SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

AUGUST 16, 2003 PAGES 97-112 VOL. 164, NO. 7

creatine for brawny brains

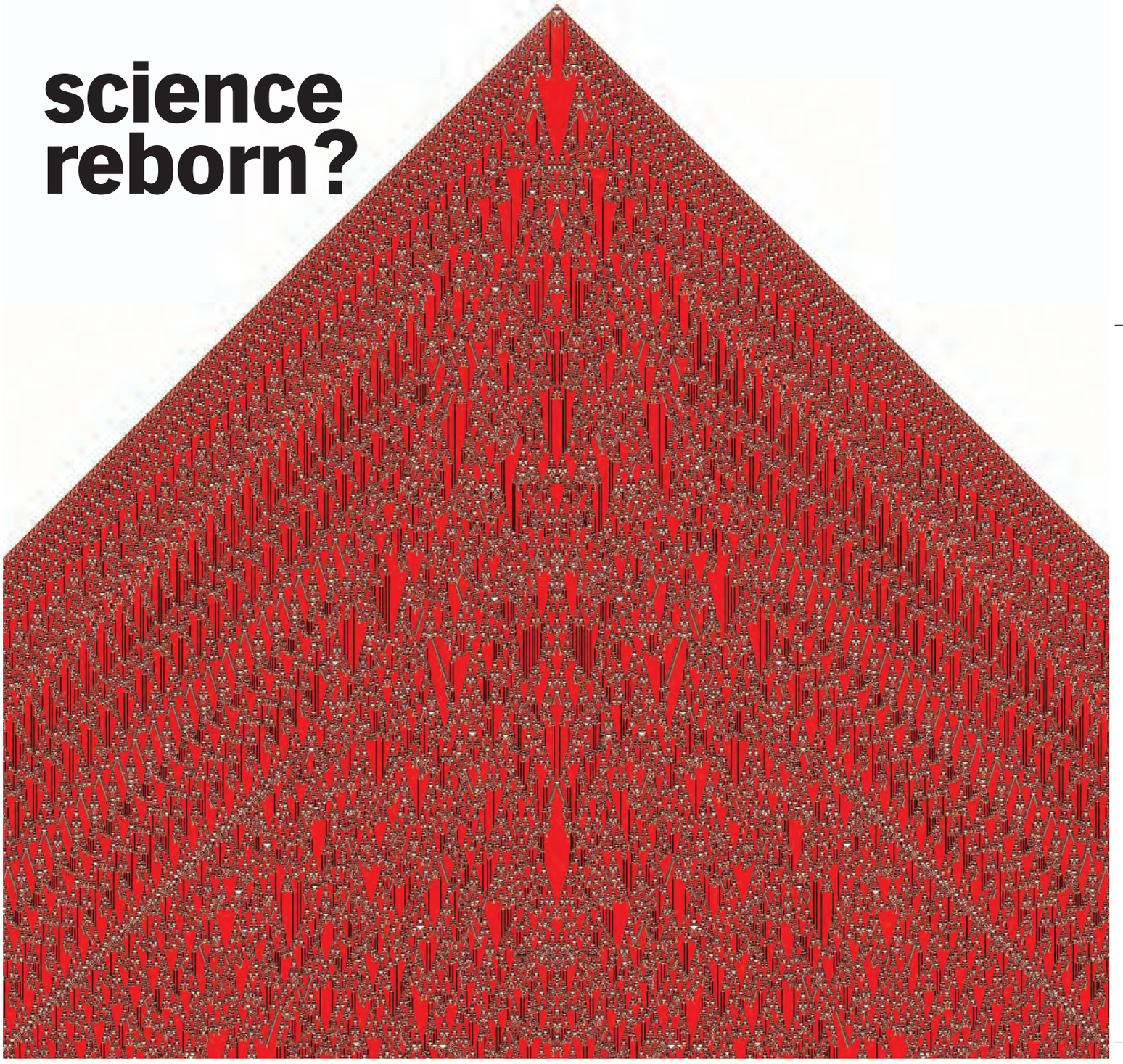
galactic cannibalism

insulin-inducing compound

ocean: more salt, less CO_2

www.sciencenews.org

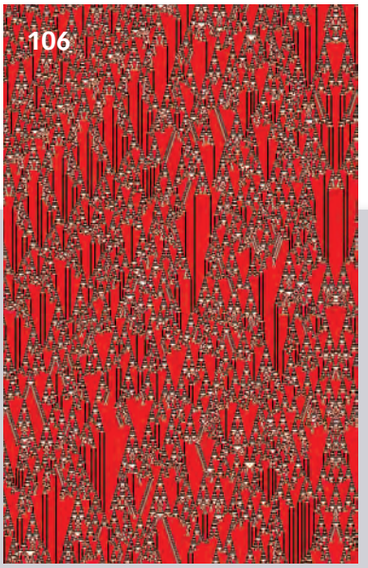
science reborn?



THE WEEKLY NEWSMAGAZINE OF SCIENCE

SCIENCE NEWS

AUGUST 16, 2003 VOL. 164, NO. 7



Features

This Week

THIS WEEK ONLINE
www.sciencenews.org

Water shortages Many nations will suffer shortfalls of water for crop irrigation in the next few decades. See Food for Thought.

Of Note

Meetings

Departments

Cover Progress on tough scientific puzzles may come from studying simple systems that generate great complexity—for instance, the computer algorithm that produced this filigree pattern. Physicist and software entrepreneur Stephen Wolfram champions this controversial approach as a major scientific movement. (Stephen Wolfram LLC) Page 106

A SCIENCE SERVICE PUBLICATION
PUBLISHER Donald R. Harless
EDITOR Julie Ann Miller
MANAGING EDITOR Keith Haglund
DESIGN/PRODUCTION DIRECTOR Eric R. Roell
PRODUCTION MANAGER Spencer K.C. Norcross
ASSOCIATE EDITOR Ivan Amato
SENIOR EDITOR/ENVIRONMENT/POLICY Janet Raloff
WEB EDITOR/MATHEMATICS Ivars Peterson
BEHAVIORAL SCIENCES Bruce Bower
ASTRONOMY Ron Cowen
BIOLOGY John Travis
BIOMEDICINE Nathan Seppa
LIFE SCIENCES Susan Milius
PHYSICS/TECHNOLOGY Peter Weiss
CHEMISTRY/MATERIALS SCIENCE Jessica Gorman
EARTH SCIENCE Sid Perkins
ENVIRONMENT/POLICY/HEALTH Ben Harder
MATHEMATICS CORRESPONDENT Erica Klarreich
SCIENCE WRITER INTERN Sorcha McDonagh
COPY EDITOR Linda Harteker
EDITORIAL ASSISTANT Kelly A. Malcom
EDITORIAL SECRETARY Gwendolyn K. Gillespie
WEB SPECIALIST Vernon Miller
BOOKS/ADVERTISING Cait Goldberg
SUBSCRIPTIONS Christina Smith
BUSINESS MANAGER Larry Sigler

Science News (ISSN 0036-8423) is published weekly on Saturday, except the last week in December, for $54.50 for 1 year or $98.00 for 2 years (foreign postage is $18.00 additional per year) by Science Service, 1719 N Street, N.W., Washington, DC 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.

POSTMASTER
Send address changes to **Science News**, P.O. Box 1925, Marion, OH 43306. Change of address: Two to four weeks' notice is required—old and new addresses, including zip codes, must be provided.

EDITORIAL, BUSINESS, AND ADVERTISING OFFICES 1719 N St. N.W., Washington, D.C. 20036
202-785-2255; scinews@sciencenews.org.
LETTERS editors@sciencenews.org

SUBSCRIPTION DEPARTMENT P.O. Box 1925, Marion, OH 43306. For new subscriptions and customer service, call 1-800-552-4412.

Science News is published by Science Service, a nonprofit corporation founded in 1921. The mission of Science Service is to advance the understanding and appreciation of science through publications and educational programs. Visit Science Service on the Web at www.sciserv.org.

Swallow Thy Neighbor

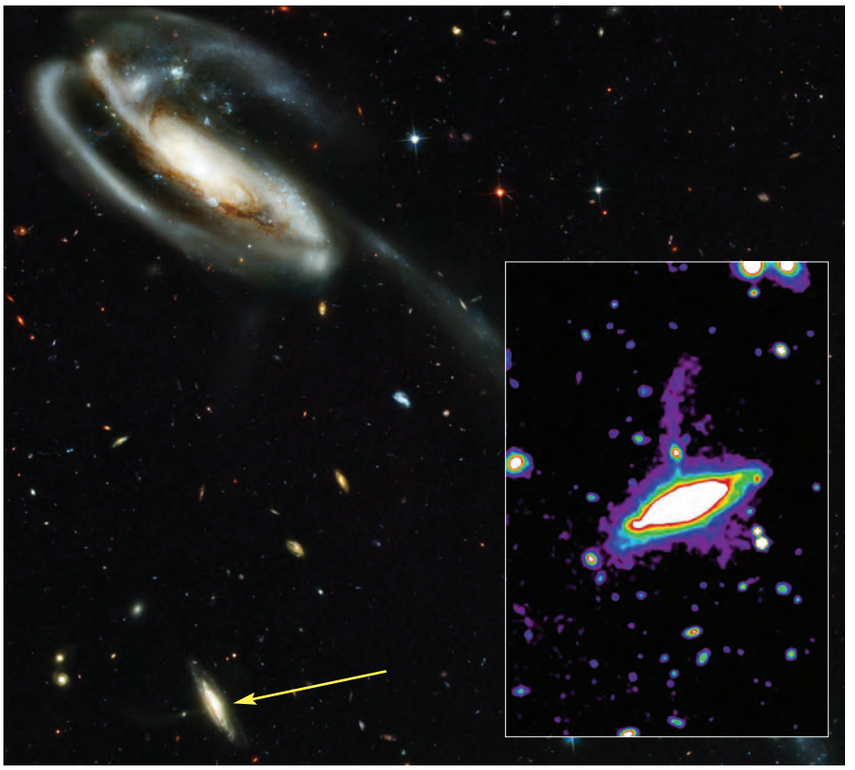
Strong evidence of galactic cannibalism

It's a violent world out there, and many large galaxies have the corpses to prove it. These massive galaxies, including our own Milky Way, are surrounded by streams of gas and stars, the fossil remains of dwarf galaxies that they tore apart long ago (*SN: 7/7/01, p. 5*). But examples of dwarf galaxies still in the process of giving up their material to a larger partner have proved more elusive, even though the standard theory of galaxy assembly suggests that such cannibalism is common.

Astronomers say that they now have a compelling case of a big galaxy caught in the act of eating a small fry. Some 2 billion light-years from Earth, a galaxy about as large as the Milky Way is pulling two plumes of stars from a tiny satellite galaxy, report Duncan A. Forbes of the Swinburne University of Technology in Hawthorn, Australia, and his colleagues in the Aug. 29 *Science*. The findings are further evidence that galaxies start out small and grow bigger over time, in part by consuming their smaller brethren, Forbes says.

The discovery appears to be "the most spectacular example of such a satellite disruption seen so far outside the Local Group of galaxies," comments François Schweizer of the Carnegie Observatories in Pasadena, Calif.

Study coauthor Michael A. Beasley of Swinburne made the initial discovery when he examined one of the first images taken by the Hubble Space Telescope's ultrasharp Advanced Camera for Surveys. The image, recorded in April 2002, features an eye-catching view of a spiral galaxy called the Tadpole, but Beasley was drawn to one of the thousands of unnamed galaxies in the background. This body, also a spiral galaxy, appears to be adjacent to two plumes of stars, each originating from a small blob—perhaps a satellite galaxy.



NASA/STSCI

RIPPER **Hubble image shows plumes of stars (purple in inset) being cannibalized by a large spiral galaxy (large white area in inset and arrow in main image). Tadpole galaxy is upper-left in main image. The spiral galaxy and its dwarf satellite lie about 2 billion light-years from Earth.**

Spectra of the background galaxy and the blob taken with the Keck 1 Telescope atop Hawaii's Mauna Kea then revealed that the two bodies reside at the same distance from Earth and therefore are physically connected.

Computer simulations show that the presence of the two plumes and their orientations are just what would be expected if the blob is a dwarf galaxy and its stars are being ripped away by its neighbor.

Forbes cites several reasons that it's been hard to find satellite galaxies just beginning to be torn asunder. The dwarf galaxies and their plumes are extremely faint, he notes. Moreover, most tiny galaxies seem to have highly elongated orbits and to spend much time far from their larger, more luminous partners, so the pairs are difficult to pick out.

Even so, the new findings don't solve a discrepancy within the leading theory of galaxy formation. That theory holds that an invisible type of material known as dark matter makes up most of the mass in the universe. Its structure indicates that there ought to be 100 to 1,000 times more small galaxies orbiting bigger ones than astronomers have observed (*SN: 10/13/01, p. 234*).

With recently refined galaxy simulations and the large, high-resolution telescopes currently available, the tools are in hand to conduct a census of such galaxies, says Kathryn V. Johnston of Wesleyan University in Middletown, Conn. —R. COWEN

Switching Off Pain

Modeling relief on the action of marijuana

Scientists have long known that tetrahydracannabinol (THC), the active ingredient in marijuana, is an effective painkiller. But THC's kaleidoscopic effects, including sedation, giddiness, and paranoia, limit its use in medicine. Now, researchers have fabricated a drug that alleviates pain through a mechanism similar to that of THC, but without the side effects.

The drug, dubbed AM1241, binds to one of the two types of cannabinoid receptors in the body. These protein-based switches, which sit on a cell's exterior, respond primarily to THC.

In tests with rats, the researchers targeted an ailment known as neuropathic pain. Often severe and disabling, this pain differs from the central nervous system's alarm-raising response to injury or inflammation. Animals feel neuropathic pain when the central nervous system itself goes awry. As a result, it can radiate pain signals without any stimulus or cause hypersensi-

tivity to stimuli that would not otherwise be painful—even something as benign as the light touch of a breeze.

While neuropathic pain doesn't respond to conventional anti-inflammatory drugs such as ibuprofen, it can sometimes be alleviated with narcotics. But there's a problem. "Virtually all the treatments we have for neuropathic pain work not only on the parts of the nervous system causing the pain, but on other parts of it as well," explains T. Philip Malan Jr. of the University of Arizona in Tucson. That leads to side effects similar to those caused by THC.

The new drug circumvents this problem by acting only on cannabinoid receptors located on cells outside the central nervous system. These so-called CB2 receptors appear primarily on immune cells.

To test the drug, Malan and his colleagues used rats that had a form of neuropathic pain. The scientists had surgically altered nerves exiting the animals' spinal cords so the rats were especially sensitive to stimuli.

The researchers tested the rats' tolerance to heat or to prodding of their paws. "All they have to do to stop the pain is lift their paw," Malan says. "We're not subjecting them to prolonged pain or restraining them."

Rats given AM1241 were less sensitive to the stimuli than nondrugged rats were. In fact, after receiving the drug, the surgically treated rats were even less sensitive than rats that hadn't had the surgery. The results will appear in an upcoming *Proceedings of the National Academy of Sciences*.

"This study provides robust evidence that the CB2 receptor is cardinal for moderating neuropathic pain," comments George Fink of the pharmaceutical company Pharmos based in Iselin, N.J. Previous research had shown that activating both types of cannabinoid receptors dulls several types of pain. The new study is the first demonstration that binding a chemical to only CB2 receptors has an analgesic effect, Fink says.

The researchers aren't sure how receptors on immune cells have a role in pain relief. Malan says that immune cells regulate pain sensitivity by releasing substances that make the nerves outside the central nervous system more or less sensitive to pain.

"AM1241 could cause the immune cells to release opioids and other substances which inhibit pain," Malan suggests.

The drug will have to undergo extensive toxicological testing before it can be tried in people. Malan cautions that one of the things that preliminary testing needs to address is whether the drug undermines the immune system. —S. MCDONAGH

Probing Ocean Depths

Photosynthetic bacteria bare their DNA

Scientists call it the invisible forest, the immense mass of ocean-dwelling microorganisms—algae, bacteria, and plants known as phytoplankton—that perform photosynthesis as trees do. Converting light, water, and carbon dioxide into energy, these microbes produce nearly the same amount of oxygen worldwide as land plants do and influence the climate by sequestering carbon inside the oceans.

Biologists have now deciphered the full DNA sequences, or genomes, of two kinds of cyanobacteria at the heart of this ocean forest. "They are the most abundant photosynthetic cells on the planet," says Sallie Chisholm of the Massachusetts Institute of Technology.

DNA DEBUT Scientists present genomes of photosynthetic cyanobacteria such as these *Prochlorococcus*.

"About half the oxygen you breathe is produced by the oceans, and a very significant portion of this oceanic production comes down to these cyanobacteria," adds Nicholas H. Mann of the University of Warwick in Coventry, England.

The photosynthetic bacteria targeted by the new research are known as *Prochlorococcus* and *Synechococcus*. The former includes strains that thrive in the top 100 meters of the ocean and other strains, adapted to less light, that primarily populate depths of 100 to 200 m. *Synechococcus* tends to inhabit the top 20 m of ocean water.

The analyses of three *Prochlorococcus* strains, to be reported in the Aug. 19 *Proceedings of the National Academy of Sciences* and an upcoming *Nature*, were spearheaded by Gabrielle Rocap of the University of Washington in Seattle and Alexis Dufresne of the University of Paris. Rocap's group, for example, found that a low-light *Prochlorococcus* had nearly 2,300 genes, while a shallower-dwelling form had about 1,700 genes.

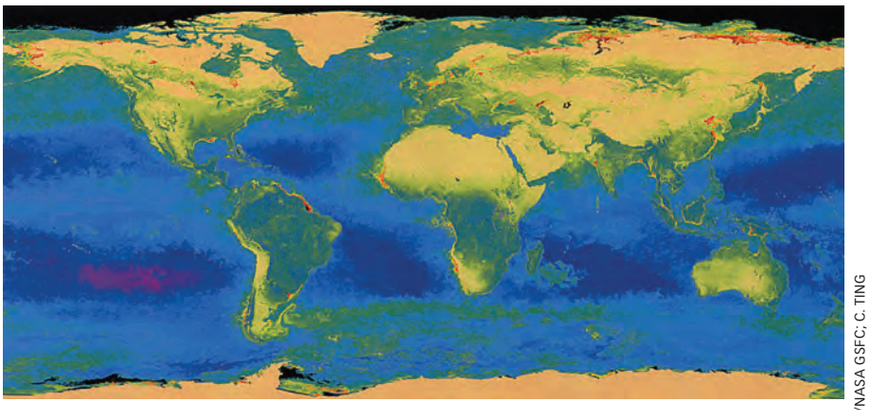
Gene differences between the strains could explain why they thrive at diverse ocean depths, but each one's gene number itself may not be telling. Chisholm, who worked with Rocap, notes that the third *Prochlorococcus* strain, studied by Dufresne's team, is adapted to low light but has fewer than 1,900 genes.

In part to resolve a mystery, Brian Palenik of the Scripps Institution of Oceanography in La Jolla, Calif., and his colleagues studied the genes of a strain of *Synechococcus*. "It has a very unique form of motility. It's able to swim, and no one knows how," he says.

His group's genome analysis, also in an upcoming *Nature*, confirms that the bacterium lacks most genes crucial to known modes of swimming. The researchers did identify a novel gene that might contribute to the strain's motility. The cyanobacterium can't swim if this gene, encoding one of the largest bacterial proteins ever documented, is mutated.

Unexpectedly, the microbe also contains genes for proteins that pump toxic substances out of a cell. That suggests the cyanobacterium, even in the open expanse of an ocean, regularly encounters other microbes that seek to kill it with chemical weapons, says Palenik.

Furthermore, he and his colleagues found evidence in the cyanobacterium's DNA of



GREEN WATERS Photosynthesis depends on chlorophyll, and this map shows the amount of chlorophyll in the oceans. Midocean purple and blue represent low ocean-chlorophyll concentrations, while green, yellow, and red in coastal waters indicate progressively higher amounts.

ORBIMAGE/NASA GSFC; C. TING

past infections by viruses known as bacteriophages or phages. Scientists have recently realized that such viruses have infected many ocean bacteria, providing one way that the bacteria acquired new genes (*SN: 7/12/03, p. 26*).

Many phages, however, don't make a permanent home inside their host. In another *Nature* report, for example, Mann and his colleagues reveal the DNA sequence of a virus that infects and replicates inside *Synechococcus* strains, eventually killing them. Mann's team discovered that this particular phage contains two genes for proteins required by the *Synechococcus*' photosynthetic process.

Normally, sunlight damages these two proteins, so bacteria must keep making replacement copies. But Mann suspects that when the virus infects a *Synechococcus*, the phage turns off most of the bacterium's genes. So, to keep energy flowing for its own reproduction, the phage supplies copies of the photosynthetic genes. "It's not an act of altruism on the part of the phage. It's a cynical takeover of the cell," concludes Mann.

One theme emerging from these studies of cyanobacteria, notes Donald A. Bryant of Pennsylvania State University in State College, is that the organisms don't have as many genes devoted to sensing and reacting to the environment as many other bacteria do. "The ocean is a big place and relatively constant as an environment. The concentration of many things in the ocean is relatively fixed, so there's no reason to sense change," he says.

Iron concentrations, however, do change in the ocean, and there's often a scarcity of that metal. Perhaps as a result, the cyanobacteria possess extra genes for enzymes that require nickel and copper, rather than iron, for their function. "That's a particularly interesting adaptation, something rather novel," says Bryant. —J. TRAVIS

Brawny Brains

Creatine pills may aid memory and cognition

The popular muscle-building supplement creatine can boost performance on mental tests. Students preparing for exams might benefit from taking creatine in much the way that some competitive athletes do, an Australian neurochemist suggests.

Creatine, an amino acid produced by the body and also obtained from meat in a person's diet, helps cells store ready-to-use energy. When taken during weight training, pills containing synthetic creatine accelerate gains in muscle strength. Creatine's popularity among athletes and body builders fuels a market of more than $200 million per year for the pills in the United States.

Increased blood flow to the brain accelerates metabolism when someone confronts a challenging mental task, but an energy debt in taxed brain cells can last for several seconds. To see whether extra creatine could help meet the brain's demands during quick thinking, Caroline Rae of the University of Sydney and her colleagues gave a daily pill to each of 45 university students who were vegetarians. The researchers suspected that creatine might help vegetarians more than omnivores, who acquire the compound from their diets.

For 6 weeks, half the volunteers received pills containing 5 grams of creatine. The rest received sham pills. Researchers tested all volunteers with a battery of memory and timed analytical tasks at the beginning and end of the trial. After 6 weeks' wait, the researchers conducted an identical trial, except that volunteers got whichever treatment—creatine or placebo—they hadn't received the first time. Neither the volunteers nor the administrators of the tests were told who was taking which pill at which time.

In both trials, volunteers receiving creatine scored better than placebo-treated volunteers on measures of memory and analytical skills, Rae and her colleagues will report in the Oct. 22 *Proceedings of the Royal Society of London B*. In one test, for example, volunteers taking creatine could recall an average of 8.5 consecutive numerical digits, but those receiving the placebo pill remembered only 7 digits.

The Australian government funded the research. Past studies had suggested that creatine supplements can protect against the effects of certain neurological diseases.

The new findings are "truly remarkable,"

Saltier Water

Climate change can slow ocean's absorption of carbon dioxide gas

A decrease in precipitation over the Pacific Ocean just north of Hawaii in recent years has left the ocean there saltier and has diminished its capacity to soak up planet-warming carbon dioxide, a new analysis shows.

Each month since the late 1980s, researchers have recorded ocean conditions about 100 kilometers north of Oahu, far enough out that waters aren't affected by nutrients washed from any island. At 5 km deep, the water at this site—which scientists have dubbed station ALOHA—has ocean layers that mix just as much as they do in more remote waters, says David M. Karl, a biogeochemist at the University of Hawaii in Honolulu.

The scientists' measurements indicate that, averaged over a year, surface waters at the site soak up carbon dioxide from the atmosphere. However, the rate of absorption of that greenhouse gas has been slowing in recent years. In 2001, the ocean at station ALOHA absorbed only about 15 percent of the carbon dioxide that it did in 1989, says Karl.

Other changes in the water during that same period—together with simple thermodynamics—help explain why. From 1989 to 2001, the ocean-surface salinity at station ALOHA went up about 1 percent. That's because in recent years there's been less rainfall and more evaporation in the area, both of which concentrate salt in the surface water. When the concentration of dissolved substances goes up, it becomes more difficult for a liquid to absorb a gas, says Karl.

Increased salinity accounts for about 40 percent of the decrease in carbon dioxide absorption over the 13-year period, says Karl. He and his colleagues haven't identified the cause of the rest of the absorption slowdown, but some candidates are changes in biological productivity and fluctuations in ocean-surface mixing. The dip in carbon sequestration doesn't seem to be related to sea-surface temperature, however, because annual averages at the site haven't changed over the period. The researchers report their findings in the Aug. 14 *Nature*.

Station ALOHA is located in the North Pacific subtropical gyre, a swirl nearly the width of the Pacific that typically has little biological activity near the sea's surface. Such gyres account for 40 percent of Earth's ocean area, says Karl.

The team's study is the first to look at the effect that a change in precipitation over an ocean would have on the rate at which the water absorbs carbon dioxide, says Rik Wanninkhof, an oceanographer at the Atlantic Oceanographic and Meteorological Laboratory in Miami. The salinity changes that Karl and his colleagues have measured aren't huge, he notes, but their effect "is much larger than I'd have thought." —S. PERKINS

says Markus Wyss of Roche Vitamins in Basel, Switzerland. Roche does not currently sell creatine supplements, he says.

"This is the first study to show a beneficial effect of creatine supplementation on mental performance. If confirmed, the findings may… justify much broader use of creatine," Wyss says. "Nevertheless, [larger] studies need to be performed before the potential impact on human health can be fully judged."

If people use creatine to enhance memory and mental performance, they might take it for years at a stretch, Wyss says. The long-term safety of creatine supplementation hasn't been well tested, but the compound can exacerbate health problems in people with diabetes or kidney dysfunction.

Ronald L. Terjung of the University of Missouri in Columbia questions whether nonvegetarians would enjoy the creatine benefits observed in the study. He also says that, despite the study's design, volunteers may have known when they were getting the real supplements. Creatine can cause bad breath, flatulence, and weight gain from excess water retention—cues that might have encouraged volunteers to unconsciously push harder on the tests, he suggests. —B. HARDER

Risky High Life

Mountain creatures prove extra-vulnerable

Climate change may literally knock the top off the world's terrestrial-animal populations, according to an Australian analysis.

The species that have specialized in living at the heights of a particular mountain and occur nowhere else face unusually dire risks from climate change, says Stephen E. Williams of James Cook University in Townsville.

In a case study of such endemic vertebrates in a strip of mountainous rain forest in Queensland, just 1°C of climate warming will deprive them of 65 percent of their core habitat, on average, Williams and his colleagues predict in an upcoming *Proceedings of the Royal Society of London B*. And with a rise of 3.5°C, which Williams calls a "moderate" scenario, the analysis shows a complete loss of core habitat for 30 of the 65 endemic vertebrates in these rain forests.

"I don't think any other studies have predicted such a catastrophic effect," says Williams. "I've never written a paper I hope so fervently is wrong."

Another modeler of climate effects agrees that concern is justified. Chris D. Thomas of the University of Leeds in England says, "When you look at all the species, it becomes a very convincing pattern."

Most other studies of climate change in ecosystems have predicted major shifting of animal ranges with species losses only here and there, says Williams. A 1999 study, however, shows that on a Costa Rican mountain, lowland bird species moved upland in the face of climate change, while upper-altitude amphibians dwindled.

"I didn't start out to study climate change," Williams says. For 10 years or so, he and his various colleagues examined habitat use by surveying birds, mammals, and other vertebrates of a region that Australians designate as the wet tropics. When the researchers modeled how about a dozen of the species' ranges would change with temperature rise, the dramatic results made Williams focus on climate change.

For the new study, he considered the region's 65 endemic rain forest species, including ring-tail possums, the golden bowerbird, and microhylid frogs, which skip the tadpole stage.

The most conservative climate change that the team considered, a 1°C rise, "might not send a lot of species extinct but would make them critically endangered," Williams says. With a 5°C rise, "there's pretty much no range left of anything among the endemics," says Williams.

According to the United Nations' Intergovernmental Panel on Climate Change, the most likely scenario for the next century is a 1.4°C to 5.8°C rise.

HIGH RISKS A tangerine nursery frog, which lives only in the mountainous rain forests of Queensland, Australia, faces grave perils from climate change.

Jane Hill of York University in England welcomes the new study as "important in highlighting the scale of the loss with relatively small temperature changes."

Both Williams and Thomas caution that fates of particular species will differ from the overall results of the model described in the Australian report. However, Thomas says, "I think this will be a very influential paper."

Williams says that international cooperation to reduce greenhouse gases is necessary for the strongest protection of mountain ecosystems. Yet keeping an ecosystem in the best health possible, by maintaining its biodiversity, would cushion the insults of climate change. "That's something that can be done locally," he says. —S. MILIUS

Amending the Genetic Code

Yeast adds new amino acids to its proteins

With only rare exceptions, every organism constructs proteins from just 20 building blocks called amino acids. Recently, however, researchers modified *Escherichia coli* bacteria so that the single-celled organisms also make an alien amino acid and incorporate it into proteins (*SN: 1/25/03, p. 53*).

Now, the same scientists have used genetic engineering techniques to coerce more-complicated organisms into placing unnatural amino acids into proteins. Led by Peter G. Schultz of the Scripps Research Institute in La Jolla, Calif., the team created yeast cells that add one of five unnatural amino acids to their natural 20-piece construction set. To give the yeast this capability, the researchers altered the cells' biochemical machinery that identifies amino acids and puts them into particular locations within a protein.

Unlike the *E. coli* on which the team previously reported, the yeast doesn't manufacture synthetic amino acids itself. Instead, it takes the molecules up from the nutrient mixture in which it's grown. The researchers describe this work on *Saccharomyces cerevisiae* in the Aug. 15 *Science*.

The Scripps team suggests that scientists could use this technology to produce proteins with new or enhanced properties. For example, improved drugs might result. The development may also improve the study of protein function in yeast, the scientists report.

The unnatural amino acids used by the engineered yeast have various useful properties, says Scripps team member T. Ashton Cropp. For example, when activated by light, two of these amino acids bond proteins together, a function that could prove valuable in studies of protein interactions. Another of the novel amino acids might help researchers using X-ray crystallography studies to elucidate protein structure.

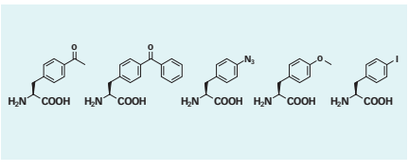
"It is another brilliant achievement from the Schultz group," says Jack F. Kirsch of the University of California, Berkeley. "The potential applications are endless."

"This technology will be very powerful and very useful," agrees Hung-wen (Ben) Liu of the University of Texas at Austin. He says he hopes the Scripps team will make the technology available to other sci-

WILLIAMS

entists for basic biological investigations.

The method should also work on organisms even more complex than yeast, says the study's lead author, Jason W. Chin, who is now at the Medical Research Council Laboratory of Molecular Biology in Cambridge, England. That's because yeast contain protein-building machinery that's similar to that in multicellular organisms, from peas to people. Yeast cells and those of the more complex organisms are classified as eukaryotes because, unlike bacteria, they contain distinct nuclei and organelles.



UNNATURAL ORIGINS Engineered yeast cells can use five new amino acids (left to right): *p*-acetyl-L-phenylalanine, *p*-benzoyl-L-phenylalanine, *p*-azido-L-phenylalanine, O-methyl-L-tyrosine, and *p*-iodo-L-tyrosine.

In fact, says Cropp, the team has already begun experiments in which it's trying to get human cells to use unnatural amino acids when making proteins. —J. GORMAN

Small World After All

Short e-mail chains reach targets worldwide

Six degrees of separation—the notion that every person on the planet can reach every other through a chain of about six social ties—has been borne out by the first large-scale study of social networks.

The more than 24,000 e-mail users who participated in the study were randomly assigned one of 18 targets in 13 countries, including a police officer in Australia, a veterinarian in the Norwegian army, and a professor at an Ivy League university. The participants were asked to help relay a message to their target by forwarding it to just one acquaintance whom they regarded as "closer" than themselves to the target.

A total of 384 chains reached their target; the others fizzled out when, for example, a recipient mistook the message for spam or was too busy to forward it to a new person. The successful chains averaged 4.05 e-mails. Taking into account the lengths of the unsuccessful chains, researchers estimate that two strangers are typically connected to each other via five to seven e-mails, says Peter Sheridan Dodds, a member of the Columbia University team that performed the study.

"Through not very many links, people can actually find someone who is incredibly different from themselves on the other side of the world with a completely different job," Dodds says. "No one along the chain knows how the rest of the chain is functioning—they're all just doing something local, moving one step."

The study shows that the six-degrees idea, originally mooted in 1967 by social psychologist Stanley Milgram, is "not just an urban legend," says Steven Strogatz, a mathematician at Cornell University.

The Columbia team asked participants several questions, including how they chose the next recipient of the e-mail. The chains that succeeded in reaching their targets tended to contain many connections to casual acquaintances. The chains that failed relied more heavily on close friends.

This phenomenon, called the strength of weak ties, is not surprising, says Mark Granovetter, a sociologist at Stanford University. His research has shown that people typically find jobs through acquaintances rather than close friends.

"Your close friends tend to know each other, but your acquaintances tend to know people you don't know," he says. "They're much more your windows on the world."

Study participants usually chose to forward the message to someone closer to the target in location or profession rather than to simply send it to a friend who knew many people. This belies the widely held belief that hubs, individuals with many social ties, are crucial to the success of chains, the Columbia researchers note. Searching the social network is "largely an egalitarian exercise, not one whose success depends on a small minority of exceptional individuals," they say in the Aug. 8 *Science*.

It's likely, however, that the successful e-mail chains involved more hubs than the senders realized, Granovetter cautions. "The study doesn't prove that people with a lot of ties aren't important in the network," he says.

Although six degrees of separation seems like a small number of steps, in social terms it represents an enormous gulf, Strogatz says. "With the people who are two steps away from you, the friends of your friends, the connection is already getting a little hazy," he says. "Once the number is three, you have very little psychological connection to these people—they're three whole universes away.

"Six or seven steps is unfathomable," he adds. "It's meaningless socially."

The new research could be relevant for analyzing not just social ties but also peer-to-peer file sharing and computer networks, Dodds says.

The Columbia researchers have launched a new study in which participants may forward their message to many acquaintances instead of just one. The scientists are recruiting volunteers at the Web site *www.smallworld.columbia.edu*. —E. KLARREICH

BLOOD SUGAR FIX

Can novel drugs rescue insulin-making cells?

BY NATHAN SEPPA

Twenty years ago, scientists discovered an unusual substance made by cells lining the intestines. It would have gone unnoticed except for one remarkable quality: The compound, called glucagon-like peptide 1 (GLP1), acted as a hormone, inducing cells in the pancreas to churn out insulin. Scientists promptly realized that GLP1 had strong potential. People with diabetes could certainly use it because they either manufacture too little insulin or need extra insulin to get by. Plus, GLP1 appeared safe, since it's a natural compound circulating in everyone's body. The finding seemed too good to be true.

Alas, it was. GLP1 turned out to have a half-life of mere minutes in the bloodstream. A compound so ephemeral has little value as a drug. So, researchers set aside GLP1 and its dazzling prospects for years until John Eng of the Veterans Affairs Medical Center in the Bronx, N.Y., discovered a form of the peptide that has longer-lasting effects.

Eng had been looking for hormones in animal venoms when he came across a component of Gila monster saliva that bears a chemical resemblance to GLP1. He tested the compound on guinea pig cells and found that it latches onto the same receptor molecule that GLP1 does.

Eng named the mysterious compound exendin-4, fashioned a synthetic version of it, and patented it for use against diabetes. When Eng injected exendin-4 into diabetes-prone mice, it lowered the animals' blood-glucose concentrations for up to a day.

Other scientists have now taken note of this strategy. An American Diabetes Association meeting in New Orleans in June featured a raft of long-lasting versions of GLP1, some being tested in diabetes patients for the first time. Early results show the compounds controlling blood sugar and curbing appetite. If this success is borne out in long-term trials, the experimental compounds could represent a new class of drugs for type 2, or adult-onset, diabetes.

Laboratory findings also reported at the meeting suggest that GLP1 not only revs up the insulin-making beta cells of the pancreas but also refurbish these cells and possibly spawn the growth of new ones. Says Riccardo Perfetti of Cedars-Sinai Medical Center in Los Angeles, "GLP1 doesn't just paint the house, it rebuilds it." If GLP1 mimics also have those effects, these substances would go well beyond current therapies, which concentrate on wringing every last molecule of insulin out of beleaguered beta cells or injecting extra insulin into the body.

UNLIKELY SOURCE — The saliva of the venomous Gila monster (*Heloderma suspectum*) contains a compound that resembles a human hormone active in the pancreas. As such, the lizard compound serves as the model for an experimental diabetes drug.

M. SEWARD

VITAL CELLS Insulin directs the body to process glucose, the simple sugar that delivers energy to cells via the bloodstream. Too much insulin causes low blood sugar, which induces shaking and sweating and can be fatal. Too little insulin makes for high blood sugar, the hallmark of diabetes.

People with type 1 or juvenile-onset diabetes, stop making insulin early in life when a misdirected immune onslaught kills off their beta cells. People with type 2 diabetes usually retain beta cells into adulthood. But at some point, their bodies begin to ignore, or resist, insulin's message. Then beta cells must make more and more insulin to have an effect. Eventually, the overwhelmed beta cells start to commit suicide, sending blood sugar concentrations soaring.

Many middle-aged people with type 2 diabetes initially can control the condition by watching their diets, but they later need to take oral medication, such as Glucophage (metformin), to spur the remaining beta cells to make more insulin. In time, these patients often require insulin injections, as people with type 1 diabetes do.

Beta cells rely on an array of molecular signals to do their job, and GLP1 appears central to the program, Perfetti says. Some evidence suggests that supplies of GLP1 arriving in the pancreas are diminished in people with type 2 diabetes. So in a series of recent laboratory studies, Perfetti and his colleagues obtained beta cells and other pancreas tissue from type 2 diabetes patients and tested whether extra GLP1 would have an effect.

GLP1 inhibits cell suicide among these overwrought beta cells, the researchers found. Moreover, GLP1 exposure boosts the number of beta cells, perhaps by inducing nascent cells in the pancreas to develop into beta cells, Perfetti says. GLP1 switches on genes encoding insulin within the nucleus of beta cells and initiates other actions that make beta cells more robust.

Tests on rats show beta cells with adequate supplies of GLP1 make needed insulin when glucose concentrations rise, a demonstration that proper signaling has been restored in the pancreas.

The peptide seems capable of "making new beta cells appear and preventing old beta cells from dying," says Daniel J. Drucker

Continued on page 108

IN SEARCH OF A SCIENTIFIC REVOLUTION

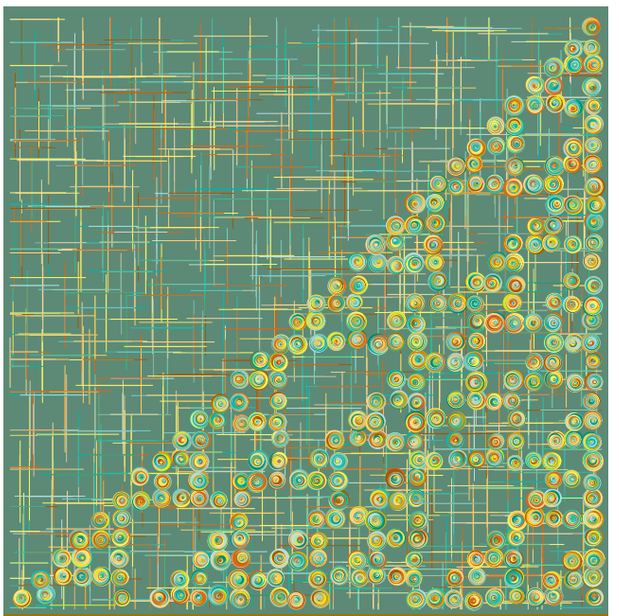
Controversial genius Stephen Wolfram presses onward

BY PETER WEISS

Plenty of people claim to have theories that will revolutionize science. What's rare is for other scientists to take one of these schemes seriously. Yet that's what's happened since May 2002 when theoretical physicist Stephen Wolfram self-published a book in which he alleged to have found a new way to address the most difficult problems of science. Tellingly, he named this treatise *A New Kind of Science.* The book, which Wolfram sent to hundreds of journalists and influential scientists, sparked a firestorm of criticism. Detractors charged that the author was peddling speculations as discoveries, asserting that decades-old research was new, and pirating the research of others without giving due credit. Many commentators concluded that the author's promise of a revolutionary upheaval in science was grandiose and unbelievable, even as they allowed that the book contained some incremental scientific discoveries, as well as intriguing ideas.

Fast-forward to this summer: Wolfram's book is in its fifth 50,000-copy printing, despite being a $45, 1,200-page, technically dense hardback. Dozens of scientific papers have cited the book. Wolfram has hosted the first international conference on his work.

What's going on? Has the man discovered a secret that will cause science textbooks to be rewritten or merely found a formula for mass-marketing science—or something in between? *Science News* takes a look at Wolfram's enterprise 15 months after the book's debut.



ARTFUL AUTOMATON — The pattern from Rule 110—a simple computer algorithm known as a cellular automaton—looks orderly in these initial rows but grows extraordinarily complex. In this artist's depiction, colored disks against an abstract design replace black boxes on a white background.

STEPHEN WOLFRAM LLC

EQUATION EVASION At the heart of Wolfram's work is the observation that extremely simple computer programs can generate patterns of extraordinary complexity. Among such programs are a type known as cellular automata, which scientists have studied for 50 years (*SN: 7/3/99, p. 8*).

To understand what a cellular automaton is, consider a sheet of graph paper on which a pattern can be marked by darkening selected boxes. The top row may have one or more boxes blackened. A simple cellular automaton draws a pattern by beginning with the second row and working its way down the page.

As it considers each box in a row, the automaton observes the box above and those on either side of that higher box. Then, on the basis of a specific rule that depends on which, if any, of those three boxes are dark, the automaton blackens its current box or leaves it blank—and moves on.

Most simple cellular automata generate boring, repetitive patterns. However, one day more than 20 years ago, Wolfram was observing the behavior of a cellular automaton known as Rule 30 when the program created an unpredictable pattern of stunning complexity on a computer printout. That event began a journey of discovery, Wolfram says, that ultimately led him to realize that elementary computer programs offer a way to solve problems in many branches of science without the drudgery and limitations of conventional equations and equation-based simulations.

Although equations have formed the foundation of math and theoretical science for centuries, they often become insoluble when applied to complex phenomena. By contrast, Wolfram contends, simple, complexity-generating programs are the tools of "a new kind of science" that, more accurately and easily than the old one, can simulate complicated phenomena, from the growth of snowflakes to the workings of the universe.

According to Wolfram, this style of simulation will be successful because it mimics how the universe works: Computational processes underlie phenomena from elementary particle interactions to life.

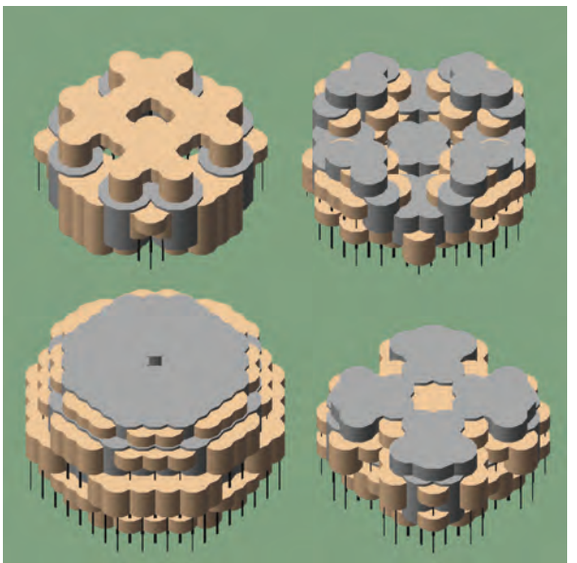
Wolfram has spun off a lot of exhilarating ideas about where this new approach can lead. For example, rather than needing Darwinian evolution to explain the complexity of living creatures (*SN: 6/10/00, p. 382*), Wolfram says that a biological computation process based on a few simple rules could do the trick. In physics, Wolfram's approach suggests that space itself may not be a continuous entity but rather some sort of network of interconnected fragments. The

unpredictability of patterns generated by simple programs, he says, explains how people can exercise free will while their brains obey strict physical laws.

Although Wolfram calls his approach a new kind of science, some elements of it, such as cellular automata, have been investigated for decades. His new work also has links to earlier theories of fractals (*SN: 2/2/02, p. 75*), of chaos (*SN: 10/31/98, p. 285*), and of complexity theory (*SN: 5/6/00, p. 296*). In fact, Wolfram has in the past made notable contributions to research on cellular automata and complexity.

For that reason among others, the man behind *A New Kind of Science* isn't easily labeled a crackpot. A British-born prodigy, he received a Ph.D. in theoretical physics from the California Institute of Technology at age 20 and won a MacArthur Foundation "genius" award 2 years later, in 1981, for his work in physics and computing. Later, he created Mathematica, a software package for scientists, engineers and mathematicians, and developed it into a highly profitable business—Wolfram Research of Champaign, Ill.—which he still leads.

Because of Wolfram's credentials, heavy hitters of science and technology have paid attention to his book, though not necessarily praised it. In the *New York Review of Books* last October, physics Nobel laureate Steven Weinberg of the University of Texas at Austin concluded that Wolfram had written a "failure," albeit "an interesting one." Weinberg found that "not one real-world complex phenomenon . . . has been convincingly explained by Wolfram's computer experiments." Still, he added, Wolfram may have taken a first step toward a much-needed theory of complexity.



BUILDING BLOCKS — A proposed architectural-design tool, inspired by cellular automata, spurs innovation design by exploiting a few simple rules for stacking and removing blocks to generate complex building-like structures.

A critique by inventor and artificial intelligence pioneer Ray Kurzweil of Kurzweil Technologies in Wellesley Hills, Mass., hails Wolfram's work as a "tour de force" on the topic of cellular automata. Nonetheless, Kurzweil says that Wolfram seriously overstated the complexity that simple programs produce. On the topic of living organisms, for instance, Kurzweil asserts that unless factors beyond simple rules are invoked, one can't explain "insects or humans or Chopin preludes."

Fans of Wolfram's work say that much of the negative reaction has stemmed more from the author's self-aggrandizing writing style than from his science. For instance, Wolfram says in his book, "I have discovered vastly more than I ever thought possible, and in fact what I have now done touches almost every existing area of science, and quite a bit besides."

Fans look beyond his habit of frequently and brashly proclaiming the historic importance of his findings. "I believe that some of the ideas in *A New Kind of Science* are going to be very valuable to us in developing predictive models," says medical researcher Elaine L. Bearer of Brown University in Providence, R.I.

RITE OF ASSEMBLY Compared with the harsh treatment Wolfram endured from many reviewers last year, the recent conference on his work was a love fest. More than 200 men and women, paying up to $325 apiece, attended the event June 26–29 at a hotel in Waltham, Mass. They ranged from college students to retirees and represented an eclectic mix of professions and interests, including physics, biology, psychology, medicine, computer science, engineering, economics, business, art, and music. Attendees came from as far away as Norway, Israel, and Australia.

Some people said they were drawn by their admiration for Wolfram; others, by the allure of participating in what could be a historical shift in scientific thought.

"This guy is the closest thing to [Isaac] Newton in 350 years," says Stanley Ruby, a physicist who retired from Stanford (Calif.) Linear Accelerator Center 9 years ago. "I think he's onto something hugely important."

Others, like Carl E. Lippitt of Sandia National Laboratories in Albuquerque, came looking for help with applying Wolfram's concepts to engineering designs.

For instance, Lippitt and his Sandia colleagues are exploring control schemes for proposed battlefield robots that would aid soldiers, for example by carrying extra gear. Because the battlefield is such a complex environment, those robots would require intricate behavioral repertoires. That's where Wolfram's ideas of generating complexity from simplicity seem to fit in, Lippitt says. Yet Lippitt couldn't find in Wolfram's book guidance for developing practical devices.

"It's somewhat difficult to understand, from an engineering perspective, how you go about implementing these ideas," Lippitt says.

During the two-and-a-half-day "minicourse," Wolfram did most of the talking—about 15 hours' worth of lectures—although there were a few panel discussions.

The meeting was too one-sided, says mathematician and science fiction author Rudy Rucker of San Jose (Calif.) State University, even though he's a fan and friend of Wolfram's. "It would be a better conference if somebody besides Stephen was organizing it. Then it could be more of a full spectrum" of opinions, he says.

Kurzweil Tech's vice president of business development Celia Black-Brooks says the meeting's science was over her head, but she had no trouble appreciating the business savvy of Wolfram's firm. "He certainly has a well-oiled marketing machine behind him," she adds.

Wolfram unveiled no new developments in his own work at the conference because there haven't been any to speak of since the book was finished, he told *Science News*. He says he's been too busy giving talks at campuses and laboratories, responding to the 30,000 or so e-mails prompted by the book, and striving to build a scientific movement based on his work. Wolfram predicts that it will be another year before he can get back to the science.

On the other hand, at the conference's poster session, about 10 of the conference goers unveiled projects in which they had used Wolfram's style of computer modeling to explore areas as diverse as explosion dynamics, quantum mechanics, data visualization, and cultural identity.

Among those projects was a cellular automaton created by physicist Larry G. Hill of Los Alamos (N.M.) National Laboratory. The algorithm yields an animation that may mark the first step toward realistic computer models of explosions caused by superheated liquids, Hill says. The dynamics of those fluids have proved too complex for today's conventional equation-based simulations, he adds.

In another project, electrical engineer Rodrigo G. Obando of Fairfield (Conn.) University statistically analyzed cellular automata patterns and translated the results into three-dimensional forms resembling disks, bowls, and hats. Comparing the shapes of those

R. KRAWCZYK/ILLINOIS INST OF TECHNOLOGY

forms may reveal relative degrees of symmetry, complexity, and randomness of automata patterns, Obando says.

VENUE MENU Besides hosting the conference, Wolfram and his associates are moving ahead on other fronts to foster a new scientific movement.

At the meeting—which planners say will be repeated next year—Wolfram distributed a booklet summarizing more than 170 problems and projects that he considers next steps for the field that he has launched: for instance, to "develop automated ways to find 'interesting' cellular automata" and to consider "what might history have been like if cellular automata had been investigated in antiquity."

Wolfram also announced the start of an online clearinghouse for related research (*http://atlas.wolfram.com*) and to found an institute devoted to the approach. What's more, he said he's planning to transform *Complex Systems*, a journal that he founded in 1987, into the flagship publication for the new field.

Although the scientific establishment has largely rejected Wolfram's revolution, academia features a few courses on the topic. For instance, San Jose State's Rucker has been teaching a graduate course on it since the fall of 2002, and Wolfram and his assistants taught a 3-week graduate course in early July at Brown University.

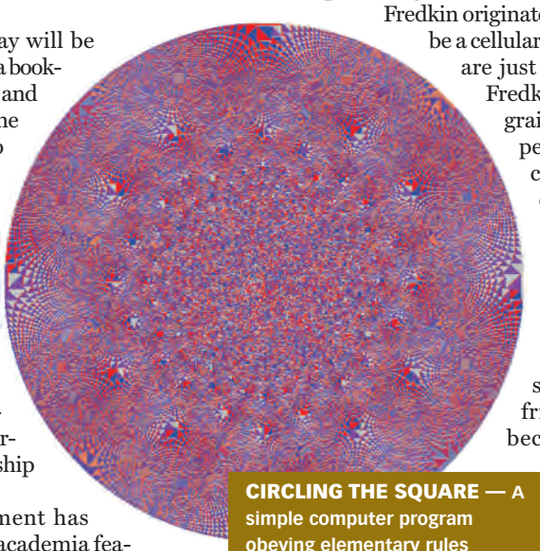
"One of the things universities should do is to be a home for ideas that are controversial, whose long-term potential is uncertain, and that generate a lot of interest and excitement," says Brown's provost, mathematician Robert J. Zimmer. He invited the Wolfram program onto the campus after a Wolfram talk at the school last October proved so popular that people had to be turned away.

One effect of Wolfram's campaign for a new science has been to intensify interest in some longstanding ideas that don't mesh with prevailing theories. For instance, in the early 1980s, Edward Fredkin originated the idea that the universe itself may be a cellular automaton and that energy and mass are just information (*SN: 8/2/97, p. 76*). In Fredkin's model, both space and time are grainy rather than continuous, so space is permeated with exquisitely small, discrete cells whose states change at extremely brief, discrete intervals, just as patterns generated by computers' cellular automata do.

Fredkin, now of Carnegie Mellon University in Pittsburgh, complains that Wolfram has taken credit for some of his ideas. At the same time, he says, his now-famous friend and rival has "done me a favor because a lot more people are interested in what I do because of Wolfram's notoriety."

Wolfram says he's pleased with the his enterprise's progress, which is "a little ahead of schedule." Looking ahead, he predicts that the "first round of serious extensions to the book" will come in 2 to 3 years.

To skeptics and enthusiasts alike, Wolfram readily declares that the revolution has begun. Nonetheless, "it's going to be a while," he admits—another 10 years or so—before his approach will take the place he thinks it deserves at the forefront of science. ■



CIRCLING THE SQUARE — A simple computer program obeying elementary rules creates a strikingly nonrectilinear pattern on a square grid.

J. PROPP/UNIV WISCONSIN-MADISON

Continued from page 104

of the University of Toronto. "We don't yet have the human evidence of that, but that's the excitement that's underlying this field."

VERSATILE VERSIONS When Eng in 1996 presented his data showing that synthetic exendin-4 showed a benefit in diabetes-prone mice, Amylin Pharmaceuticals of San Diego took note. Since then, the company and several other research groups have begun testing long-lasting GLP1 mimics in people with type 2 diabetes. Like GLP1, the experimental drugs seem to have the uncanny capability to trigger only enough insulin production for efficient glucose metabolism. They switch on insulin secretion by beta cells when blood-glucose concentrations rise after a meal.

Amylin's Alain D. Baron reported at the June diabetes meeting that exenatide, the synthetic version of exendin-4, lasts 6 hours in type 2 diabetes patients. Twice-daily injections of the drug induced significant blood-glucose declines in roughly half of 63 patients who had insulin resistance so severe that oral medication had failed them.

What's more, the activity of exenatide doesn't shut off completely when it's no longer detectable in the blood, Baron notes. "Clearly, the drug has an effect above and beyond the time it's administered," he says.

Exenatide caused nausea in some patients, but this side effect faded after several weeks, Baron adds.

If exenatide works as well in a larger study, it might substitute for insulin injections. Amylin is working with Eli Lilly and Co. of Indianapolis to develop a long-acting, slow-release version contained in injectable biodegradable polymer beads.

At the same meeting, the drug company Novo Nordisk of Bagsvaerd, Denmark, presented promising results in diabetes patients receiving injections of a GLP1 mimic called NN2211. Ten diabetes patients showed higher beta cell sensitivity to glucose when getting NN2211 than when receiving a placebo.

Two other GLP1-based drugs enlist the services of albumin, a blood protein with a long half-life. One, a GLP1 mimic called CJC-1131, links with albumin in the blood to increase the drug's durability. Montreal-based ConjuChem is now testing CJC-1131 in people, says Drucker. Although, tests haven't yet established how long its effects last, he would like eventually to see a version that might be given weekly.

The other drug that relies on albumin is called Albugon. Scientists at Human Genome Sciences of Rockville, Md., bioengineered it from the genes for GLP1 and albumin. Albugon lasts roughly 11 hours when injected into mice and 3 days when given to monkeys, says Adam C. Bell, one of the drug's developers.

> "Turning some of these gut hormones into drugs may, in fact, open us up to new treatments for diabetes."
>
> —DANIEL J. DRUCKER

The way that GLP1—and the drugs patterned after it—appropriately switch on insulin secretion by beta cells only when blood-glucose concentrations rise would give such therapy a great advantage over current injected insulin, Bell says.

"The body has evolved an intricate system to sense intake of energy," Drucker explains, and gut cells making GLP1 and other compounds are an integral part of it. "Turning some of these gut hormones into drugs may, in fact, open us up to new treatments for diabetes," he says.

"To promote the formation of new beta cells and prevent the death of susceptible beta cells—that may well transform the way we think about the natural history of diabetes," Drucker says.

Baron predicts that Amylin Pharmaceuticals will next year apply to the Food and Drug Administration for approval for exenatide. ■

OF NOTE

BEHAVIOR

Near-death events take arresting turn

At least 1 in 10 people treated for cardiac arrest, a condition in which the heart stops pumping after it beats unusually quickly, describes mystical-seeming experiences that accompanied the brush with death, according to the largest survey to date of this phenomenon among heart patients.

In contrast, only about 1 in 100 people treated for other comparably serious cardiac problems, such as a heart attack or unstable angina, says that his or her current physical symptoms led to near-death experiences, says psychiatrist Bruce Greyson of the University of Virginia Health System in Charlottesville.

Greyson directed interviews of 1,595 people admitted to his hospital's cardiac-care unit during a recent 30-month period. A total of 27 individuals, including 11 of 116 cardiac-arrest patients, reported having had a near-death experience along with their latest heart symptoms. Near-death events often included sensations of time speeding up or slowing down, peacefulness, separation from one's body, and being in an unearthly place.

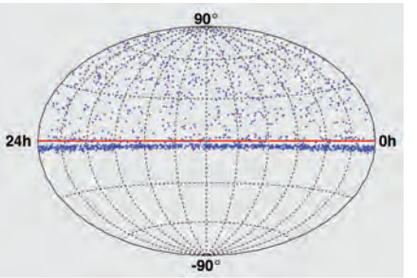
Near-death patients cited more instances of losing consciousness when their symptoms struck and greater acceptance of death than other cardiac patients did. Many members of the near-death group also reported prior instances of extrasensory perception or other purportedly paranormal experiences.

The new results underestimate the frequency of near-death experiences among cardiac-arrest patients, Greyson contends in the July/August *General Hospital Psychiatry*. Amnesia, which often accompanies cardiac arrest, may make it difficult to recall near-death sensations, and some of those who do remember them may stay quiet for fear of being ridiculed or diagnosed as mentally ill. —B.B.

ASTRONOMY

Icy telescope spots hot neutrinos

Scientists have unveiled the first glimpse of the sky by a telescope that detects high-energy neutrinos. By spotting extremely energized neutrinos that emerge from the universe's most violent events, such as collisions between black holes, the new telescope is expected to provide unprecedented insights into such distant phenomena. It can also view high-energy subatomic particles that come from cosmic-ray collisions with atoms in Earth's atmosphere.



AMANDA PROJECT

SUBATOMIC SPRINKLES Clues to distant cosmic cataclysms may lurk in this first sky map of high-energy neutrino sightings.

The telescope is the Arctic Muon and Neutrino Detector Array II (AMANDA II)—a collection of hundreds of sensitive photodetectors sunk deep into the South Pole ice (*SN: 3/27/99, p. 207*). After high-energy neutrinos pass through Earth from north to south, some strike atoms in the ice and produce streaks of blue light. By sensing those streaks, the telescope in effect peers through Earth at the northern sky.

Previously, scientists using other underground detectors have been able to study only relatively low-energy neutrinos from such sources as atmospheric collisions and the sun (*SN: 12/14/02, p. 371*).

AMANDA II's first year of data indicates that nearly all the neutrinos seen were of atmospheric, not deep-space, origin. Because the map correlates to distributions of low-energy, atmospheric neutrinos collected at other detectors, the new telescope is working properly, says AMANDA II team member Francis L. Halzen of the University of Wisconsin–Madison.

Closer scrutiny of the map, plus analysis of 2 years worth of more-recent observations, may reveal hints of more-exciting sources, he adds. The scientists presented their map to a meeting of the International Astronomical Union in Sydney, Australia, on July 15. —P.W.

Botany 2003
July 26 – 31
Mobile, Ala.

SAWGRASS

Everglades plant is he, then she, then he

The signature plant of the Everglades switches gender twice during a week of flowering, according to a Florida study. This synchronized sex change may prevent self-fertilization except in a reproductive emergency.

Great sweeps of sawgrass (*Cladium jamaicense*) inspired the region's nickname, "river of grass," although botanists classify the plant not as a grass but as a sedge, explains Jenise M. Snyder of Florida International University in Miami. Sawgrass does have saws, though. "If you put your hands on the edges of the leaves, you'll get the worst paper cut you could have," she says.

"It's the dominant plant in the Everglades, but there's very little known about its biology," Snyder adds. As the $8-billion, 30-year restoration of the Everglades moves forward, she and her colleague Jennifer Richards are starting to work out the biological basics for the crucial species.

Sawgrass expanses look as if they might have arisen from one plant spreading vegetatively, but Richards' earlier work indicated that the plants often reproduce sexually. Of the dozens of meter-square plots she tested, only 20 percent comprised a single clone of sawgrass. The great sawgrass vista comes from intermingled, small clones.

Richards' finding prompted interest in sawgrass sexuality. A plant's flowering stalk may stretch 3 meters high and scatter 5,000 seeds, Snyder says. Tiny individual flowers bristle on this stalk, and their sex organs mature in close synchrony. At first, one set of male parts in each pair of flowers releases its pollen; then, a female organ matures and captures pollen from other plants. Finally, a second set of male parts releases pollen.

To test whether the wind-pollinated plants could fertilize themselves, Snyder kept sawgrass flowers in bags and dusted ripe female parts with pollen from the same clone. To make sure that the brief exposure to air during hand pollination didn't let windborne pollen confuse the results, the researchers opened other bags for the same amount of time. Quick bag openings proved trivial, and the hand-pollinated flowers set as many seeds as did flowers left to natural pollination.

Botanists haven't analyzed many wind-pollinated plants, Snyder says, but she speculates that the synchronous gender switching reduces a plant's chances of pollinating itself. A complete barrier of self-incompatibility, however, might invite occasional disaster if a plant does get surrounded by clones of itself. —S.M.

LICHENS

Misunderstood stripes confuse individuality

A lichen may have seemed complicated enough back in the good old days, when biologists described it as a partnership between a fungal and an algal species. Lichenologists are now debating even trickier arrangements, such as the stripes of *Neuropogon*.

This lichen genus shows up mostly in polar regions. The typical form grows light and dark bands. Biologists have theorized that the colors represent some fancy adaptation to changing light conditions, but Elfie Stocker-Wörgötter of the University of Salzburg in Austria proposes a quite different explanation. When she teased out bits from each band and grew them as individuals, they showed different forms and chemistry. The bands represent algae pairing with different fungal species, she contends, and DNA tests show they're not even closely related fungi.

Lichenologists had wondered whether what a casual observer would point to as one lichen actually includes genetically different fungi. "This idea had never been rigorously tested," says James Lawrey of George Mason University in Fairfax, Va., but molecular biology now wields the tools to do so. Before Stocker-Wörgötter's report, other lichenologists had found some molecular data suggesting fungal differences, but *Neuropogon* may rank as the most extreme case of an individual lichen including multiple fungi. Stocker-Wörgötter's idea fuels the debate that Lawrey characterizes as, "What—if anything—is an individual lichen?" —S.M.

WATER PLANTS

Next loosestrife is already loose

Water gardeners and aquarium enthusiasts need to be warned about recent escapees from their creations that menace wild wetlands, says a Florida botanist.

Rotala rotundifolia turned up uninvited last year in a northern Alabama pond, and it's moving into Florida canals, according to Kathleen Burks of the Florida Department of Environmental Protection in Tallahassee. It belongs to the same family as the notoriously invasive purple loosestrife, which is choking out natives on stream banks across the country. The new *Rotala*, originally from Asia, grows lush bands of foliage along the water's edge, blooms in swaths of pink spikes, and also thrives underwater. Aquarists treasure the plant's rosy foliage, and aquarium dumping probably loosed it on North America, says Burks.

The snowflake or crested floating-heart (*Nymphoides cristata*), which arrived from Asia in the past 6 years, is also spreading through Florida. Its heart-shaped leaves float on the water surface and five-petaled white flowers rise on little stalks above the leaves. A white ruffle lining the middle of each petal distinguishes the plant from the two natives in the same genus. The introduced species may look just as lovely, but Burks says it quickly covers the water surface with a canopy of its leaves and shades out the native plants underneath. —S.M.

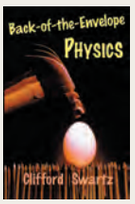
Books

A selection of new and notable books of scientific interest

BACK-OF-THE-ENVELOPE PHYSICS

CLIFFORD SWARTZ

This compilation of some 100 calculations celebrates the quantitative approach physicists use to solve problems. Swartz, the editor of *The Physics Teacher*, provides simple, approximate solutions to physics problems that span a broad range of topics. The author also answers questions such as: Could you lose weight on a diet of ice cubes? How can a person lie on a bed of nails without getting hurt? What is the thickness of the atmosphere? How can you figure out the weight of a car using the footprint of its tires? In each instance, only a few lines of arithmetic and some natural constants are needed to approximate the solution. ***Johns Hopkins, 2003, 155 p., b&w illus., paperback, $19.95.***



GALILEO'S FINGER: The Ten Great Ideas of Science

PETER ATKINS

By isolating and elaborating on 10 great ideas, Atkins summarizes scientific thought since Galileo's time. The core ideas profiled address topics in evolution and the emergence of complexity, DNA and genetics, energy, entropy, the atomic structure of matter, symmetry, quantum theory, curved spacetime, the expanding universe, and mathematics. Atkins introduces readers to the basic concepts behind these ideas and then elaborates on each idea's impact on the world. His overview is an accessible and informative introduction to Western scientific thought. ***OUP, 2003, 380 p., b&w photos/illus., hardcover, $30.00.***

POWER PLAY: The Fight to Control the World's Electricity

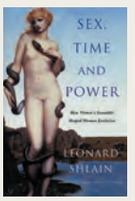
SHARON BEDER

Corporations such as Enron fought long and hard to deregulate the world's electricity supply. They argued that private industry could provide cheaper and better power to more people. The fall of Enron, widespread blackouts in California and Auckland, New Zealand, and electricity rationing in Brazil suggest that this might not be the case. Beder takes a hard look at all aspects of this situation. She reports that electricity wasn't always a public utility. In the early 20th century, several large corporations competed with municipalities for the business. In fact, Beder gives these companies credit for inventing public relations as practiced by corporations today. About 100 years ago, companies were spending heavily on lobbying efforts and propaganda campaigns to shift public opinion to the view that private utilities represented free enterprise. The stock market crash of 1929 changed that because some of these companies crashed with it. Federal legislation reined in the power of such companies, and those Depression-era laws held until the 1990s. Then, countries around the world began to return power supplies to private enterprises. Since then, more than 100 countries have privatized electric companies, in some cases because of pressure from the World Bank and the International Monetary Fund. Beder examines why this latest shift occurred and how it has affected energy consumers around the world. ***New Pr, 2003, 400 p., b&w illus., hardcover, $25.95.***

SEX, TIME, AND POWER: How Women's Sexuality Shaped Human Evolution

LEONARD SHLAIN

Working from the premise that *Homo sapiens* emerged 150,000 years ago in Africa from Mitochondrial Eve, Shlain argues that humans succeeded because of the dramatic change in hormonal cycle that Eve and her female successors experienced. Women evolved from having constant estrus to having monthly menses and hidden ovulation in response to a surge in the death rate of women and infants during childbirth. This was due to cranial size outpacing growth of the pelvis and birth canal. Shlain, a surgeon as well as the author of *Art and Physics* and *The Alphabet Versus the Goddess*, argues that occasional ovulation gave woman control over their sexuality. Since then, the author asserts, men have been battling to regain through misogyny and patriarchal cultures the power they lost 150,000 years. To bolster his arguments, Shlain links the change in women's sexuality to art, calendars, marriage, mayhem, and homosexuality. For instance, Shlain argues that language came about as a means for men to negotiate having sex with women. A monthly cycle gave women a sense of time and foresight, aided humans in becoming fierce predators, made people aware of their mortality, and gave rise to religion. ***Viking, 2003, 420 p., b&w photos/illus., hardcover, $25.95.***



WHERE STUFF COMES FROM: How Toasters, Toilets, Cars, Computers, and Many Other Things Come to Be As They Are

HARVEY MOLOTCH

Most of us put bread into a toaster without really considering how this machine works or how it was designed. Molotch considers those issues for toasters and scores of other inventions, as well as how people desire, produce, and discard durable products. A toaster actually requires a lot of thought before it reaches the consumer: What raw materials are needed to construct it? How is its patent protected? Does its plug meet government standards? How can it be made cheaply enough for consumers to buy? From a sociological perspective, the author considers how such machines influence who we are and how we connect to one other. Interviews with designers, salespeople, and marketing executives forge Molotch's discourse on how utilitarian things go from concept to consumption. ***Routledge, 2003, 324 p., b&w photos, hardcover, $24.95.***

HOW TO ORDER To order these books, please contact your favorite bookstore. *Science News* regrets that at this time it can't provide books by mail.

LETTERS

To be human

I have always been fascinated by the subject of "African Legacy: Fossils plug gap in human origins" (*SN: 6/14/03, p. 371*). I have a simple question: Is there a definitive set of standards (physical or behavioral or both) that defines modern *Homo sapiens*?

LEW ROBERTS, FRANKLIN SQUARE, N.Y.

No. This is a topic that inspires much discussion and debate. —B. BOWER

Not so great

Your article "Not So Green? Using hydrogen as fuel may hurt environment" (*SN: 6/14/03, p. 373*) worries that hydrogen-fuel leakage may add to stratospheric ozone problems. Doesn't that presuppose that the hydrogen for fuel is generated from a fossil source? What if the hydrogen is generated from air, seawater, or biomass?

CLARK WAITE, DESCANSO, CALIF.

The source of the extra hydrogen molecules doesn't matter, says geochemist John M. Eiler of the California Institute of Technology. It's the concentration of atmospheric hydrogen that moisturizes the high-altitude air, which in turn drives the ozone-destroying chemical reactions. —S. PERKINS

In the short article, the words "might," "could," and "may" appear frequently. Whatever happened to the use of the words such as "will" and "won't" by scientists, economists, and environmentalists?

JAMES HENDRY, FLORISSANT, MO.

Take a closer look

"Lithium Sees the Light: Images of tiny ion may help battery designers" (*SN: 6/21/03, p. 388*) exaggerates the capability of transmission electron microscopy by stating that "individual lithium ions" are seen. The research paper described says that the features imaged correspond to columns of lithium, cobalt, and oxygen atoms in a sample estimated to be 17 unit cells thick.

ELIOT D. SPECHT, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENN.

True, but the image we presented from the paper shows the rows of atoms from one end, in effect giving a view of single ions. —J. GORMAN

Correction *In "Why do two-sex geckos triumph?"* (SN: 8/2/03, p. 78*), the genus name for the unisexual geckos should have been spelled* Lepidodactylus *(not* Lepidodactylas*).*

NOW UPDATED WEEKLY!

WWW.SCIENCENEWSFORKIDS.ORG

SCIENCE NEWS for KIDS

Kid-friendly, weekly science articles

Brainteasers and online games

Science fair tips, topics, and news

Cool hands-on activities

Science-fiction writing challenges, book recommendations, and student art

Resources for teachers and parents

Presented by SCIENCE NEWS www.sciencenewsforkids.org