than ever.

"I'm not sure how the general population will feel," says Coplen. "But the precision in measurements that's led to these changes have allowed governments to track down narcotics, explosives and nuclear material. They provide a real benefit to law enforcement and others who keep the world safe."

Now that it has completed the initial round, the International Union of Pure and Applied Chemistry's commission in charge of atomic weights will reassess the rest of the elements in the coming years. Helium, nickel, copper, zinc, selenium, strontium, argon and lead are currently under investigation. Some elements, such as gold, fluorine and arsenic, exist in only one stable version in nature, so their atomic weights will be left alone. ■

Back Story | CHEMISTRY BY COMMITTEE

Atomic weight refers to the averaged mass of the atoms of a chemical element using a scale based on a standard atomic nucleus. Currently the standard is the nucleus of a carbon atom containing six protons and six neutrons (carbon-12). An atomic weight of 1 corresponds to an average mass equal to one-twelfth the mass of the carbon-12 nucleus. Previous scales were based on hydrogen or oxygen:

1803
John Dalton (top), an English schoolteacher, compiles the first table of atomic weights for various elements, using units where the atomic weight of hydrogen was equal to 1.

1810
Swedish chemist Jöns Jacob Berzelius (center) begins work on developing an atomic weight scale based on oxygen equal to 100. But most chemists continue to use the scale based on hydrogen equal to 1.

1860
At a conference held in Karlsruhe, Germany, chemists discuss the need for an improved and consistent atomic weight scale.

1869
Listing the elements in order of atomic weight, Russian chemist Dmitri Mendeleyev (bottom) creates a table in which elements with similar properties fall in the same row (columns in later versions of the table). Mendeleyev's chart becomes known as the periodic table of the elements. A similar table was created at about the same time by the German chemist Lothar Meyer.

1898
A German committee of chemists recommends basing atomic weights on a scale fixing oxygen equal to 16.

1906
The International Committee on Atomic Weights adopts the oxygen equals 16 scale.

1929
Discovery of heavy forms of oxygen (O-17 and O-18) creates a discrepancy between chemists' atomic weight for oxygen and physicists' atomic mass for the oxygen-16 isotope.

1961
Following approval by the International Union of Pure and Applied Physics and the International Union of Pure and Applied Chemistry, atomic weights are based on the carbon-12 nucleus equals 12 scale.

TOP: T. COPLEN *ET AL./CHEMISTRY INTERNATIONAL* 2011; BACK STORY FROM TOP: SCEWING/WIKIMEDIA COMMONS; KUEBI/WIKIMEDIA COMMONS; MAV/WIKIMEDIA COMMONS

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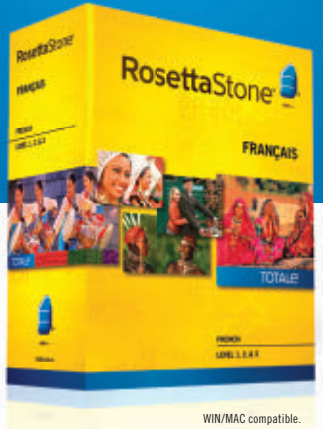

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Body & Brain

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Uncontrolled epilepsy can be fatal

Study finds more deaths in adults whose seizures persist

By Nathan Seppa

Epilepsy that strikes in childhood and lingers into adulthood triples a person's risk of dying, a recent study found. But those who "outgrow" epilepsy and see their seizures fade as adults don't have this added mortality risk, researchers report in the Dec. 23 *New England Journal of Medicine*.

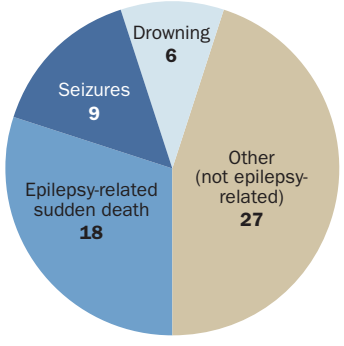
The findings, from a 40-year study in Finland, provide a long-term look that doctors can use as they puzzle over whether to recommend surgery for patients or continue with medication, says neurologist David Ficker of the University of Cincinnati, who wasn't involved in the study. "We probably should be treating epilepsy aggressively in people who aren't seizure-free," he says.

Doctors tracked 245 children diagnosed with epilepsy in the early 1960s. All patients got checkups every five years until 2002. By then, 60 had died, a rate three times the average for people in Finland of comparable age. Of those 60 deaths, 51 occurred in the 107 patients who were still having seizures. Only five occurred in the 35 who had been in remission for five years or more with the help of medication, and four deaths occurred in the 103 people whose seizures had been in remission for that long without medication. Overall, 33 deaths were tied to epilepsy. The others were mainly due to pneumonia and heart disease.

The danger of persistent seizures

A 40-year study of 245 epilepsy patients in Finland recorded 60 deaths, 33 of them from causes that could be traced to the disease.

Cause of death in epilepsy patients



SOURCE: M. SILLANPÄÄ AND S. SHINNAR/*NEJM* 2010

"The cumulative risk is quite high among the seizure-related groups," says neurologist Shlomo Shinnar of the Albert Einstein College of Medicine and the Montefiore Medical Center in New York City, who teamed with physician Matti Sillanpää of the University of Turku in Finland on the study. It's less clear whether people taking medication to suppress seizures are still at an increased risk of death. "Quite possibly, in fact, they are," Shinnar says.

Surgery for epilepsy has been shown to outperform medication and help some patients dramatically (*SN: 8/4/01, p. 69*), and recent refinements have made surgery an option for more people (*SN: 9/8/07, p. 158*). But even with these advances many doctors believe surgery remains underused (*SN: 7/9/05, p. 30*).

This is your brain going shopping

Research locates neurons involved in valuing objects

By Laura Sanders

Individual human brain cells can be savvy shoppers, tuning their behavior to precisely reflect the worth of a candy bar, finds a study published in the Jan. 5 *Journal of Neuroscience*. Understanding how these bean-counting neurons operate may help scientists get a better idea of how the brain assigns value to objects.

Evaluating objects is "something we all do on a moment-to-moment basis," says study coauthor Rick Jenison of the University of Wisconsin–Madison. But just how the brain tallies value isn't clear.

To eavesdrop on the discerning human brain, Jenison and his team took advantage of a rare opportunity: volunteers who were undergoing a procedure that uses electrodes to pinpoint the origin of severe seizures. As a by-product, these electrodes could also listen to the activity rates of single neurons in the amygdala — a pair of almond-shaped structures located on each side of the brain — as the volunteers assessed the value of junk food.

After the electrodes were in place, three participants viewed pictures of 50 different kinds of junk food, ranging from chocolate-chip cookies to M&M's to salty chips. The participants viewed each image for one second, and then came up with a subjective value rating of the snack by bidding between zero and $3 for the item.

Of the 51 neurons that the researchers tracked in three volunteers, 16 performed in lockstep with the reported value of the food item, changing their activity in a predictable way as the value increased. As a volunteer's bids went up, some of these neurons' activity went up too. Others showed an inverse relationship, with their activity declining as the value increased.

Neuroscientist Daeyeol Lee of Yale University says that along with other studies, the new work "expands the role of the amygdala," a region that is traditionally associated with fear. Lee cautions that due to the necessity of working with human volunteers who had electrodes implanted in their heads, the sample size is inherently small, precluding many repetitions of the experiment. "The opportunity is limited, but it's a really, really exciting opportunity."

E. FELICIANO

29.5 per million | Hospitalizations for chicken pox in U.S. population in 1994, a year before vaccination began

2.5 per million | Hospitalizations for chicken pox in U.S. population in 2002

Possible relief for an irritable bowel

Local-acting antibiotic beats placebo in two clinical trials

By Nathan Seppa

An antibiotic typically used to combat traveler's diarrhea might benefit some people with irritable bowel syndrome, a vexing condition that has few good treatment options, a pair of studies has found.

There is no antibiotic approved for use against IBS, gastroenterologist Jan Tack of the University of Leuven in Belgium notes. Part of the reason stems from the mystery of IBS itself. Patients clearly have a problem with food movement in the gut — either too rapid (diarrhea) or too slow (constipation) — and experience pain and cramping.

The GI tract of some people might just sense poorly when to advance food, says William Chey, a gastroenterologist at the University of Michigan Health System in Ann Arbor and a coauthor of the new report. But an overgrowth of bacteria in the intestines apparently contributes to the problem as well, he says. That suggests an antibiotic could help.

In two clinical trials, Chey and his colleagues pitted the drug rifaximin against a placebo in 1,260 patients who had IBS marked by pain and diarrhea but not constipation. All participants received three pills a day for two weeks without knowing whether they were getting the drug. Over the next four weeks, 41 percent of those getting rifaximin had clear improvement of symptoms in at least two of those four weeks, compared with 32 percent of those getting a placebo, the researchers report in the Jan. 6 *New England Journal of Medicine*.

Although the benefits didn't extend to all patients — or even a majority — the report is good news for people with IBS, Chey says. Approved IBS treatments mainly speed up or slow down motility, the movement of food through the gut, he says, whereas this drug takes on bacterial overgrowth. "This is just the initial salvo in this whole area," he says, and should clear the way for further trials testing antibiotics against IBS.

The benefits of rifaximin lingered for 10 weeks after the two-week treatment. Although the percentage of people reporting improved IBS symptoms dropped off gradually, the average scores of people taking the drug remained better than those on the placebo.

Rifaximin is poorly absorbed through the intestines, a drawback against some diseases. For example, it wouldn't work against pneumonia, says Herbert DuPont, an infectious disease physician at the Baylor College of Medicine in Houston. But remaining localized to the bowel, particularly the small intestine, makes rifaximin valuable against traveler's diarrhea and now potentially against IBS, he says.

The U.S. Food and Drug Administration is considering licensing rifaximin for IBS. The drug is sold as Xifaxan by its manufacturer, Salix Pharmaceuticals, which funded the new research.

Better coverage with second shot

Giving chicken pox vaccine twice increases protection

By Nathan Seppa

Two are better than one when it comes to chicken pox shots, scientists have found.

The chicken pox shot, first made available in the United States in 1995, has already proved able to prevent the disease in about 80 to 85 percent of children who get a single dose. In 2006, the Centers for Disease Control and Prevention and the American Academy of Pediatrics jointly recommended a two-shot approach, suggesting that children get the shot just after 12 months and again at age 4 to 6. A new study in the Feb. 1 *Journal of Infectious Diseases* supports this revision: Adding another shot ups disease prevention to nearly 100 percent.

> "The effectiveness of the two-dose schedule is welcome news indeed."
> DAVID KIMBERLIN

Pediatrician Eugene Shapiro of Yale School of Medicine and his colleagues identified 71 children who had contracted chicken pox between 2006 and 2010, verifying the diagnoses with tests showing viral DNA in skin lesions on the kids. The children had attended 28 clinics in Connecticut. The researchers found that five of these 71 children hadn't been vaccinated, and that 66 others had received a single shot. But none had been vaccinated twice.

As a comparison group, the researchers identified 140 other children who matched the first group in age and had gone to the same clinics. None had come down with chicken pox. Of this group, 117 had gotten one shot, 22 had received two and one child hadn't been vaccinated. The authors calculate that the two-shot regimen was 98.3 percent effective in preventing chicken pox.

The new study "is the first to evaluate the effectiveness of two doses of [chicken pox] vaccine in a 'real-world' setting," says physician David Kimberlin of the University of Alabama at Birmingham. "The effectiveness of the two-dose schedule is welcome news indeed," he writes in the same issue in which the study appeared.

Shapiro notes the recommended separation in the two doses is based on convenience, allowing doctors to give the second shot with other scheduled vaccinations. The second chicken pox vaccine shot can be given as soon as three months after the first dose, he says.

Humans

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Ancient farmers spread swiftly

Agricultural villages sprouted in Croatia 8,000 years ago

By Bruce Bower

Croatia does not have a reputation as a hotbed of ancient agriculture. But new excavations, described January 7 in San Antonio at the annual meeting of the Archaeological Institute of America, unveil a Mediterranean Sea–hugging strip of southern Croatia as a hub for early farmers who spread their sedentary lifestyle from the Middle East into Europe.

Farming villages sprouted swiftly in this coastal region, called Dalmatia, nearly 8,000 years ago, apparently with the arrival of Middle Easterners already adept at growing crops and herding animals, says archaeologist Andrew Moore of Rochester Institute of Technology in New York.

Moore codirects a research team, with archaeologist Marko Menđušić of Croatia's Ministry of Culture in Šibenik, that has uncovered evidence of intensive farming at Pokrovnik and Danilo Bitinj, two Neolithic settlements in Dalmatia. Plant cultivation and animal husbandry started almost 8,000 years ago at Pokrovnik and lasted for close to a millennium, according to radiocarbon dating of charred seeds and bones from layers in the settlement. Comparable practices at Danilo Bitinj lasted from about 7,300 to 6,800 years ago.

"Farming came to Dalmatia abruptly, spread rapidly and took hold immediately," Moore says.

Other evidence supports a fast spread of sophisticated farming from the Middle East into Europe (*SN: 2/5/05, p. 88*), remarks Harvard University archaeologist Ofer Bar-Yosef. Farming villages in western Greece date to about 9,000 years ago, and Middle Eastern farmers exploited a wide array of domesticated plants and animals by 10,500 years ago.

The discoveries support the idea that agricultural newcomers to southern Europe built villages without encountering local nomadic groups, Moore asserts. Earlier excavations at Neolithic sites in Germany and France raise the possibility that hunter-gatherers clashed with incoming villagers in northern Europe.

Surprisingly, Pokrovnik and Danilo Bitinj residents grew the same plants and raised the same animals, in the same proportions, as today's Dalmatian farmers do. "This is an astonishing demonstration of agricultural continuity from the Neolithic to present times," Moore says.

Women's tears douse men's desire

Diminished sexual allure hints at influence of pheromones

By Bruce Bower

Crying women may literally turn men off. Odorless chemical signals in a woman's waterworks lessen any stirrings of sexual interest in a guy who whiffs her tear-stained cheeks, a new study suggests.

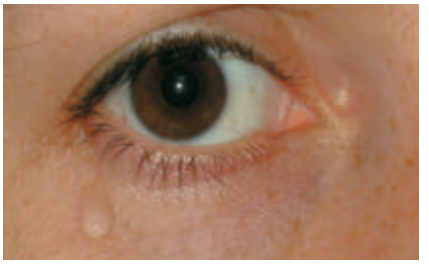
Reporting online January 6 in *Science*, Shani Gelstein and Noam Sobel of the Weizmann Institute of Science in Israel and colleagues present the first evidence that human tears contain pheromones, molecules that influence behavior via the olfactory system. "Our experiments suggest that women's emotional tears contain a chemosignal that reduces sexual arousal in men," Sobel says.

Compounds in tears that douse men's desire have yet to be identified.

"This new report makes a strong case for pheromones in women's tears, but the results clearly warrant replication," says neuroscientist Robert Provine of the University of Maryland Baltimore County.

Why people, but not other animals, cry at sad thoughts is poorly understood. Tears provide key visual cues to a person's inner emotional distress. In a 2009 study that Provine directed, men and women rated the faces of crying people with visible tears as much sadder than the same faces digitally altered to remove tears.

In the new study, Gelstein and Sobel's group asked 24 men, ages 23 to 30, to sniff a jar containing either tears collected from women as they watched sad film clips or drops of salt solution that had been trickled down the same women's faces. A pad containing tears or a salt solution was then attached to each man's upper lip as he rated the sadness and sexual attractiveness of images of women's faces.



A woman's tear, shed while watching a sad film clip, may contain pheromones.

COURTESY OF *SCIENCE*/AAAS

For 17 of the 24 participants, female faces generally looked less sexually alluring just after whiffing tears than after sniffing a salt solution. Neither substance had a perceptible odor.

Another 50 men who sniffed women's tears displayed physiological signs of reduced sexual arousal, such as a slow breathing rate and low salivary levels of the male sex hormone testosterone, relative to levels after sniffing a salt solution.

Finally, 16 men who sniffed women's tears while watching a sad movie in a brain-scan machine displayed markedly lower blood-flow rates — a sign of reduced brain-cell activity — in areas that had previously reacted strongly to an erotic, R-rated movie. No sex-related brain drain appeared when the men sniffed a salt solution while watching a sad movie.

Environment

BP spill's methane goes missing

Researchers claim bacteria gobbled it all up—and fast

By Janet Raloff

Methane gas, the predominant hydrocarbon produced by the BP blowout last year, has all but vanished from Gulf of Mexico waters, a new study reports—presumably eaten by marine bacteria. That hadn't been expected to happen for years.

Two-thirds of the hydrocarbons released by the BP accident were forms of natural gas: largely methane, ethane and propane. While Gulf microbes quickly began devouring the larger gas molecules, they initially left tiny methane—an estimated 87.5 percent of the gas emitted during the active flow—largely untouched.

> "Just because you can't find methane ... doesn't mean there's no methane out there."
>
> SAMANTHA JOYE

A study done last June, and reported in the Oct. 8 *Science*, found almost no microbial breakdown of BP methane at that time. Estimated rates of biodegradation in subsea plumes, where this gas had been accumulating, "indicated methane would persist for many, many years, if not almost a decade," says John Kessler, a chemical oceanographer at Texas A&M University in College Station and coauthor of that report.

Kessler and colleagues returned to the Gulf for three research cruises between August 18 and October 4. Their sampling at more than 200 sites turned up no BP methane. In fact, concentrations of the gas in seawater throughout the spill zone were lower than typical background levels for the Gulf, Kessler's team reports online January 6 in *Science*.

"We were caught off guard," he says. "But that highlights the beauty of the scientific process. You put together hypotheses based on the information at hand and test them. And whether we're right or wrong, at the end of the day we'll have learned something new."

Not so fast, counters another BP-plume investigator, marine ecologist Samantha Joye of the University of Georgia in Athens. "Just because you can't find methane in the spot where you lowered your [instruments] doesn't mean there's no methane out there somewhere," she says.

Her team and others tracked plumes migrating from the wellhead early in the spill. These deep, diffuse clouds of oil and gas proved very localized and mobile, she says. From late June until early August, however, no one tracked their whereabouts, Joye observes. So her "more parsimonious explanation" for why Kessler's group found no BP methane: "They lost track of the freaking plume."

David Valentine of the University of California, Santa Barbara, a coauthor of the new report, disagrees. "The ocean doesn't flow like a river," he says. "The water at the wellhead still contains some of the water that's been there over the last couple months." His team saw evidence of microbial activity in this water and throughout the water moving southwest for "a couple hundred miles."

He points to a huge drawdown in oxygen as a sign that the methane-munching bugs—called methanotrophs—had consumed the gas. "We saw a loss of about a million tons of dissolved oxygen," he says, which would explain the disappearance of almost all of the natural gas. His group saw almost no methanotrophs in plume zones last June, but plenty of these and other oil-degrading species in subsequent voyages. The reported change in the types of microbes in plume residues "is dramatic and very convincing," says Ian MacDonald of Florida State University in Tallahassee. But, he adds, the paper contains too little data to convince him that microbes really ate up all the methane.

Atom & Cosmos

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Solar conundrum may be cracked

Observations could reveal why sun's corona is so hot

By Ron Cowen

Fountainlike jets of hot gas that shoot into the sun's outer atmosphere, the corona, may explain why it is millions of degrees hotter than the solar surface — a puzzle that researchers have struggled to explain since they first took the corona's temperature seven decades ago.

The newly discovered jets originate in the chromosphere, the region just above the sun's visible surface. Too narrow and short-lived to have been seen with older instruments, the jets were imaged in visible light by a high-resolution telescope aboard the Hinode spacecraft, launched in 2006. Ultraviolet observations, from NASA's recently launched Solar Dynamics Observatory, revealed that just seconds after the appearance of the jets in the chromosphere, the corona briefly brightened at temperatures ranging from 100,000 to as high as 2 million kelvins.

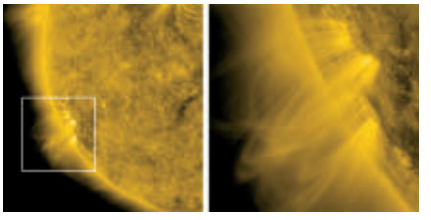
Although only a small fraction of the jets may carry hot gas, calculations show that the features can transport enough high-temperature material to keep the corona heated to several million kelvins, says Bart De Pontieu of the Lockheed Martin Solar and Astrophysics Laboratory in Palo Alto, Calif. He and his colleagues describe their findings in the Jan. 7 *Science*.

"This is an important and startling breakthrough in understanding how the solar corona may be heated, and I am certainly convinced by it," comments solar researcher Eric Priest of the University of St. Andrews in Scotland.

Researchers had assumed that the corona acquires its heat locally — for instance, from the energy unleashed when tangled magnetic fields high above the sun snap like rubber bands and reconnect. But the new observations suggest instead that high-speed jets of gas originating in the chromosphere are heated to high temperatures before they arrive at the corona, providing a substantial source of hot gas to the sun's outer atmosphere, Priest notes.

"This is a great step forward," says theorist Spiro Antiochos of NASA's Goddard Space Flight Center in Greenbelt, Md., but "we still need a strong theoretical understanding of the processes that are going on."

A detailed understanding of how the corona is heated should provide a more accurate assessment of how much X-ray and ultraviolet light the sun radiates, which has a profound impact on the extent and density of Earth's upper atmosphere, Antiochos says. It's also likely that any mechanism that can explain the sun's hot corona could account for the high-temperature coronas of other stars, he adds.



A NASA spacecraft observed solar activity (left, close-up at right) indicating that the sun's corona is heated by jets of gas originating in the chromosphere.

SOLAR DYNAMICS OBSERVATORY/NASA

One possibility that could now be tested, says Priest, is that tens of thousands of small bundles of magnetic fields known to carpet the sun's surface (*SN: 11/8/97, p. 295*) may power the jets. The energy released when these bundles move around the sun and become stretched or tangled might provide enough oomph.

An odd place for life's ingredients

Asteroid may have made amino acids with water-free recipe

By Ron Cowen

Planetary scientists have found amino acids, the building blocks of proteins, in an unexpected place: a chunk of rock from an asteroid that formed at temperatures so high that such fragile organic compounds should have been destroyed. One explanation for the surprising discovery is that some amino acids might form through a mechanism that does not require water, says Daniel Glavin of NASA's Goddard Space Flight Center in Greenbelt, Md.

Analysis of a bit of asteroid 2008 TC_3, which fell to Earth over Sudan in 2008, suggests that the asteroid was once heated to temperatures exceeding 1,100° Celsius and was later subjected to a series of violent collisions with other asteroids, fusing different space rocks. Such an asteroid would be devoid of water, and the daughter chunk analyzed by Glavin's team would not be expected to form amino acids by any known mechanisms.

But the team did find amino acids in the rock that are either rare or nonexistent on Earth. More important, the two forms of the compounds — a left-handed structure and its mirror image — were equally common. Amino acids in life on Earth are predominantly left-handed.

"The pattern of amino acid abundances ... are hard to explain via terrestrial contamination," comments Conel Alexander of the Carnegie Institution for Science in Washington, D.C.

The extraterrestrial origin of these amino acids also can't be explained by a familiar process in which organic compounds react with ammonia, hydrogen cyanide and water to produce the protein building blocks.

The researchers describe their discovery online December 13 in *Meteoritics & Planetary Science*.

Earth

"What we're looking at is the aftermath of the crime scene." —BENJAMIN GILL

Ancient sea life faced toxic brew

Lots of sulfur, little oxygen stalled burst of biodiversity

By Alexandra Witze

Soon after complex animals made their first great strides onto the stage of life, the oceans brewed up a toxic chemical mix that put the brakes on evolutionary innovation, suggests a paper in the Jan. 6 *Nature*.

The culprits: Too little oxygen and too much sulfur in coastal waters, reports a team led by geochemist Benjamin Gill of Harvard University. Ancient creatures such as trilobites and brachiopods could not cope with the changes, and many went extinct.

The "remarkable" new data are the first to link a changing ocean environment to some of the extinctions that took place between about 490 million and 520 million years ago, says Graham Shields-Zhou, a geologist at University College London who was not on the research team.

Perhaps not surprisingly, marine creatures are exquisitely sensitive to oxygen levels. Other big extinctions, such as one occurring around 400 million years ago and another around 250 million years ago, have been blamed on low levels of oceanic oxygen. But the more ancient extinctions that Gill studied are of particular interest because they came soon after the "Cambrian explosion," during which animals blossomed in biodiversity.

Gill's team decided to look at a subset of extinctions that began 499 million years ago and lasted for 2 million to 4 million years. Other researchers had proposed that low oxygen levels could be involved, but no one had marshaled enough evidence to prove it. Gill and his colleagues are the first to look at sulfur, which at high levels can kill marine creatures.

The researchers traveled the globe to collect rock samples from Nevada, Utah, Missouri, Australia and Sweden and analyzed isotopes — different forms of an element that vary in atomic mass — of sulfur and carbon.

The amount of carbon in the rocks, as compared with the amount of sulfur, could have come about only if the water were low in oxygen and high in the sulfide form of sulfur, the team reports. Today, Gill says, a similar environment can be found in the oxygen-starved Black Sea.

Although the researchers think the Cambrian oceans were toxic, they don't know why. "What we're looking at is the aftermath of the crime scene," Gill says. "We don't have the cause for why the oceans suddenly went anoxic."

Life

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Robins reject blushing caterpillars

Parasitic worms redden their hosts to avoid being devoured

By Susan Milius

Some worms may be saving their own little hides when they induce the caterpillars they infest to blush a furious glowing red.

When the parasitic nematode *Heterorhabditis bacteriophora* infects caterpillars of the greater wax moth, the normally pale caterpillars turn persistently pink-red and temporarily luminescent.

Infected caterpillars take on a red shade and dim glow that repels predators.

In outdoor taste tests with 16 European robins, birds overall preferred uninfected wax moth caterpillars to ones that had been infected for at least three days. By day seven of infection, odd-colored caterpillars rarely even got tentatively picked up by the birds, Andy Fenton of the University of Liverpool in England and his colleagues report in an upcoming issue of *Animal Behaviour*.

"I think the cool thing is that it's the first example, to our knowledge, of a parasite manipulating its host to avoid being eaten," Fenton says.

It's to the parasite's advantage not to be eaten, Fenton explains, because these nematodes don't infect vertebrates. So if a bird happens to eat a parasitized caterpillar, it's bye-bye wormy.

"This is an old idea but a fun one," comments Richard ffrench-Constant of the University of Exeter in England, who has studied the glowing effect but wasn't involved in the new research.

Biologists have already uncovered weird examples of the opposite approach, in which some parasites change the appearance or behavior of hosts in ways that attract predators. Ants infected with the parasitic *Dicrocoelium dendriticum* worm, for example, crawl up grass blades until some grazing cow or sheep inadvertently scoops them up with a mouthful of forage. This worm does infect grazers and thus sacrifices its current host to the next one.

Young nematodes of the species in the new study search through soil for larvae of a range of flies, beetles, butterflies and moths. Slipping into victims through the mouth, breathing hole or anus, the nematodes release live-in luminescent bacteria that reduce the host's innards to a nutritious broth for both the nematodes and their microbial passengers.

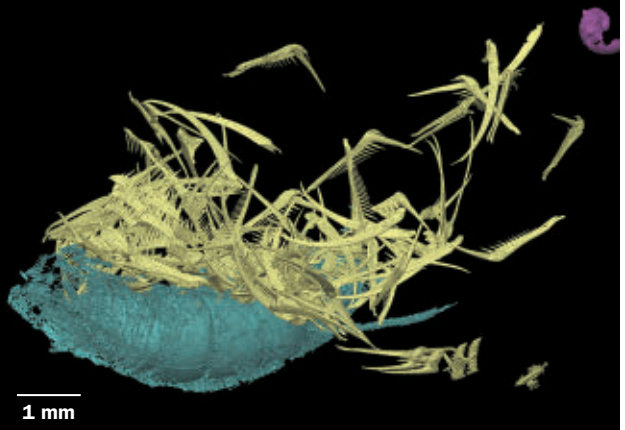
Whether the parasites benefit in some way from their hosts' reddening and weak, transient glow — which is undetectable to the human eye in daylight but easily visible in a darkened room — has inspired considerable speculation, Fenton says. Researchers have mused about whether the color change may be just a side effect of reducing the buildup of highly reactive forms of oxygen. As far as he knows, Fenton says, his is the first test of the warning-color idea with real birds, caterpillars and parasites. ■

An ammonite's last supper

The final meal of an ammonite, one of those extinct marine creatures that feature so prominently at fossil shows, has been revealed by three-dimensional X-ray analysis of a specimen from South Dakota. The pointy yellow things (right) are individual ammonite teeth, stripped off a structure called a radula that acts like a tongue to get prey into the animal's mouth. The teal-colored blob stuck in the ammonite's teeth is the remains of a small shrimplike crustacean, while the purple object at upper right is a fragment of a larval gastropod.

Finding these dinner fragments within the ammonite's mouth strongly suggests that it ate small prey floating in the water, a team led by Isabelle Kruta reports in the Jan. 7 *Science*. Kruta, of France's national natural history museum, and her colleagues made images of ammonite fossils at the powerful European Synchrotron Radiation Facility in Grenoble, France.

This particular specimen, of the genus *Baculites*, dates to between 70 million and 83 million years ago. Ammonites thrived for about 340 million years before dying out 65 million years ago in the same extinction that did in the dinosaurs. Kruta and her team speculate that diet may have played a role: When many groups of plankton and associated small animals died out, the ammonites no longer had enough to eat. In contrast, a related cephalopod known as the nautilus survived the extinction, perhaps because it can eat larger prey and a wider variety of food. —*Alexandra Witze*



FROM TOP: SARAH CLARK; I. KRUTA/MNHN

"I thought it would sound silly if I called my talk 'Spider Sex Play,' but that's essentially what it is." —JONATHAN PRUITT

As aspens die, deer mice go viral

Decline of trees in U.S. West swells rodents' infection rate

By Susan Milius

Recent diebacks of aspen trees in the U.S. West may end up increasing the risk posed by a lethal human pathogen.

A tree-killing syndrome called sudden aspen decline has wiped out swaths of trees across the West in the past decade. It has also changed the kinds, numbers and interactions of creatures living around the trees, scientists have found — including some carriers of human disease. Deer mice at hard-hit sites in 2009 were almost three times as likely to carry the *sin nombre* virus — which can be fatal to humans — compared with mice in less-ravaged aspen stands, Erin Lehmer of Fort Lewis College in Durango, Colo., and her colleagues reported January 4.

The deer mouse looks cute in pictures,

Deer mice carrying a deadly virus are becoming more common in the West following a mysterious aspen die-off.

but the Centers for Disease Control and Prevention ranks the species, *Peromyscus maniculatus,* as the main U.S. rodent reservoir for *sin nombre* virus. Infected deer mice don't show many symptoms, but people inhaling the virus from mouse urine or saliva can get sick with hantavirus pulmonary syndrome. In 2010, the CDC logged 560 cases in 32 states. The virus has killed more than a third of victims.

"Both plant diseases and animal diseases are rapidly emerging globally, and we should be looking for ways that the two might interact," said Richard Ostfeld of the Cary Institute of Ecosystem Studies in Millbrook, N.Y.

What causes sudden aspen decline seems to be complex, Lehmer noted. Severe drought from the late 1990s into the 2000s stressed aspens and may have allowed cankers, fungi and other maladies to deliver death blows to the trees.

Among aspen stands in the San Juan Mountains of Colorado, Lehmer and colleagues found more small mammal species in places that still had most of their aspens compared with devastated plots. In healthier stands, the most abundant small mammal was the montane vole, which isn't a good host for the virus. In sites that had lost at least two-thirds of their aspens, however, the most abundant small mammal was the deer mouse, which is less picky about living in ravaged tree stands than the vole is.

Lehmer speculated that infection might have risen among deer mice as their growing dominance in the landscape let them encounter each other more frequently.

For spiders, sex play has its pluses

Mock-mating seems to yield later benefits for young arachnids

By Susan Milius

When pairs of young comb-footed spiders engage in an arachnid version of heavy petting, the males gain experience that appears to pay off later.

A male spider that repeatedly courts and mock-mates with a not-quite-mature female ends up reaping benefits later, Jonathan Pruitt of the University of California, Davis said January 4. Pruitt proposed that such seemingly pointless spider encounters, which can't produce offspring, may function much like other young animals' racing and wrestling by providing practice for life's future tasks.

"I thought it would sound silly if I called my talk 'Spider Sex Play,'" Pruitt said, "but that's essentially what it is." He ranked it as the first example of any kind of play behavior demonstrated in spiders.

Among *Anelosimus studiosus* spiders, which live and spin webs by rivers and under bridges from Maine to Patagonia, females don't develop an opening to their reproductive tract until their final molt. Males mature faster and hang around not-quite-mature females, often practicing most of the mating routine.

During almost-sex, the male doesn't load his sex organs with sperm but performs a courtship display by drumming the female's web with his legs and sex organs. If she assumes a cooperative posture, he approximates a mating position too. He then taps her body where the reproductive tract will eventually open.

Sexual behavior even at this stage brings some risks, such as a chance that the male spider will be killed by the potentially cannibalistic female. So sex that can't produce offspring is puzzling. To test the idea that such encounters might be more than wishful mistakes, Pruitt and Susan Riechert of the University of Tennessee, Knoxville set up some young spider pairs for near-matings, but kept other maturing individuals isolated.

After the spiders developed, the scientists observed real matings. If either spider partner had participated at least once in mock sex, a pair tended to reach the point of real mating faster than inexperienced spiders did. Speed should benefit the male by reducing the opportunity for an intruder to displace him. Timing matters because the first male will father most of the eggs in an egg case.

DAVID CAPPAERT/MICHIGAN STATE UNIV., BUGWOOD.ORG

Molecules

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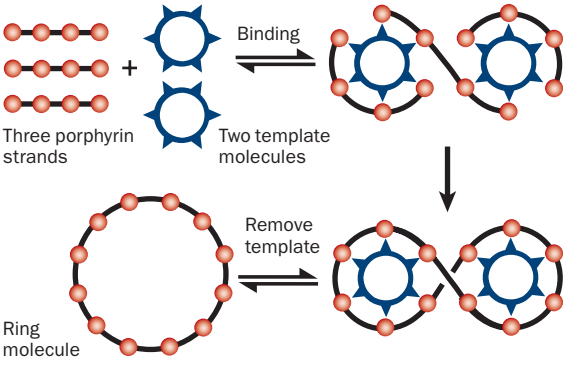
Big molecules, from bottom up

Chemists use templates to build precise ring structures

By Rachel Ehrenberg

Just tossing mortar and bricks together won't yield a tidy structure, but chemists must often resort to similar measures when building molecules the size of proteins, the workhorses of cells. Now researchers have developed a cleaner strategy for constructing such compounds. By employing one kind of molecule as a template, scientists can string together small biologically important molecules into larger, ringed structures with unprecedented precision and no mess, a team reports in the Jan. 6 *Nature*.

The new technique hits a previously inaccessible sweet spot, yielding hefty molecules that approach the size of the macromolecules that are the movers and shakers of the cellular world. The method could be useful for building big molecular structures, including more templates to build even larger compounds. And because the rings in the new study were built from strands of compounds of the same class as the pigment chlorophyll, the large loops may exhibit unusual properties and could help researchers better understand how photosynthesis pigments harvest light.



Small template molecules guide production of supersized ringed structures from porphyrin strands.

"We'd like to think the use would be very general. There's no reason it shouldn't be," says chemist Harry Anderson of the University of Oxford in England. "People often want to make objects that are a particular size and shape."

While nature is fond of using templates to build structures — a single strand of DNA, for example, is the template for the other strand — tools that enable such precision have eluded chemists.

"It's difficult to create well-defined architectures. We can't achieve the same specificity and efficiency that nature routinely does," says Jonathan Lindsey of North Carolina State University in Raleigh, who wasn't on the research team.

Anderson and colleagues began with a solution containing their template — star-like rings that had six sites available for binding. The researchers then added their bricks: strands of four linked porphyrins, round molecules of the same class as the pigments that make blood red and grass green. The ropy strands of porphyrins wound around the templates like a bike chain looping around a gear. Because of the intentional mismatch in the number of binding sites on the template (six) and the porphyrin strands (four), leftover links looped around a second template, creating a figure eight. Removing the templates yielded perfect 12-porphyrin rings, one of the largest organic molecular rings ever synthesized.

Typically, building such a hefty compound from scratch requires "step after step after step," notes Lindsey. Yet such compounds are too small to be made with top-down methods such as lithography, where bulk material is pared down.

"There's a realm that's been really hard to penetrate — this intermediate dimension that's been hard to get at with chemistry and ... lithography," Lindsey says. "That's what makes it cool." ■

A new twist to rules of chemistry

Quantum insight explains quirk in aromatic Möbius molecules

By Marissa Cevallos

Rings of carbon with an iconic twist in their structures break the rules for building strongly stable molecules, and now a mathematical proof explains why.

Strongly stable molecules are useful in plastics. Some such molecules that hold together especially well are called aromatic (though not all have odors).

Ring-shaped molecules like benzene, used in making many plastics, are aromatic when a particular orbital shell is filled by six, 10 or 14 electrons and so forth (two plus a multiple of four). In 1964, chemist Edgar Heilbronner suggested that putting a single twist in the ring — creating a "Möbius molecule" — would change the rules: Möbius molecules would be aromatic with any multiple of four electrons.

Now, chemist Evangelos Miliordos at Michigan State University in East Lansing has proven Heilbronner's conjecture by simulating the quantum mechanics of electrons trapped on a Möbius ring.

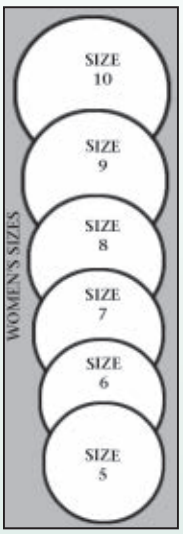
Miliordos' insight was that electrons don't travel on the surface of the twisted ring band, like ants in a famous Escher painting, but are confined inside the plane of the ring. So instead of traveling twice the distance of the strip to get back to where they started, the electrons travel exactly the length of the ring. A Möbius molecule will be aromatic only when the electron number is a multiple of four, Miliordos reports online December 28 in *Physical Review A*.

M.C. O'SULLIVAN *ET AL*/*NATURE* 2011

The Sigh Heard 'Round the World

One soldier's incredible true story about the top secret operation that took his wife's breath away.

It was an American soldier in Iraq who showed me the true power of a piece of jewelry. He wrote to tell us that shortly after marrying his sweetheart he received orders to return to active duty as part of Operation Iraqi Freedom. Like a true romantic, he wasn't about to let 7000 miles (or a war) ruin their first Christmas as husband and wife. He found the perfect gift from Stauer and asked his new bride to call him when it arrived.



USING THE RING SIZE CHART
Place one of her rings on top of one of the circle diagrams. Her ring size is the circle that matches the inside diameter of the ring diagram. If her ring falls between sizes, order the next larger size.

"So far away, I would not be able to see her reaction, but I wanted to hear it," he wrote. On the day the package arrived, she called as promised. With her husband listening, halfway around the world on the end of the line, she opened the box and slowly lifted the lid.

"As soon as I heard her breath stop, I knew she'd seen it", the soldier wrote. Even though they were oceans and continents apart, in that instant the newlyweds were reunited. Romance wins again.

I love that story. I want to hear more of those stories, lots more. Those kind of unforgettable moments are the reason that the ***Emerald-Cut Diamond*Aura® *Gial Ring*** exists. In the fine tradition of jewelry designed to take her breath away, we created this stunning showcase for a magnificent 4 ¾-carat yellow, lab-created Diamond*Aura*. Layered in platinum over sterling silver, the luxurious golden yellow centerpiece is highlighted by dozens of sparkling white Diamond*Aura* rounds.

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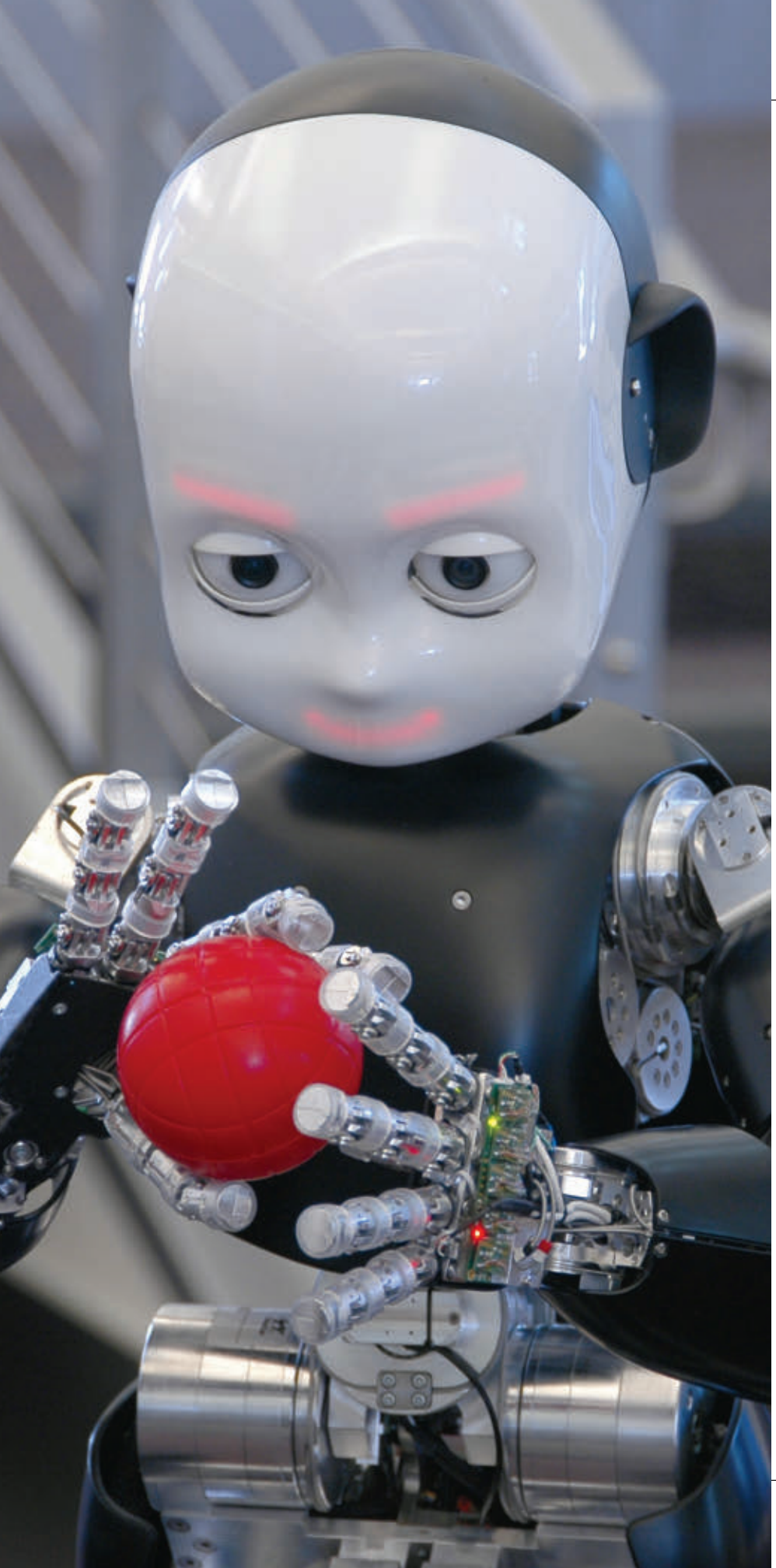


Meet

Social robots take baby steps toward humanlike smarts

By Bruce Bower

Boldly going where most computer scientists fear to tread, Rajesh Rao watches intently as 1-year-olds lock eyes with their mothers in a developmental psychology lab at the University of Washington in Seattle. Time after time, tiny upturned heads tilt in whatever direction the caretakers look. Naturally, Rao thinks of robots.

Not many cyberspecialists would forgo motherboards for mother love. Rao's rationale: He wants to create a robot that sponges up knowledge baby-style. Job No. 1, Rao suspects, is getting a machine to look where an experimenter looks, just as a baby homes in on an adult's visual perspective. Evidence suggests that an ability to follow another person's gaze emerges toward the end of a child's first year. This subtle skill enables infants to learn what words refer to, what adults are thinking and feeling, and when to imitate what others do.

A gaze-tracking robot would have one metallic foot in the door to the inner sanctum of social intelligence.

"This would be the first step in getting a robot to interact with a human partner in order to build an internal model of what it sees in the world," Rao says. Eventually, he predicts, such a robot would use feedback from its mechanical body and from encounters with people

Figuring out how to make robots, including the childlike iCub shown here, into social learners marks a new approach in artificial intelligence.

THE ROBOTCUB CONSORTIUM

the growbots

to revise its knowledge. The bot would learn by trial and error.

Rao's goal deviates sharply from that of traditional artificial intelligence research. For more than 50 years, AI researchers have sought to program computers with complex rules for achieving cognitive feats that a typical 3-year-old takes for granted, such as speaking a native language and recognizing familiar faces. So far, 3-year-olds have left disembodied data crunchers in the dust.

Traditional AI has had successes, including creating robots that assemble cars and perform other complex, rote tasks. In the last five years, though, an expanding number of computer scientists have embraced developmental psychology's proposal that infants possess basic abilities, including gaze tracking, for engaging with others in order to learn. Social interactions (*SN: 5/24/03, p. 330*), combined with sensory experiences gained as a child explores the world (*SN: 10/25/08, p. 24*), set off a learning explosion, researchers hypothesize.

Developmental psychology's advice for producing smarter robots is simple: Make them social learners. Give machines the capacity to move about, sense the world and engage with people.

That's a tall order. But at least two dozen labs in various countries have launched projects that use different software strategies to produce robots that learn through social interactions. Some of the latest research appears in the October-November *Neural Networks*.

"A robot that learned could potentially be more adaptive than a robot that had to be programmed," says psychologist Nora Newcombe of Temple University in Philadelphia. Possible duties for social robots run the gamut from live-in nurses for the elderly to team members on interplanetary space journeys.

Some psychologists suspect that people will come to view learning robots, or "growbots," as a new kind of social partner — not human, but alive in some respects.

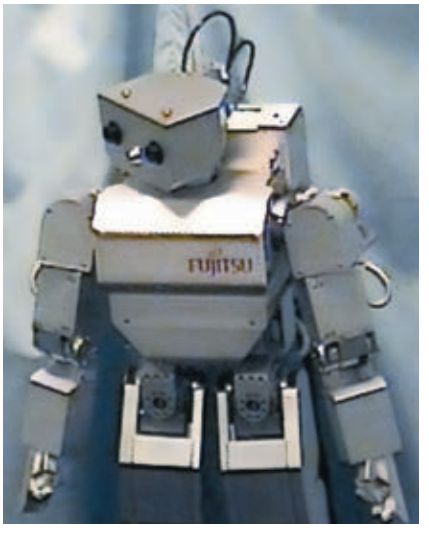
Eyeing contact

Rao hopes to transplant a babylike aptitude for gaze tracking into a 50-centimeter-tall Japanese-built robot with video cameras embedded in its black-rimmed eye openings. Software designed by Rao's team animates the robot's cube-shaped head, which swivels atop a chunky torso.

During trials, an instructor sits across a table from the robot and turns to look at one of several preselected objects, such as a ball. The robot tries to identify what has grabbed the person's attention by estimating gaze angle and turning accordingly.

The robot's motors keep track of camera positions to provide ongoing feedback about the instructor's shifting gaze. Once focused in the right direction, the robot picks a few prime candidate objects based on features such as bright colors and sharp edges. Then the robot uses a speech synthesizer to say out loud what the instructor is looking at.

The Japanese-built robot below is learning to track an instructor's gaze to spot interesting objects. Most children can follow a parent's gaze by age 1.



At first, the robot may mistakenly tag two overlapping items as one object or simply err in its choices. But as trials proceed, Rao's creation builds a map of the instructor's looking preferences that guides the machine's choice. Thanks to this unprogrammed learning process, speed and accuracy climb dramatically.

Rao wants to see whether a robot capable of focusing on, say, a set of blocks with an instructor can learn to imitate how the instructor arranges the blocks.

"We aspire to build a robot that learns from others and from its own errors, so it could potentially assist the sick, keep the elderly company or tutor a child in a second language," Rao says.

Scientists face a massive challenge in trying to nudge robots into humanity's messy social world, he acknowledges. A basic conversation about the weather or work depends on a raft of cultural and linguistic assumptions, as well as a capacity to imagine what someone else has experienced and how that person feels.

Only by integrating sensations from their own mechanical bodies will robots have a shot at understanding what it means for a chair to be soft and a person to be softhearted, Rao says.

Picky learner

An early version of another robot undulates across Josh Bongard's lab like a big metal inchworm. Its three flexing segments ably mirror the crawling style of a nearby robot with the same body structure, but Bongard's bot makes no attempt to copy another creature with differently arranged body parts creeping nearby.

The wormy bot has learned to be a selective copycat, says Bongard, a computer scientist at the University

of Vermont in Burlington. This metal mimic constructs a three-dimensional map of itself and uses that map to assess the possibility of imitating other robots' movements. Several labs have designed robots that learn to copy actions of designated teacher-bots. But Bongard's tells good teachers from bad ones, a feat that has gone largely unexplored. A machine that can discern its own potential and limitations in learning from others has an advantage when operating in an uncertain, unruly social world.

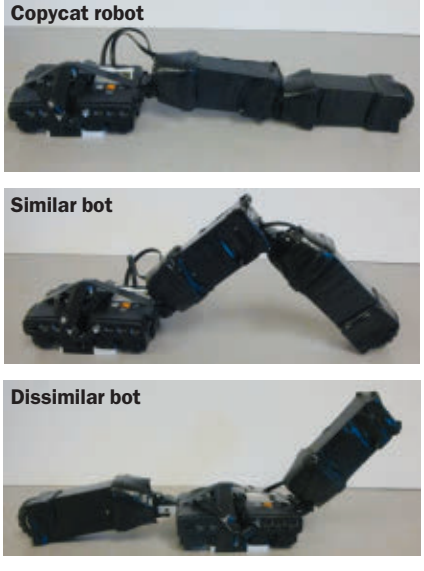
"We want to see if a robot that can select appropriate teachers will show a humanlike learning curve from imitation to more abstract achievements, such as figuring out the meaning of a teacher's simple gestures," Bongard says.

His student robot consists of a main body equipped with cameras that allow for binocular vision as well as two limbs, the first attached to the main body and the second to the first limb. Rotating joints connect body parts. Bongard programs the apparatus to know that it has three parts, how they're positioned at any point in time and the properties of the parts, such as shape and size.

In response to randomly generated commands, the bot crawls about haphazardly and gradually creates an internal, visual map of its physical structure. It then observes crawling approaches taken by two other robots, one with the same body plan and one with two limbs connected to opposite sides of the main body.

Comparing its self-map with visual simulations that it creates of the two robotic teachers, the student robot imitates the crawling motions only of its structural twin, in trials done by Bongard's team. Bongard plans to try out the mapping software in robots that have more humanlike bodies than his current crop of crawlers do.

A smart copycat A robot created by Josh Bongard (top) mimics the actions of another robot with the same body plan (middle), but it doesn't try to replicate the movements of a third bot with body segments that are organized in a different way (bottom).



J. BONGARD

Playing games

Another crawler, this time with a child's face and dexterous, five-fingered hands, moves across a play space in computer scientist Giorgio Metta's lab at the Italian Institute of Technology in Genoa. It's iCub, a mechanical tyke edging toward a place where *Sesame Street* meets *The Twilight Zone*.

Twenty iCubs, each containing about 5,000 mechanical and electrical parts, now roam 11 labs in Europe and one in the United States. Researchers at these sites are collaborating to develop a robot that learns from experience how to make decisions, adapt to new surroundings and interact nimbly with people.

Each iCub stands about as tall as an average 3- to 4-year-old child and weighs 22 kilograms (almost 50 pounds), with a moving head and eyes. When not crawling, iCub can sit up and grasp objects. It possesses the robotic equivalent of sight, hearing and touch and has a sense of balance. Flexible skin is in the works.

In line with recent evidence on early childhood learning, iCub's software brain and mechanical body allow it to discover how its actions affect objects of different types. On an indoor playground devised by Metta's team, iCub has gradually managed to grasp, tap and touch boxes and balls of different shapes and sizes. A robot that learns to play on its own and to make increasingly sophisticated predictions about the consequences of its actions will have readied itself for tracking a person's gaze and playing imitation games, Metta hypothesizes.

Other iCubs have learned to follow the direction in which an experimenter's face turns or, with practice, to imitate simple actions, such as rolling a ball.

Several labs plan to put iCub through more complex social paces, such as seeing if the robot can learn to recognize words for objects that an experimenter repeatedly points to and names.

"We're still struggling to build a robot that has robust perception and can access a wide body of knowledge through social interactions," Metta says.

More than machines

No one knows when scientists will reach that goal, but there's a broad consensus that growbots such as iCub will become increasingly lifelike. Some psychologists monitoring advances in social robotics suspect that people will regard even early versions of growbots as having feelings, intelligence and social rights, heralding a new way of thinking about who — or what — counts as a social partner.

Generations that grow up interacting with increasingly lifelike learning bots will recast these machines as a new category of social being, predicts University of Washington psychologist Peter Kahn. Glimmers of that transformation in thinking appear when school-age kids spend time with a rudimentary social robot named Robovie.

Kahn's team examined how 90 children, ages 9, 12 and 15, interacted with Robovie, which carries on basic conversations and plays simple games. Kids regularly displayed signs of personally connecting with the robot as they would with a flesh-and-blood friend, Kahn says.

One girl got upset when an experimenter told Robovie to stop playing a game with her and go into a closet. Eyeing the closet, the girl said, "It looks uncomfortable," before bidding good-bye to Robovie. The robot voiced an objection as it moved toward the closet. "Robovie, you're just a robot," the experimenter said. Smacking her hand on a table, the girl exclaimed, "He's not just a robot!"

Other youngsters casually exchanged

greetings and social niceties and shared personal interests with Robovie. Some offered consolation after the machine made simple mistakes and attempted to fill in awkward silences when left alone with it.

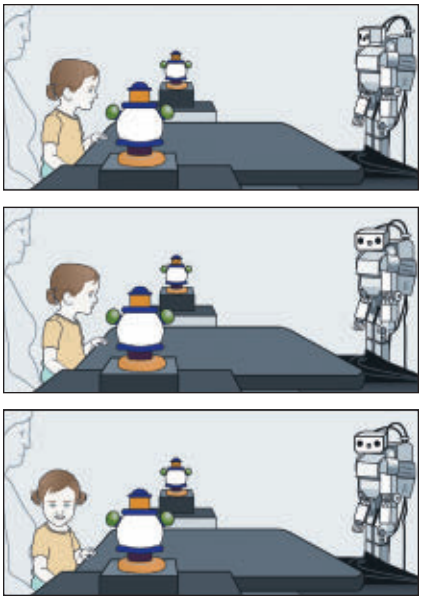
It's possible that people will mindlessly slip into treating social robots as thinking entities for brief periods while still thinking of them as inanimate objects. Or people may pretend that growbots are alive while dealing with them, much as children play pretend games with stuffed animals.

Psychologist Jennifer Jipson of California Polytechnic State University in San Luis Obispo considers it more likely that people of all ages will invent a new way to think about lifelike robots. In a 2007 study, she and a colleague found that 52 preschoolers, ages 3 to 5, generally regarded a robotic dog that they had watched playing with an adult on videos as having thoughts, feelings and eyesight, although the kids did not see it as a biological creature that ate or slept.

The mechanical pooch — far more so than stuffed animals, toy cars or real animals — was described as having psychological but not biological traits.

"Children truly seem to reason about social robots in unique ways," Jipson says.

Even infants take a shine to social robots, contends University of Washington psychologist Andrew Meltzoff.



Real to kids In one study (depicted above), kids were more likely to follow a robot's gaze toward a toy if they had watched the robot play an imitation game with an adult. Kids assume that robots engaged in such a game are social agents and know what they are doing.

By age 18 months, he says, most youngsters who watch a robot play a simple imitation game with an adult want to later look where that robot looks. If the robot turns its head toward a clown toy, these kids assiduously follow the robot's gaze, Meltzoff and his colleagues find.

In Meltzoff's imitation game, an experimenter asks a small robot to play and the robot nods yes. The robot then touches its head and torso when asked and mimics the experimenter's arm movements and a few other actions.

Infants showed much less interest in tracking the robot's gaze after having watched it perform the same actions with an unmoving experimenter, or with an experimenter who didn't react in a synchronized way typical of game playing.

Kids barely old enough to talk assume that robots engaged in a real-looking interaction know what they're doing, Meltzoff proposes. "Just by eavesdropping, babies learn that a robot is a social agent," he says. "This also suggests that infants, perhaps by their first birthdays, watch others across the dinner table and learn from social interactions that they observe."

Meltzoff plans to see if 18-month-olds who eavesdrop on robot-experimenter games will later test the robot for signs of intelligence, say by holding up a toy and looking at it while peeking to see if the robot does the same.

If that scenario plays out, babies and bots will have joined forces in tracking each other's gaze. A robot capable of naming a toy for an infant would then become a cybernetic teacher.

"We'd enter a brave new social world," Meltzoff muses. ■

Explore more

■ More on iCub: www.robotcub.org

Becoming human(like) A 2007 paper in the journal *Interaction Studies* sets out criteria for judging how "human" robots seem to a person interacting with them. Such criteria could be used to assess progress in the field of social robotics.

Autonomy A humanlike robot would appear to have a level of independence, while still considering the wants and needs of others and the larger society.

Imitation A successful robot would appear to actively imitate people — not just blindly mimicking behaviors but projecting its understanding of itself onto others so as to come to understand them too.

Intrinsic moral value People would see a truly humanlike robot as having some intrinsic value, along with rights and desires, and care for it as such.

Moral accountability A humanlike robot would appear to have responsibility for its behavior, and thus would be deserving of blame when it acted unfairly or caused harm.

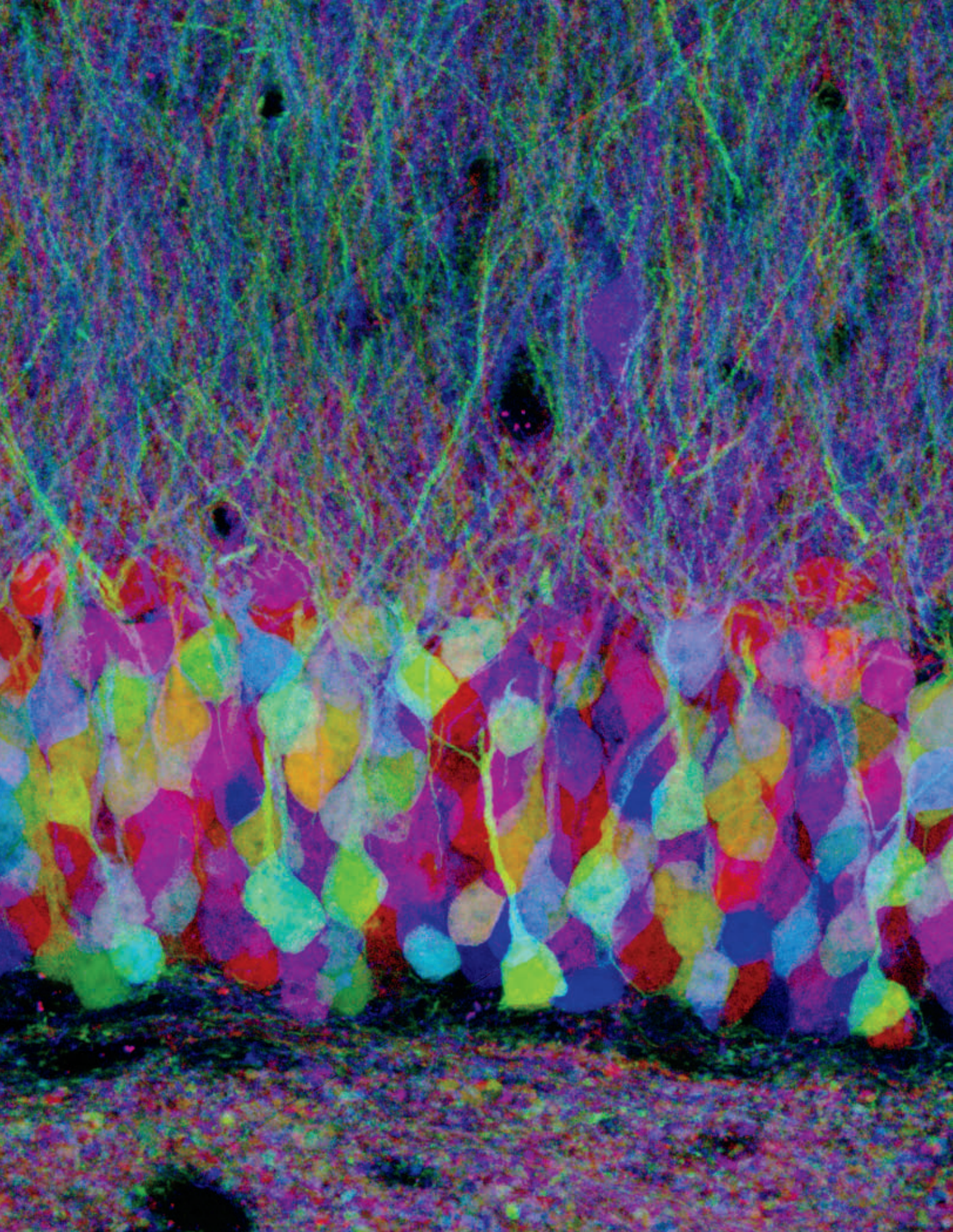
Privacy People can feel that their privacy has been violated when another person uncovers personal information, even if that information is never shared or used. A humanlike robot that looks through e-mail or tracks a person's comings and goings would engender similar feelings of privacy invasion.

Reciprocity A humanlike robot would engage in reciprocal relationships in which it adjusts its expectations and desires. Such a robot would, for example, bargain at a yard sale or compromise to pick a movie when there is disagreement.

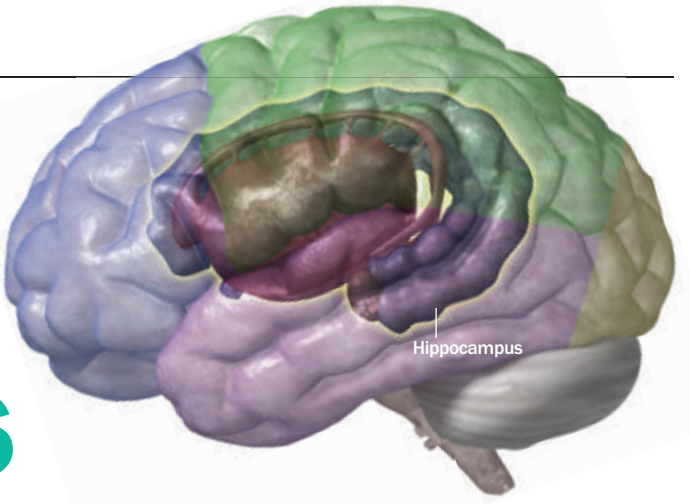
Conventionality When dealing with other people, even children can distinguish between actions that break convention, such as calling teachers by first names, and those that are morally wrong. People would make such distinctions for a humanlike robot too.

Creativity People would partner and interact with a truly humanlike robot in enterprises requiring skill and imagination.

Authenticity of relation People would not think about "using" a robot the way they "use" a computer, but would instead think about engaging with a partner that can experience and react.



Making nuanced memories



New nerve cells help the brain tell similar experiences apart

By Laura Beil

Mice aren't known for their skill with complicated memory tricks, but they can usually recall their last meal. Once they happen upon food in a laboratory maze, they are pretty good at remembering the location from one trial to the next. In one recent study, though, half the mice got too confused to find their snacks.

All the mice in two groups tested could remember the location of a new reward stashed in a vastly different place from an earlier one. But one group had trouble when the payoff lay just slightly off from a previous spot. Those mice had a good excuse, though: Their brains were incapable of creating new nerve cells, or neurons, in a region important for memory.

In the late '90s, scientists stunned the research world with the discovery that human adults aren't stuck with only the neurons they're born with — an idea long entrenched in neuroscience dogma.

Mice have long been known to make new neurons (left, in a fluorescing brain) into adulthood. Now studies reveal that neurogenesis in a region in the human hippocampus (top right) may be important for sorting experiences.

FACING PAGE: COURTESY OF JEFF LICHTMAN/HARVARD UNIV.; THIS PAGE: MEDICALRF.COM

In fact, adult brains are getting fresh batches of nerve cells every day. Since that revelation, researchers have been trying to answer a nagging question: What are the new neurons good for?

While it's now widely accepted that new cells are appearing in a part of the brain that codes and packages memories, the precise function of these newborn brain cells remains unclear. Many researchers are now convinced that new cells are indeed vital for recording memories, but not all forms of memory — just those that tend to get jumbled with other similar ones (such as what you had for lunch yesterday or where you parked your car).

Besides investigating what the cells do, researchers are discovering ways that people could encourage fresh neurons to grow, through diet and lifestyle. One day soon, medical science might offer ways to enhance memory and protect the brain from erosion that comes with age — a goal so fundamental to human existence that the ancient Greeks even worshiped a goddess of memory.

"We are closer to understanding how memories are truly formed and stored in the brain," says Craig Stark, director of the Center for the Neurobiology of Learning and Memory at the University of California, Irvine. "If we want to try to help get better memories, we'd darn well better know how the system works."

Enduring birth

New nerve cells in the brain arise from the hippocampus, a sea horse–shaped relay of cells important for learning and memory. In particular, the hippocampus encodes and prepares new memories for storage, then dispatches them to different parts of the brain. In 1998, scientists reported evidence that the human hippocampus is not only a depot for memories, but also a birthplace for neurons — thousands each month. (The olfactory bulb, a brain structure involved in odor perception, also gets new cells via neurogenesis, the formation of new neurons.) Even after more experiments supported the finding, many scientists were slow to accept such a revolutionary idea.

These adult-born nerve cells are now revealing that the science of memory is more complex than ever imagined. Despite the common perception that the nervous system has one central filing cabinet for memories, the ability to remember is a function spread throughout the brain, with events recorded in different ways depending on the kind of information (a phone number or the technique of a golf swing) and how often it's retrieved (just for the next five minutes or every Saturday).

While the hippocampus and the network around it are vital for saving new experiences, the nursery for nerve cells is restricted to a raisin-sized region of the hippocampus called the dentate gyrus. At any given time, about 3 to 5 percent of the cells in the dentate gyrus are in some stage of growth, says Fred Gage, a neuroscientist at the Salk Institute for Biological Studies in La Jolla, Calif.

New nerve cells begin their lives as what are called "neuronal progenitor cells." A population of these progenitor

cells permanently resides in the dentate. Once they divide and start to mature, new nerve cells do not immediately resemble adult neurons and aren't connected to the brain's neural network. During their first month, the cells mature into a kind of highly excitable teenage phase and begin to send feelers into the surrounding brain tissue. At about 16 days, the cells elongate and start to look more like nerve cells in the rest of the brain.

After a couple more weeks, the newly minted cells take on the appearance of mature nerve cells, and after two months, they are indistinguishable from neurons elsewhere in the brain. Once the cells finish maturing, they integrate into the rest of the hippocampus, where they remain for a lifetime. "Most of the dentate gyrus is formed after birth," Gage says. "A lot of it is formed in the first four years of life. That's when you're getting your baseline of memories. Then a low level of neurogenesis persists."

Memory lane

In part, this continuous crop of fresh cells may keep new memories from disrupting old ones, like increasing the storage capacity on your hard drive. But scientists including Gage believe that the main purpose of these adult-born nerve cells is to encode a kind of memory called pattern separation, which is necessary for the accuracy of memories because it keeps similar experiences from overlapping.

"New neurons are helping to distinguish between events that are close to each other," Gage says. Let's say someone offers you a banana. The dentate gyrus records the fact that you've just seen a yellow tropical fruit. "It's like a bar code," he says. "You put the bar code of the banana into the dentate. It's coded with lots of information." When you see another banana, the dentate will determine whether it's the same one. But if the next fruit is an apple, the dentate doesn't get excited, Gage says, because the difference is so big you know it's not déjà vu.

New neurons don't bother with vastly different information, instead working to separate locations and images that are similar, like one departure gate from the next at the airport. In 2009, Gage and his colleagues described in *Science* some of the strongest evidence for the theory, with the food-finding experiment comparing how two groups of mice learned to navigate a maze to find a reward. One group had a normal dentate gyrus, and the other was incapable of neurogenesis because researchers had knocked out the dentate with X-rays.

New nerve cells may help to distinguish not only among related locations, but also events occurring close in time. A computer program written by Gage and colleagues to mimic the neural network of the dentate gyrus suggests that the adolescent cells respond easily to a new stimulus. But as those cells mature, they lose their hair trigger for reacting to new events, the team reported in 2009 in *Neuron*.

Those cells that fire together during their youth are forever linked, Gage proposes, sequencing and connecting events in time when the memories finally crystallize in the brain. That's one reason, he says, why people often bring up associated memories when trying to recall something (what was I doing when I put down my keys?).

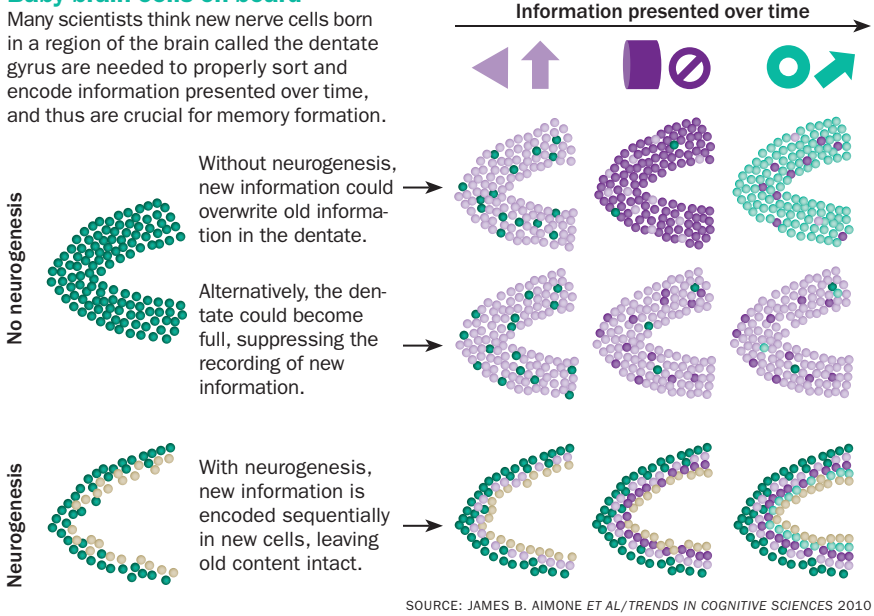
For memory to be accurate, the brain doesn't record just an image but the entire context, says Raymond Kesner, a psychology professor at the University of Utah in Salt Lake City. "If you try to remember a story, time and place will always be important."

Work by Kesner and his colleagues has helped scientists understand exactly what kinds of patterns undergo separation (similarities in distance, time or sequence), and how the dentate gyrus works in concert with the rest of the hippocampus. For example, in experiments described in 2008 in *Hippocampus*, Kesner's team demonstrated that rats with a disabled dentate gyrus had difficulty remembering the locations of objects, along with the order they were presented, when the distance between the two objects in the test was small. But the rats had no difficulty when the objects were far apart. His experiments support the idea that neurons in the dentate gyrus are vital for remembering the order in which the brain encounters similar objects in space — like the locations of landmarks passed on a road trip.

Much of the evidence for the dentate gyrus's involvement in pattern separation comes from experiments done in animals and with theoretical models. But Stark and his team have also demonstrated the effect in people. Volunteers were shown images while undergoing functional MRI

Baby brain cells on board

Many scientists think new nerve cells born in a region of the brain called the dentate gyrus are needed to properly sort and encode information presented over time, and thus are crucial for memory formation.



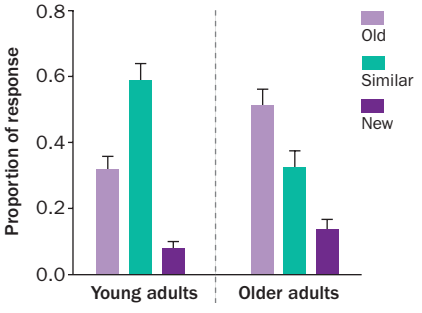
SOURCE: JAMES B. AIMONE *ET AL/TRENDS IN COGNITIVE SCIENCES* 2010

ADAPTED BY E. FELICIANO

An eye for subtlety

Neurogenesis appears to slow in old age, perhaps explaining why the elderly have trouble telling a new but similar image (outlined in green above) from a previously seen version. In one study (below), older adults were more likely to label such images as "old," thinking they'd been seen before, while the young correctly pegged the images as "similar."

How adults label new but similar images



SOURCE: MICHAEL A. YASSA *ET AL*/*HIPPOCAMPUS* 2010

scans that detected brain activity. First, the participants saw a series of new images. Not surprisingly, the dentate gyrus appeared active — the brain was recording the new images. In another round of the experiment, people were shown a series in which many of the images were unique, but only subtly so (such as a picture of a jack-o'-lantern, followed by a picture of another jack-o'-lantern with a differently carved face). When people could detect the difference, their brains lit up as if the images were completely new. But when people mistook a new image for a previous one, the dentate gyrus did not stir, Stark's group reported in 2008 in *Science*.

Using similar tests and technology, Stark and others are now trying to understand why short-term memories become more difficult to capture as people get older, even among adults who remain mentally sharp into their later years. In 2010, in *Hippocampus*, Stark and his colleagues described evidence of a sluggishness in new neurons that arise in the dentate gyrus of aged brains. In older tissue, the newborn nerve cells appear to require greater contrasts among images and experiences before reacting and capturing a memory. As people age, Stark says, "we seem to be less good about details and specifics."

Brain food

But researchers are also exploring ways to keep newborn neurons of old age as numerous and eager as those formed in younger years. First, scientists are identifying influences that, in animal studies, appear to decrease neurogenesis in the dentate — including stress, alcohol consumption and, according to a study in *Neuroscience Letters* in 2010, a high-fat diet. In addition to the enemies of neurogenesis, researchers have identified habits that protect and nurture all vintages of brain cells, including physical activity and some common components of plants.

"Exercise is the strongest neurogenic stimulus I know of," says Henriette van Praag of the Neuroplasticity and Behavioral Unit at the National Institute on Aging in Bethesda, Md. Van Praag and her colleagues discovered the role of exercise almost by accident in 1999, when they were testing whether learning increased the rate of neurogenesis. Learning itself didn't make a difference, but surprisingly, one group of mice did do better: those whose cages had an exercise wheel, and were included in the experiment as one of the comparison groups. "Not only did the exercising animals have more new neurons, they also learned better in a maze," she says.

The finding launched a series of investigations into the influence of exercise on neurogenesis and learning, with later research finding that even elderly mice (by rodent measures) could improve neurogenesis and memory function by regularly running. Supporting the link with neurogenesis, van Praag and colleagues reported last year in the *Proceedings of the National Academy of Sciences* that mice that exercise regularly perform better in pattern separation tests. In the experiment, the mice would receive a reward if they touched a certain icon on a computer screen. When the images were placed close together, the sedentary mice had to make almost twice as many attempts to find the payoff as the active mice did. Another 2010 study in mice, described in the journal *Cancer Research*, found that exercise, by encouraging neurogenesis, might help maintain memory function during a kind of brain irradiation often used in the treatment of tumors.

While exercise encourages new nerve cells, a healthy diet may help keep more of those cells, and even mature cells, in top form. Research is steadily revealing compounds in fruits, vegetables and herbs that appear to enhance the survival of neurons new and old. Among the apparent brain foods: the omega-3 fatty acids found in fish such as salmon and sardines, flavonoids found in non-green vegetables and berries, and curcumin, a common component of curry. Van Praag has found that epicatechin, in green tea and chocolate, doesn't promote the birth of neurons directly but does encourage existing neurons to sprout more connections to neighbors, improving memory. The effect is particularly strong when combined with exercise.

It's still unknown whether people can eat and exercise their way to better neurogenesis, but researchers including van Praag hope to have an answer sometime during the next decade. While the Greeks may have sought help from the spiritual realm, the true route to better memory may lie in the choices people make every day. ■

Explore more

- James B. Aimone *et al*. "Adult neurogenesis: Integrating theories and separating functions." *Trends in Cognitive Sciences*. July 2010.

Worming your way to better health

To battle autoimmune disease and allergy, scientists tune in to the tricks of parasites

By Nathan Seppa

Back in the bad old Stone Age, humans had to put up with all sorts of creepy crawlies. Parasites ran amok in people's innards, freeloading on nutrient supplies. The parasites took a toll, but over the millennia, those that killed off their meal ticket too quickly didn't make it. The survivors of this evolutionary shakeout include parasitic roundworms and flatworms, hitchhikers that allow their human host to live on — and to provide three hots and a cot.

While this scenario might appear to be win-lose, with humans the clear losers, research now suggests that may not be the whole story. In their drive to make humans hospitable hosts, parasites have developed the ability to suppress inflammation aimed against them. And this, it turns out, isn't necessarily a bad thing.

"They have evolutionarily adapted to this long-standing interaction with their hosts — that's us — and developed strategies to help the host dampen its immune response," says Helmut Haas, an immunologist at the Research Center Borstel in Germany.

These strategies are not subtle. But humans have survived the effects and even adapted well to them: A toned-down immunity is, perhaps, the norm. A sober immune system might still defend against enemies while not overreacting to everyday substances in the environment, or otherwise going awry. Suddenly those prehistoric times don't sound so bad — no Crohn's disease, no multiple sclerosis, no asthma. Good old Stone Age.

In a stroke of medical inspiration as bold as it is counterintuitive, scientists are now testing this theory by treating patients with live microscopic eggs or larvae of parasitic worms designed to quell these very afflictions. Several clinical research trials are under way and more are planned. Whether promising early results will lead to treatments for these known or suspected autoimmune conditions — and extend to allergy, type 1 diabetes, psoriasis and other cases of immune revolt — remains to be seen.

A marriage on the rocks

Parasitic worms, or helminths, elicit a visceral response from people — in every sense. Worms don't make for polite dinner conversation and, in industrialized countries, are considered a relic of days thankfully in the past. The notion that helminths are bad guys has been drummed into children of Western nations for several generations, as well as their doctors. (The Latin name for one hookworm is *Necator americanus*, meaning American killer.)

But helminths have thrived in mammals for millions of years, fine-tuning the parasite act along the way. "These parasites do some harm to the host," says immunophysiologist Derek McKay of the University of Calgary in Canada. "But if I'm [a parasite] inside a host, at the very least I want the host to reproduce and make more host babies, since my babies will need hosts."

Besides, an all-out immune war on a helminth might damage the gut. "What we have instead is détente," says David Elliott, a gastroenterologist at the University of Iowa Carver College of Medicine in Iowa City.

Parasitic hookworms cling to the intestinal wall, living on human blood. They may also keep inflammation at bay.

Only recently did the advent of better sanitation and potent drugs break up this marriage. Shoe-wearing put hookworms out of business in the United States. But the 20th century also ushered in asthma, allergy and a host of autoimmune diseases that had been uncommon previously and remain so in less developed countries. All are marked by out-of-control immunity. Vanquishing worm parasites in particular might have disrupted an equilibrium that had served humans well.

Changes in latitudes

Of course, parasitic worms have not really gone away. Some estimates suggest that more than 1 billion people, mainly in the tropics, are infected, giving scientists a chance to study the link between immunity and parasites in context.

In 2003, researchers at the University of Nottingham in England and colleagues found that toddlers living in an Ethiopian city were twice as likely to wheeze — a symptom related to asthma — than were kids living in less sanitary rural areas. Similarly, Ethiopian kids with roundworm infections were half as likely to wheeze as those free of parasitic worms.

At about that time in Argentina, physicians Jorge Correale and Mauricio Farez began a small study that brought the helminth issue into sharp focus. Studies had shown that mice with a disease similar to multiple sclerosis, marked by damage to the fatty sheaths insulating nerves in the central nervous system, improved when infected with parasitic flatworms.

That prompted Correale and Farez to examine a group of MS patients and identify 12, average age 34, who had recently acquired a parasitic worm infection. Then the doctors found 12 other MS patients who matched the first group in age and other respects, but who didn't have parasites. The rate of MS relapse, or symptom recurrence, had been similar in both groups.

As part of the study, which followed patients for an average of 4.6 years, those harboring parasites agreed not to be treated for them. Perhaps it's just as well, because MS symptoms in this group became mild to nonexistent. Only three of the patients had a relapse — one apiece — during the study period. The other nine worm-infected patients had none at all. In contrast, the MS patients without parasites had 56 relapses in all, about one per year each. Relapses were treated with prednisone, a steroid drug.

MRI scans, which can detect brain damage that might go unnoticed otherwise, showed 14 brain lesions in the worm-infected patients during the study and 164 in the other group. Mild anemia showed up in four people with worms, but the other eight had no serious ill effects from the parasites. The results appeared in the *Annals of Neurology* in 2007.

Despite the dramatic difference, the scientists acknowledged that such observational studies need to be borne out in trials in which scientists randomly assign patients to one of two groups with different courses of treatment.

Maria Yazdanbakhsh, an immune-parasitologist at Leiden University in the Netherlands, and colleagues had done just that in Gabon in equatorial Africa. To assess whether a parasitic worm infection protects against allergy, the scientists enlisted 317 schoolchildren, age 5 to 13, in a study. All of the kids had intestinal parasites, mainly roundworms, but none had an active allergy to house-dust mites. Then researchers randomly assigned half the children to get drugs ridding them of the parasites.

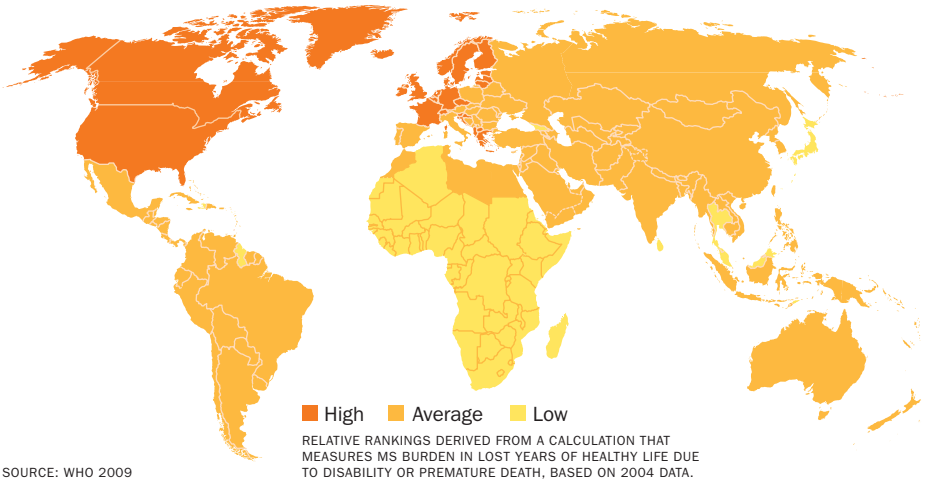
Within a year, 14 percent of the children treated for parasites had developed a dust mite allergy, skin-prick tests showed, compared with fewer than 7 percent of those who retained their parasites. The report appeared in the *Journal of Infectious Diseases* in 2004.

Some people beset by allergies, asthma or autoimmune disease saw these early findings and took to stomping around in less-than-sanitary conditions in Central Africa in hopes of acquiring a parasite to cure ailments. Anecdotal evidence suggests it can work, but the approach is unverified and dangerous. Health risks from worm infections can range from mild (pinworm) to debilitating and sometimes lethal (schistosomiasis).

Others have resorted to buying unregulated parasite eggs on the Internet. "It's available in this underground market, with mixed results," says gastroenterologist Jonathan Terdiman of the University of California, San Francisco. He doesn't endorse the approach, but he does regularly see patients with inflammatory bowel disease even if they are using it. "A lot of these patients are in great need," Terdiman says. "The pharmaceutical approach has failed them."

So controlled clinical trials are needed. To get a treatment trusted and cleared, scientists need to test it on people

Multiple sclerosis impact worldwide



SOURCE: WHO 2009

High-risk zones MS is most common in northern industrialized countries. The disorder, caused when one's own body triggers an attack on nerve coatings, might be limited in less developed tropical countries because parasites found there tone down such strong immune reactions.

GEOATLAS/GRAPHI-OGRE, ADAPTED BY T. DUBÉ

randomly assigned to get the real thing or a placebo. This is the gold standard of medicine and, unlikely as it might have seemed a decade ago, it's where parasitic worm therapy has now arrived.

Cringe-worthy treatment

Joel Weinstock had a perfectly good career as a parasitologist in the early 1990s when he and Elliott, then colleagues at the University of Iowa, noticed the lack of autoimmune diseases in the tropics. They knew about the hygiene hypothesis, which suggests that early exposure to germs is crucial for normal immune function later on (see "Autoimmunity and the hygiene hypothesis" on Page 29). And the two knew about the rise of autoimmunity in the West.

"We asked, 'What's missing in developed countries?'" Elliott says. "We still had viruses and bacteria, but we were missing a whole class — helminths — which used to be universal." Lab work and tests in animals soon convinced Elliott and Weinstock that helminth infection could quell inflammation. By 2000, they were speculating openly that failure to get parasitic infections might contribute to inflammatory bowel diseases such as Crohn's disease or ulcerative colitis.

The researchers found an innocuous gut parasite, the pig whipworm *Trichuris suis*, that didn't cause disease in people. They asked patients with ulcerative colitis to drink a solution containing either a placebo or cleaned-up, microscopic *T. suis* eggs every two weeks for 12 weeks. Roughly half the patients were randomly assigned to receive each. Of 30 people getting the helminth therapy, 13 improved substantially, compared with only four of 24 people on the placebo.

Two subsequent studies without placebo comparison groups found that helminth therapy could benefit people with Crohn's disease. Of 29 Iowa volunteers who got *T. suis* eggs, 21 went into remission. A British-Australian research team injected hookworm larvae into nine volunteers who had Crohn's disease. Most showed improvement, marked by less intestinal distress.

Despite the promising findings, helminth therapy isn't a shoo-in. A placebo-controlled trial in Denmark found no benefit from whipworm eggs given over three weeks for hay fever, scientists reported in January 2010 in the *Journal of Allergy and Clinical Immunology*. Another trial, at Nottingham, showed that very small doses of hookworm larvae proved no better than a placebo at controlling symptoms in 32 asthma patients. Those data appeared online in December 2009 in *Clinical & Experimental Allergy*.

But those results haven't dimmed interest in the strategy. At the University of Wisconsin–Madison, neurologist John Fleming and his colleagues are testing pig whipworm eggs in MS patients, using what tastes like a sports drink to deliver the eggs. At Mount Sinai School of Medicine in New York City, scientists are recruiting participants to test the treatment against autism, which some people hypothesize has autoimmune links. In Boston, researchers at Beth Israel Deaconess Medical Center plan to try it for peanut allergy. A large Crohn's disease trial is planned for Europe, Weinstock says, and Denmark will host an MS trial. For some trials, the German company Ovamed GmbH is providing live whipworm eggs that are free of bacteria and viruses and are of uniform size.

Purposely ingesting parasitic larvae or eggs "has an audacity about it," says Fleming. "It doesn't seem like mainstream science at first pass."

Not everyone is sold on the approach. "The problem with giving people helminths is you're introducing a foreign organism, and that has the specter of unforeseen consequences," McKay says. Though the pig whipworm eggs currently used in clinical trials don't cause disease in humans, even the idea is, for some, a bit hard to swallow.

The nitty-gritty

Instead of using live organisms, some scientists propose figuring out and mimicking what the parasites do to ratchet down inflammation. The problem is, Fleming says, "Worms know more about the human immune system than we do."

To catch up, scientists have delved into the molecular mechanisms by which parasites tone down aberrant immune reactions, particularly inflammation. Although inflammation is a normal response to infection that helps in healing, chronic inflammation can damage healthy tissues and plays a central role in most allergy, asthma and autoimmunity.

Weinstock, now at Tufts Medical Center in Boston, links parasites' effects to changes in innate immunity, the first-line, nonspecific branch of the immune system that reacts against foreign materials or pathogens (in contrast with adaptive immunity in which the body generates agents against specific pathogens). Helminth exposure seems to tilt two innate immune cells, macrophages and dendritic cells, away from promoting inflammation and toward suppressing it, he says.

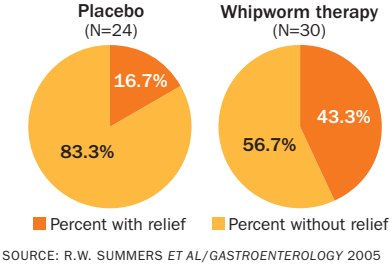
McKay and his team have studied the effects of helminth exposure by inducing colitis in rodents and then knocking out this inflammatory condition with a tapeworm infection. In response to the infection, the rodents produce more of the immune messenger protein interleukin-10. "We're very convinced that interleukin-10 is an important part of the anti-inflammatory response driven by worms to block colitis," he says.

How interleukin-10 got this role is less

Pass the swill

Live eggs (right) from the parasitic pig whipworm, *Trichuris suis*, can quell inflammation in people with ulcerative colitis. In a 12-week University of Iowa study, more of the patients given such eggs reported improvement than those given a placebo (below).

Colitis patients and symptom relief



SOURCE: R.W. SUMMERS *ET AL/GASTROENTEROLOGY* 2005

PHOTO: DETLEV GOJ, OVAMED GMBH GERMANY; GRAPH: T. DUBÉ

clear, but McKay thinks it might function as a corrective mechanism, settling down immunity after the body has taken its best shot at killing a parasite. "Maybe interleukin-10 is upregulated to reset the immune system back to normal after the worm is rejected," he says.

Other researchers are focusing on anti-inflammatory agents of the immune system called regulatory T cells, or T-regs. Run-of-the-mill T cells morph into T-regs when a parasitic infection triggers production of a protein called Foxp3. Also attracting scientific attention: the inflammation-stopping protein TGF-beta and the immune protein interleukin-22.

These cells and proteins could be the active agents knocking back symptoms in people with autoimmunity who have benefited from helminth therapy, Elliott says. And they might all be necessary.

"It appears it's a lot like getting a kid to clean his room," he says. "You offer money, turn off the TV, hide the video games — then the room gets cleaned. Any one thing won't do it."

The next step is to find out how the parasites induce the host's cells to make these anti-inflammatory agents.

To that end, Haas of Borstel and his team are studying a nasty helminth called *Schistosoma mansoni*, which causes schistosomiasis, and focusing on three compounds in the parasite's eggs that seem to affect only the host. "The worm would not take the effort to make compounds like this, which clearly mediate the interaction with the host immune system, without this being an advantage for them," Haas says. Sure enough, animal studies show that these parasite compounds ratchet down inflammation.

In Scotland, Rick Maizels and colleagues at the University of Edinburgh have also focused on helminth-secreted compounds, particularly one called cystatin. And other studies in animals point to parasite compounds called glycans. "We're trying to establish a hierarchy of strength-of-effect," says Maizels, among parasites and the compounds they unleash to modulate the human immune system.

Some scientists wonder whether helminth therapy (or infection) might even cause permanent changes in immunity.

"Very early imprinting and reprogramming of our immune systems is exciting and possible," Yazdanbakhsh says. She cites the hygiene hypothesis: "It seems to me that early life events are determining things later."

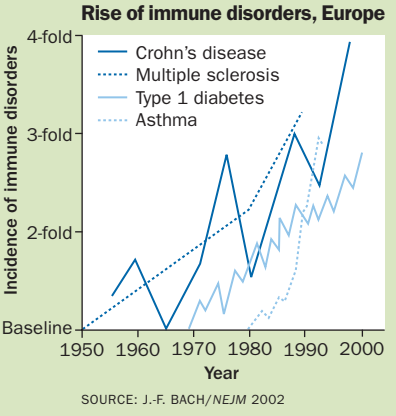
Maizels, Haas, McKay and others hope to lay the groundwork for a therapy that tricks the immune system into toning down inflammation, just as the parasites do. "Identifying these [parasite] products could be the blueprints for new drugs," McKay says.

Yazdanbakhsh predicts the key will be to get precise inflammation-regulating molecules from the parasites. "I tell my students that we don't want another set of nonspecific immune suppressants, like steroids. We need to be really specific." ■

Autoimmunity and the hygiene hypothesis

Genetics would seem to account for why some people get autoimmune diseases and others don't. To find out, researchers have looked at identical twins, who share a single set of genes. Sure enough, a person whose identical twin has an autoimmune disease, allergy or asthma runs a greater risk than the average person of developing that same problem. Yet genes alone don't explain all of the risk. For example, studies show that having an identical twin with asthma bumps the other twin's risk up more than 60 percent. But this "concordance" rate is less than half in identical twins with type 1 diabetes and considerably lower in twins with lupus, multiple sclerosis or rheumatoid arthritis.

Proponents of the hygiene hypothesis argue that while genetics matter, environmental factors play a key role in most autoimmune disorders, which surged in developed nations in the late 20th century (graph, left, shows increases in some diseases from baseline levels in various European nations). The hygiene hypothesis originated when British researcher David Strachan noted in 1989 that people with lots of siblings had less hay fever than those with fewer siblings. The hypothesis holds that squeaky-clean living and few routine infections in youth can leave the immune system unchallenged, leading to poor immune-cell education and aberrant reactions down the road. Plenty of studies support the theory (*SN: 1/29/05, p. 68*; *9/7/02, p. 150*).



SOURCE: J.-F. BACH/*NEJM* 2002

Parasite regulation of immunity emerged as an offshoot of this hypothesis, but intestinal worms aren't the only pathogens steering immune development. A study in Arizona showed that attending day care, and presumedly exposure to viruses and bacteria, might limit asthma (*SN: 8/26/00, p. 134*).

Immune instruction might even start before birth. Bianca Schaub of University Children's Hospital in Munich and colleagues compared the umbilical cord blood of babies born to women who, while pregnant, had spent time on a farm with those who had spent time only in towns. Newborns whose moms were on the farm developed more of the anti-inflammatory immune cells called T-regs than the others did, tilting the farm-exposed babies away from the chronic inflammation of autoimmune diseases. —*Nathan Seppa*

Explore more

- D.M. McKay. "The therapeutic helminth?" *Trends in Parasitology*. March 2009.

Massive: The Missing Particle That Sparked the Greatest Hunt in Science

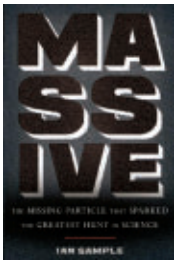
Ian Sample

The only thing more elusive than the Higgs boson, the so-called "God particle" that physicists built a $10 billion device to capture, is Peter Higgs himself.

The Scottish physicist first imagined 47 years ago that a new particle was needed to explain how other particles get their mass. Newspapers and TV stations have barraged Higgs with phone calls in recent years as particle accelerators get closer to finding the particle, but the retired professor ignores the ringing unless he's expecting a call. He doesn't bother with e-mail.

Massive has achieved the journalistic equivalent of capturing the particle: The story pins down how a young Higgs, disenchanted with the use of atomic physics for weapons, came to propose a new type of particle that solved a snafu in a theory on symmetries. The theoretical seed Higgs planted, which five other physicists independently derived in 1964 but without as much credit, steadily began to bear fruit as it was invoked to complete physicists' "standard model" of particles and forces.

The race was on to find the particles that the theory predicted. American and European accelerator labs competed to build a machine powerful enough to find the Higgs boson, along with other elementary particles. It wasn't long before Higgs felt like his idea had taken off and left him behind. After decades of progressively higher-energy machines on both sides of the Atlantic, and heartbreaking funding decisions, the Higgs-finding machine called the Large Hadron Collider was eventually turned on in 2008.

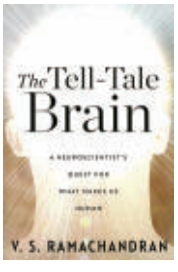


Massive offers a larger window into the minds that dreamed of the Higgs and the culture that shaped their search, not a text to explain the basics of modern physics, and is accessible for the curious science layperson. —*Marissa Cevallos*
Basic Books, 2010, 260 p., $25.95.

The Tell-Tale Brain

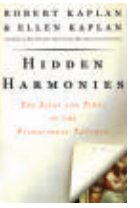
V.S. Ramachandran

Dismissing those who dismiss humans as "just apes," this book examines all that makes the human brain — and thus human beings — different from their primate cousins. Language (and the brain parts that evolved to deal with it) is one such distinction. This guided tour of the mind and its quirks describes the roots of especially human abilities, from aesthetics to introspection, in the physical brain.



Ramachandran, a neurologist and scientist, skillfully walks the line between intriguing storytelling and detailed science in these readable tales of unusual patients. How he and others make sense of what's going on in these people's brains is a starting point for understanding normal brain function and its evolution. To him, drama lurks in the anatomy of each part of the brain, so that a description of the essential, if primitive, brain stem is punctuated with: "A hemorrhage from even a tiny artery supplying this region can spell instant death."

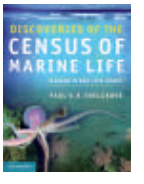
Never averse to speculation, Ramachandran argues that mirror neurons — brain cells that enable imitation of others and a glimpse of another's point of view — were crucial to the emergence of culture and language. Problems with the mirror-neuron system might even lie at the core of autism, he proposes. In synesthesia ("a surreal blending of sensation, perception and emotion" in which people may see sounds or hear shapes), he looks for the roots of creativity. Elsewhere, he puzzles through issues in vision, the appreciation of beauty and art, and the origins of self-awareness. —*Eva Emerson*
W.W. Norton, 2011, 384 p., $26.95.



Hidden Harmonies
Robert and Ellen Kaplan
Inspired by their Harvard-based math program, two educators delve into the history and uses of the Pythagorean theorem. *Bloomsbury Press, 2011, 304 p., $25.*

Mysteries of the Komodo Dragon
Marty Crump
For kids 9 to 11 who like all the gory details, this children's book doesn't shy away from showing dragons at their fiercest. *Boyds Mills Press, 2010, 40 p., $18.95.*

Alone Together
Sherry Turkle
A psychologist explores the ramifications of constant online connectivity for real-world human connections. *Basic Books, 2011, 360 p., $28.95.*



Discoveries of the Census of Marine Life
Paul V.R. Snelgrove
Stunning photographs illustrate this compendium of new scientific knowledge gleaned from the largest-ever cataloging of ocean life. *Cambridge Univ. Press, 2011, 270 p., $45.*

Chasing the Sun
Richard Cohen
Traveling to nearly 20 countries, the author traces efforts to understand Earth's nearest star, from ancient Egyptian sun myths to a modern-day Antarctic observatory. *Random House, 2010, 574 p., $35.*

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Prescient Editor in Chief?

I got behind on magazine reading over the summer; now that colder weather is here I'm catching up, randomly. I read the Nov. 6 issue one day, with the Life article on microbes that walk on their pili ("Sure, but can they chew gum too?" *SN: 11/6/10, p. 8*); the next day I opened up the Sept. 26, 2009 issue. There right up front was Tom Siegfried's "From the Editor" note where he says, "Picture ... a bacterium with legs that lived on a cosmic-sized sheet of paper." Did he have advance knowledge, was it a pie-in-the-sky, never-gonna-happen wild guess, or is he a wise foreteller of the future?

Gerry Beard, Edgewood, N.M.

This is an enduring mystery to all of us here at Science News. *—Eva Emerson*

Over time, it gets complicated

After reading "Getting to know you less and less" (*SN: 11/6/10, p. 16*), I felt the researchers' assumptions were incomplete. So I asked my wife of 42 years what her favorite color was. Her response was just as I expected: "I don't have a favorite color," she said, "only a range of colors." This was true for me also. Thus, I think that one factor is not that couples get to know each other less the longer they've been together, it is that over the years they experience more and more things, and their likes and dislikes are more complicated than when they were young. Each partner then is less likely to know what the other likes because the other has no simple answer.

O. Frank Turner, Pueblo West, Colo.

Sticky and all lit up

In response to "Electrons tell a tale of the tape" (*SN: 11/6/10, p. 13*), some adhesive tape can also radiate visible light, and it doesn't need a vacuum to do it. If you remove the gummed wrapper from a Breathe Right nasal strip in the dark, it will create a dramatic flash of light. Is this the same phenomenon at work? If so, this might be an easier example to study.

David Taylor, Half Moon Bay, Calif.

Scotch tape emits visible blue light when adhesive bonds between the sticky side and the smooth side are broken. Biting into certain Life Savers mints also creates a burst of visible light. But the light you see from cracking into a mint or tearing off some kinds of tape comes from breaking chemical bonds in the material. This is different from what the new research found: Unexpectedly, peeling tape also emits X-rays, a much higher-energy type of radiation. Electric charge is separated when the tape peels, producing an electric field that accelerates free electrons to produce X-rays. —Marissa Cevallos

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

Helen Neville

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Neuroscience exposes pernicious effects of poverty

At the 2010 Society for Neuroscience meeting in San Diego, a group of scientists held a session on how poverty changes the brain. Neuroscientist Helen Neville of the University of Oregon in Eugene joined the discussion and described some of her group's studies on the brains of 3- to 5-year-old children who grow up poor. She met with Science News *neuroscience writer Laura Sanders after the November 14 session to discuss some of the Oregon group's findings about what a low socioeconomic status does to the brain, and how intervention can help counter those effects.*

How does poverty affect the brain?

Children growing up in poverty, for various reasons, have much poorer brain development and cognitive development than children growing up in not-poor environments. This has been shown by many people around the world for many decades. We now have animal models showing some key characteristics of an impoverished environment, for example, parental neglect. Rats that neglect their offspring create differences in brains and learning that are very parallel to those in humans.

What is different in the brains of kids brought up in lower socioeconomic environments?

Executive function and self-control is lower, language skills are lower, IQ is lower, attention — the ability to focus on one thing and ignore distracting information — is poorer and working memory is poorer. Those cognitive skills are different.

When we look at electrophysiological and MRI studies of their brains we can see differences between higher and lower SES [socioeconomic status] children. We've also observed, it's important to note, these same differences in adults. Most people focus just on kids. But ... in our lab we've gone beyond the university community to look at adults from lower socioeconomic status backgrounds, and their brains and cognition look really different too. So these effects are long-lasting.

What can be done?

After several training studies targeting different processes, we observed that the two most effective [interventions] we could do is to train attention in kids — low SES kids, Head Start kids — so we've developed little games and puzzles for kids to do that they enjoy doing, to target self-control and attention. And the other training we're doing at the same time is with the parents of those children, who we talk to about parent skills, the importance of talking to your child and using consistent discipline, giving choices and the importance of attention and self-regulation. So it's a two-pronged program.

People ... need to know the importance of the brain.... They need to know it's changed by experience. They need to know that genes are not destiny.

How well is this approach working?

With over 100 kids now with this particular program, we see that the parents' behavior changes with their children, their stress levels go down, the children's problem behaviors diminish and their social skills improve, as rated by their teachers. In terms of language and IQ and preliteracy, all those tests show marked improvements. Their brain function improves, so they look like high SES kids.

How long do you follow these kids?

After the end of the intervention, we've been following them for about two years. And they're hanging on to their gains. And we're not doing any more; we're not boosting them. We think it's working.... We have one more year to go before we have all the data we're hoping to get.

What's next?

All the kids we've been working with are monolingual, typically developing, mostly white kids. Because we know bilingual brains look different in a way, the next step is to adapt this for Latino families, because Latino families make up 40 percent of the Head Start population in Oregon. In California, it's more like 80. The Latino population is the fastest growing segment of the U.S. population. And they're at high risk. They're failing school at enormously high rates.

We're doing structural imaging of white matter and gray matter in 4-year-olds and 3-year-olds.... We're getting structural and functional imaging and we'll continue to analyze it. We're looking at gene-environment interaction effects. That's very important and we're looking at more data there.

Your group runs an educational website (changingbrains.org) and made a DVD about how the brain changes. Why?

I want people to have evidence about the importance of the brain. Most people don't even know it does everything. They need to know the importance of the brain; they need to know that it develops over 25, 30 years. They need to know it's changed by experience. They need to know that genes are not destiny. They need to know what's going on. ■

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