

Stone Age Apes | Climate Complications | Rodent Junkies

Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE

NOVEMBER 21, 2009

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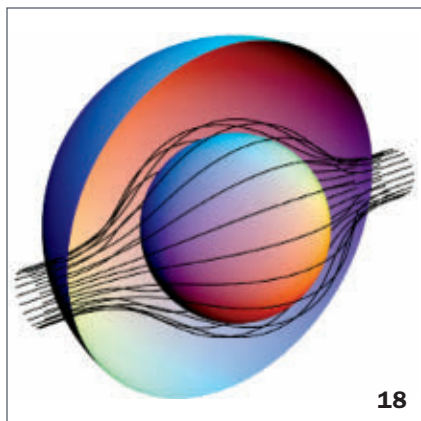
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COVER Invisibility cloaks aren't just the stuff of science fiction anymore. On a tiny scale in the lab, cloaking devices are all the rage in the emerging field of transformation optics.
Cary Wolinsky and Rick Kyle

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FROM THE EDITOR

Value of basic research emerges from under cloak



On Stardate 1709.2 (December 15, 1966 Earth calendar), Kirk, Spock and the rest of the *Enterprise* crew first encountered an enemy ship with a cloaking device, which conferred invisibility by some sort of technological wizardry. Three decades later, a young wizard named Harry Potter brought invisibility

cloaking down to personal size. As freelance writer Charles Petit reports in this issue (Page 18), such fictional cloaking concepts actually have a longer history, with roots stretching back to Plato's *Republic* — not to mention the invisibility cap possessed by Hades, Greek god of the underworld.

But enough of Greek myth. Much more alluring is the non-fiction version of cloaking, brought from fantasy to reality in recent years by research in the field technically known as transformation optics. It seems like magic, and in a way it is. “Any sufficiently advanced technology is indistinguishable from magic,” Arthur C. Clarke, one of the most prescient of science fiction writers, once observed.

Cloaking is not yet hiding anybody from Voldemort's lackeys or thwarting interstellar rescue missions. But its uses will come — for the military if nowhere else. And in any case, its emergence from science fiction into photonic laboratories clearly underscores the intimate relationship between imagination and technology. Flying machines, ray guns, video chatting all were once fictional visions of a distant (and for all anyone knew, impossible) future. Isaac Asimov wrote about pocket calculators decades before they invaded labs and schools. He also foresaw cameras that transmitted photos wirelessly to computers (although he didn't mention that you could use the same devices to make phone calls). Jules Verne imagined rocketry for voyaging to the moon. And Clarke himself famously conceived of communication satellites.

Besides reinforcing the wonder of imagination's prognosticative power, the cloaking story also reiterates that getting from the imagination to its technological realization requires the raw knowledge of basic research. Today's cloaking devices rely on fundamentals of electricity and magnetism and quantum physics and other mathematical insights into natural phenomena produced by basic science, which itself has a history that extends back at least to ancient Greece. Future realizations of science fiction dreams will no doubt also flow from that same stream. When they do, you'll read it here first. — *Tom Siegfried, Editor in Chief*

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Scientific Observations

"You really do hope that when people see something like [gender balance among telomere researchers] working, that this could be seen as, that this would be, the norm. And, the different ratios of men and women researchers in other fields would be the aberrancy. That's what

I'd like to see, because you want women to have access to science because it's such a wonderful thing to do. Anything that makes it more feasible for women to be in science and do the science they like, that's good."

— BIOLOGIST ELIZABETH BLACKBURN IN AN INTERVIEW WITH NOBELPRIZE.ORG ON OCTOBER 5, AFTER LEARNING THAT SHE WAS ONE OF THREE RECIPIENTS OF THE 2009 NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

Science Past | FROM THE ISSUE OF NOVEMBER 21, 1959

MORE PSYCHIATRISTS TODAY BUT STILL ONLY 1 TO 16,400 — Although the total number of psychiatrists in the United States has increased 21% in the last three years, there are still very few in proportion to the population, especially in remote regions away from the big cities The U.S. now has on an average one psychiatrist for every 16,400 persons. But in North Dakota there is only one for every 72,000 persons. South Carolina and Alabama also have ratios of more than 65,000 persons to each psychiatrist. The psychiatrists in the U.S., few in number though they are, do not devote all their time to treating patients Only 15% are engaged solely in private practice. Others must devote part of their time to ...teaching, research, hospital work and clinic work.



Science Future

November 23–24

Global health experts and researchers meet in Toronto to discuss swine flu. Visit new-fields.com/isfc_canada

December 5–9

The American Society for Cell Biology hosts its annual meeting in San Diego. See www.ascb.org/meetings

December 7–18

World leaders and U.N. representatives meet in Copenhagen to hash out a global climate agreement. Visit en.cop15.dk

SN Online

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ON THE SCENE BLOG

Infectious disease experts decry vaccination opposition. Check out "What's with the vaccine-o-phobia?"

Researchers and doctors hope better statistical literacy could improve health care. See "A health care communication revolution."

ATOM & COSMOS

Constructing the space shuttle's replacement may cost too much and take too long, experts say. See "Panel says planned NASA rocket won't do the job."

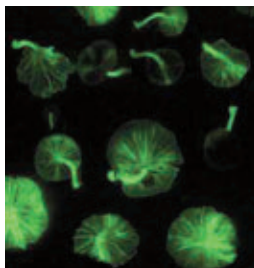


ENVIRONMENT

Traffic pollution is written in the tree leaves nearby. Read "How leaves could monitor pollution."

Introducing...

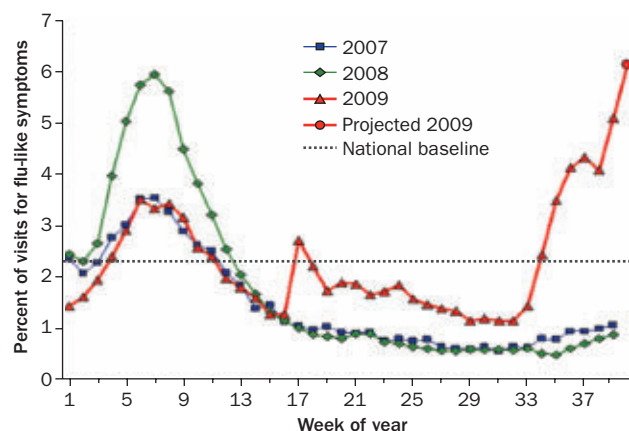
A mushroom from Borneo looks grayish brown in the sun but reveals an eerie glow in the right light. The discovery of *Mycena silvaeuensis* (shown) and six more glowing mushrooms brings the total of known bioluminescent fungi to 71, says taxonomist Dennis E. Desjardin of San Francisco State University. He and his colleagues report the four new species — plus three previously known but now shown



to glow — online October 6 in *Mycologia*. Finding such fungi can mean creeping through jungles at night, trying not to think of jaguars, Desjardin says. Other times though, he simply steps into a closet to view samples collected during day. "The things you do for science."

Science Stats | FLU-LIKE SYMPTOM REPORTS GO UP

Percent of doctor visits for unconfirmed flu cases by week, 2007–09



SOURCE: U.S. OUTPATIENT INFLUENZA-LIKE ILLNESS SURVEILLANCE NETWORK/CENTERS FOR DISEASE CONTROL AND PREVENTION

“ I made a brand new dinosaur hall at the museum three years ago, and now I have to change it. ” — JACK HORNER, PAGE 13

Neuroscience Meeting report

Earth Flood flowed like mighty Mississippi

Genes & Cells Possible speech gene

Life Birds eye magnetic fields

Atom & Cosmos Gift-wrapped solar system

Body & Brain Flu shots for moms-to-be

In the News

STORY ONE

Aerosols cloud climate picture

Reactions may have mixed effects on temperatures

By Sid Perkins

Modeling the climate just got a little more complex. A new simulation that considers chemical interactions among various gases and atmospheric aerosols is giving scientists and policy makers better estimates of the climate-altering effects of those gases, scientists report.

Some atmospheric gases — known as greenhouse gases — trap heat and boost the planet's surface temperature. This process keeps Earth habitable, but nowadays, scientists say, the planet may be getting too much of a good thing. Though most climate simulations include the direct, heat-trapping effects of these atmospheric constituents, few account for how the gases' presence impacts atmospheric concentrations of planet-cooling aerosols, says Drew Shindell, a climate scientist at NASA's Goddard Institute for Space Studies in New York City. "These effects are generally understood but not well quantified," he notes.

Aerosols, particles so small that they remain suspended in the air, come from natural sources such as volcanoes and sea spray but also form in chemical reactions involving the pollutant gases spewing from tailpipes and smokestacks. Light-colored aerosols, such as sulfate droplets, scatter sunlight and reflect some of it back into space, cooling Earth's surface just as natural clouds do.

Recently, Shindell and his colleagues modified a NASA climate model for the first time to consider chemical reactions among major atmospheric constituents and the resulting effect on aerosol concentration. The team's report, in the Oct. 30 *Science*, reveals that some greenhouse gases have a substantially stronger warming effect than previously recognized because they take part in reactions that destroy aerosols, while others actually tend to boost concentrations of cooling aerosols.

The new study "shows that you can't make efficient climate policy without considering the effects of air pollution,"

New work reveals how greenhouse gases interact with aerosols, components of this haze over Los Angeles.

says Almut Arneth, an ecosystem modeler at Lund University in Sweden.

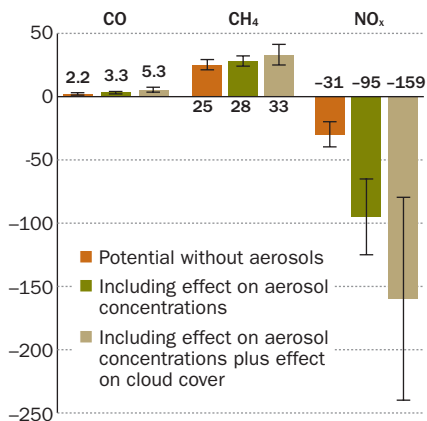
The revised model considers the influence of gases including methane, carbon monoxide and nitrogen oxides on the atmospheric concentration of hydroxyl radicals, highly reactive molecules sometimes referred to as the atmosphere's detergent. Hydroxyl concentrations can be depleted as these radicals react with gases in the atmosphere, slowing the reactions that produce light-colored, light-scattering sulfate aerosols, Shindell says. "And a lower number of aerosols means a lower cooling effect," he notes.

Analyses using the revised model suggest that the aerosol-stifling power of methane and carbon monoxide considerably boosts the planet-warming effect of these gases. Previous studies have shown that a kilogram of methane, over the course of a century, warms Earth



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Gases' warming potential, by weight



Interactions The warming potentials of carbon monoxide and methane increase compared with carbon dioxide, which has a potential of 1, when aerosols are considered. Nitrogen oxides have greater cooling potential.

about 25 times more effectively than a kilogram of carbon dioxide does. But add in methane's hydroxyl-consuming effect, and its planet-warming potential jumps to 28 times that of CO₂, Shindell says, an increase of 12 percent. (Scientists use carbon dioxide as a baseline largely because it is a common, long-lived greenhouse gas in the atmosphere and its warming effects are well known.)

Similarly, carbon monoxide's greenhouse warming potential rises from 2.2 times to 3.3 times that of CO₂ when its hydroxyl-consuming effect is considered. If the inhibiting influence of these two gases on the formation of planet-cooling clouds is also incorporated into the model, their greenhouse effect increases even further.

But the news isn't all bad: The team's model also looked at nitrogen oxides, which can indirectly contribute to warming through ozone production. Various NO_x produced by burning fossil fuels tend to boost hydroxyl concentrations and therefore increase aerosols, tripling the cooling power of the gases. Such emissions are increasing in developing countries but are generally present in trace amounts and are relatively short-lived.

Shindell and his colleagues haven't yet used these new values to make long-term climate predictions under various emissions scenarios. For now, however, the new model could give scientists insight into recent climatic trends. For instance, Shindell notes, "We'll be able to learn how much greenhouse gas warming that aerosols have been masking." Recent studies suggest that as much as 20 percent of the warming in Europe since the 1970s stems from a decline in aerosols, such as fog and haze, during that period (*SN*: 2/14/09, p. 9).

Results of the new model will also enable policy makers to better determine the possible climatic effects of reducing specific types of emissions, especially those that substantially affect pollutants and other aerosols.

Because some greenhouse gases also trim aerosol concentrations, Arneth says, people will have to cut emissions even further to keep Earth's average temperature from rising 2 degrees Celsius above pre-Industrial Revolution levels. "We not only have to think about greenhouse gases, but about pollution too," she says.

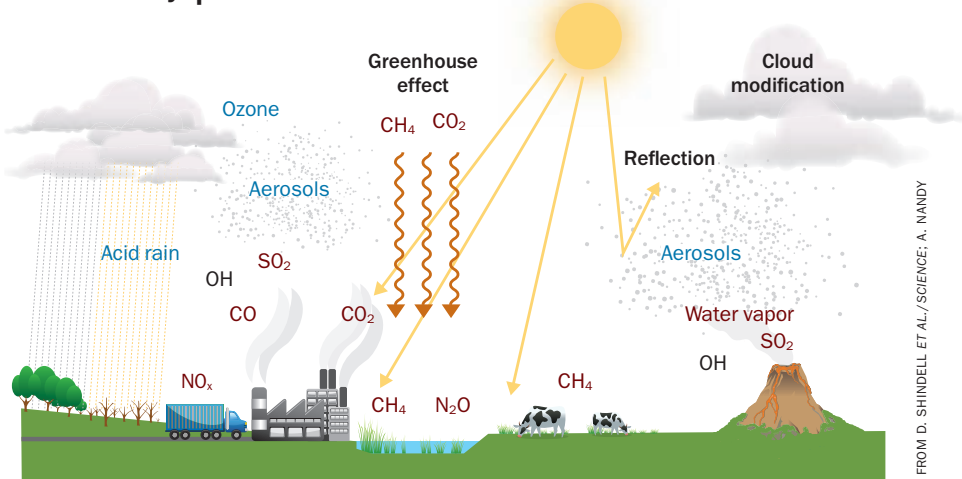
A commentary in the same issue of

Science suggests that megacities, areas with more than 10 million residents (*SN*: 9/8/07, p. 152), are tempting targets for emissions controls. Those areas are large economic engines and can provide a source of funding to address issues of climate change and air quality, says David D. Parrish, an atmospheric scientist at NOAA's Earth System Research Laboratory in Boulder, Colo. Megacities also have sufficient population density to make energy-efficient buildings and cars, as well as mass transit systems, effective tools in the fight to reduce CO₂ emissions, he and colleague Tong Zhu of Peking University in Beijing note.

The newly revised NASA model only begins to address the complexities of atmospheric chemistry, Shindell says. It doesn't, for example, consider how pollutants such as ozone and acid rain suppress the uptake of CO₂ by trees and other plants. "What we're doing is state-of-the-art, but we need to advance substantially," he adds. However, he admits, "some of the effects we're missing locally may not be important globally."

Arneth agrees, "There's quite a lot of work left to be done." ■

Back Story | PLAYERS IN THE TROPOSPHERE



A complex system Natural and man-made processes release all kinds of gases into the air. Some, such as CO₂, trap heat directly, while others contribute to warming through additional reactions. Aerosols can form when SO₂ reacts with water vapor and OH. Though light-scattering aerosols can have a cooling effect, they can also contribute to acid rain and cloud formation. Darker-colored aerosols can contribute to warming. Climate modelers must consider such complex interactions.

FROM TOP: ADAPTED FROM D. SHINDELL ET AL./SCIENCE; A. NANDY

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Junk food turns rats into addicts

Bacon, cheesecake, Ho Hos alter brain's pleasure centers

By Laura Sanders

Junk food elicits addictive behavior in rats similar to that caused by heroin, a new study finds. Pleasure centers in the brains of rats addicted to high-fat, high-calorie diets become less responsive as binging wears on, making the rats consume more and more food, researchers reported October 20. The findings may help explain how changes in the brain could lead people to overeat.

"This is the most complete evidence to date that suggests obesity and drug addiction have common neurobiological underpinnings," said study coauthor Paul Johnson of the Scripps Research Institute's Florida facility in Jupiter.

To see how junk food affects the brain's natural reward system — the network of nerve cells that release feel-good chemicals — Johnson started at the grocery store, loading up on Ho Hos, sausage, pound cake, bacon and cheesecake. He fed rats either a standard diet of high-



Lab rats had to eat more and more junk food over time to get a pleasure high.

nutrient, low-calorie chow or unlimited amounts of the palatable junk food. Rats that ate the junk food soon developed compulsive eating habits and became obese. "They're taking in twice the amount of calories as the control rats," said Johnson's coauthor Paul Kenny, also of Scripps Florida.

Johnson and Kenny used electrical stimulations to activate pleasure centers in the rats' brains, regions responsible

for drug addiction. Rats controlled the amount of feel-good stimulation by running on a wheel — the more they ran, the more stimulation they got. Rats fed junk food ran more, indicating that they needed more stimulation to feel good.

After five days on the junk food diet, rats showed "profound reductions" in the sensitivity of their brains' pleasure centers, suggesting that the animals quickly became habituated to the food, Kenny said. As a result, the rats ate more to get the same amount of pleasure — just as heroin addicts require more and more drug to feel good. "They lose control," Kenny said. "This is the hallmark of addiction."

Reward pathway deficits persisted for weeks after the rats stopped eating the junk food.

Scientists are interested in determining the long-term effect of altering the brain's reward system. "We might not see it when we look at the animal," said obesity expert Ralph DiLeone of Yale University School of Medicine. "They might be a normal weight, but how they respond to food in the future may be permanently altered."

Exercise helps brain rebound

Running protects neurons in monkeys from damage

By Laura Sanders

A toned, buff bod isn't the only thing a workout is good for. Exercise protects special brain cells in monkeys and improves motor function, a new study finds. The data, presented October 18, add to a growing body of evidence that shows exercise is good for the brain, too.

"This is sort of a quiet revolution that's been occurring in neuroscience, to realize that physical activity at a certain level impacts the brain in a really profound

way," said brain aging expert Carl Cotman of the University of California, Irvine.

In the new study, researchers led by Judy Cameron of the University of Pittsburgh trained six adult female rhesus monkeys to run on treadmills built for humans. Over three months, monkeys ran, jogged or sat on a treadmill for five hours each week. Monkeys that ran reached heart rates of about 80 percent of maximum, comparable to a human training program for cardiovascular fitness. The jogging monkeys' heart rates reached about 60 percent of maximum.

After this training, researchers hit the right side of the monkeys' brains with MPTP, a neurotoxin that selectively kills neurons that produce the signaling chemical dopamine. These neurons and their dopamine regulate movement.

Sedentary monkeys showed a decrease in dopamine neurons after the neurotoxin was applied. But in the brains of monkeys that had run for three months, the neurotoxin had almost no effect. Jogging also had a protective effect, though it was slightly weaker than running's effect, Cameron said. "This is really good news. It means that any little bit more activity you can do is positive for your brain."

When the researchers continued the experiment for another six weeks, the results held. Brain scans revealed that "the animals that were exercising had virtually no loss of dopamine in those neurons," Cameron said.

In separate experiments, the researchers found that monkeys that didn't exercise were unable to perform some movements that the runners could.

“This is the most complete evidence to date that suggests obesity and drug addiction have common neurobiological underpinnings.” — PAUL JOHNSON

Single brain cells selectively fire in response to specific thoughts

Thinking about her face activates ‘Halle Berry’ neuron

By Laura Sanders

The Halle Berry fan club is expanding one brain cell at a time. By eavesdropping on the activity of single neurons in the human brain, scientists have figured out which brain cells go wild for superstars such as the popular actress. And the newest research shows that people can activate those cells selectively.

“This study is the first demonstration of humans’ ability to control the activity of single neurons,” the researchers wrote in a summary of their study, presented October 19 by Moran Cerf of the California Institute of Technology. The work may help explain how each cell in the brain sees and responds to the world.

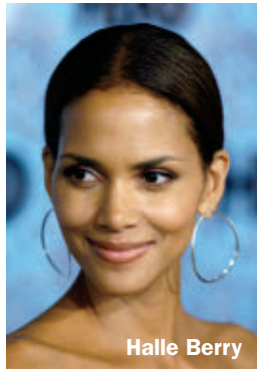
“This type of work gives us some clues about what’s going on in the brain,” comments Christoph Weidemann of the University of Pennsylvania, who studies how the brain processes information. “It’s quite an amazing feat for the brain to make sense of its input and reliably recognize people and objects.”

The new study was conducted on people with epilepsy. Doctors had implanted electrodes in these patients’ brains to track where seizures originate. Researchers used the same electrodes to record the activity of single brain cells in a part of the brain called the medial temporal lobe, which is important for memory, attention, perception — “the things that we care about the most,” Cerf said.

Before the experiment, Cerf and colleagues showed volunteers familiar images of people, objects or places, including images of Bill Clinton, Michael


Jackson and Venus Williams, among others. “We hoped to locate neurons in their brains that respond selectively to one of those concepts,” Cerf said in his talk.

In each patient, researchers found about five neurons that fired when the patient viewed an image of a certain person or object. A person might have, for example, a spider neuron, a Michael Jackson neuron, a Marilyn Monroe neuron, an Eiffel Tower neuron and a Halle Berry neuron.




Halle Berry

Once these neurons were identified, researchers wanted to know if the patients could control each neuron by thinking about that certain person or object. Cerf and colleagues hooked up the neuron-sensing electrodes to a computer that then displayed images representative of the person’s thought, so when a patient’s Marilyn Monroe neuron became active, the screen showed her image.


To see how well the patients could control single neurons, researchers set up “fade” experiments. One version involved a neuron that responded to Josh Brolin and another that responded to Marilyn Monroe. Initially, the person was shown a hybrid image of the two stars. When the person was told to think of Josh Brolin, electrodes recorded that neuron’s activity and sent the data to the computer, causing the Monroe image to fade and the Brolin image to brighten. The experiment was finished when the picture was completely Brolin or Monroe, or when 10 seconds had elapsed. Ten patients successfully directed the pictures between 60 and 90 percent of the time. With practice, the patients became better at controlling the neurons. 

MEETING NOTES

Obesity’s long reach on brain

Sons of obese mother mice grow up fat, anxious and with signs of brain inflammation, Staci D. Bilbo of Duke University in Durham, N.C., and colleagues reported October 18. Comparing the offspring of female mice that ate a low-fat diet or one of two kinds of high-fat diets, researchers found that the brains of pups born to moms fed a diet high in saturated fats showed increased levels of interleukin-1, a marker of inflammation. Previous work showed that high levels of IL-1 impair learning and memory. But to Bilbo’s surprise, the affected offspring didn’t have obvious problems when tested in a water maze. Males born to moms on the diet high in saturated fats were also fatter and more anxious than other pups. The male mice’s obesity persisted into adulthood even though they were switched to low-fat diets when weaned. Bilbo is analyzing data to find out how many generations might pay the price for mom’s over-indulgence. — Tina Hesman Saey 

Beetle bifocals

Sunburst diving beetle (*Thermonectus marmoratus*) larvae possess a grand total of 12 eyes, four of which are naturally bifocal, researchers reported October 17. These marine beetle larvae are voracious predators, tracking and eating mosquito larvae. Annette Stowasser and her colleagues at the University of Cincinnati found that the four most prominent eyes on these aquatic hunters hold several retinas apiece, allowing the eyes to clearly focus on objects at two distinct distances. Researchers speculate that the strange eyes might help beetle larvae better spy prey. — Laura Sanders 

Earth



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Deadly Johnstown Flood matched torrential force of Mississippi River

New work determines flow rate after catastrophic dam failure

By Sid Perkins

A famously devastating 1889 flood in Johnstown, Pa., transformed a small river into a torrent that briefly rivaled the mighty Mississippi, a new study reveals.

Johnstown, which lies about 100 kilometers east of Pittsburgh, was a thriving coal- and iron-producing town in the years after the Civil War, says Carrie Davis Todd, a hydrologist at the University of Pittsburgh at Johnstown. Then, on the rainy afternoon of May 31, 1889, a dam about 23 kilometers upstream of the town burst, sending a wall of water down the narrow valley of the Little Conemaugh River. More than 2,200 people died — a death toll aggravated by the fact that floodwaters had already filled the streets and trapped many residents in their homes, Davis Todd reported October 19.



These buildings sat within the 30-acre area that was devastated in downtown Johnstown, Pa., in 1889.


“There’s a ton of anecdotal information, but few people have ever looked at [the flood] in a scientific way,” says Dan Ingram, curator at the Johnstown Area Heritage Association.

Using modern-day surveys of the area and archival photos, Davis Todd and her colleagues estimate that the 1.6-square-kilometer reservoir behind the dam held about 15 million cubic meters of water. The pressure of accumulated waters

and erosion from water spilling over the top of the dam triggered a sudden, catastrophic failure, Davis Todd said. Peak discharge through the 90-meter-wide, 13-meter-high breach in the dam exceeded 8,500 cubic meters per second — about three times the flow rate across Niagara Falls.

As devastating as that torrent would have been, the flow that slammed into Johnstown moved even faster, Davis Todd and her colleagues estimate. Debris swept along by the initial surge of floodwaters added to the deluge, and more than 12,000 cubic meters of debris-filled water hit the town each second. Flow rates in the Mississippi River typically vary between 7,000 and 20,000 cubic meters per second, Davis Todd said.

Eyewitnesses said the flood arrived as “a wall of black mist,” Ingram says. That initial surge was quickly followed by a 10-meter-deep torrent chock-full of rocks, trees and even locomotives swept off the rails along the river.

The new findings will help researchers better explain the devastating force of the flood and how the disaster unfolded. “This is one of those events that everyone’s heard of but nobody knows the story behind,” Ingram notes. 

Ancient beavers did not eat trees

Now-extinct giant creatures had hippopotamus-like diet

By Sid Perkins

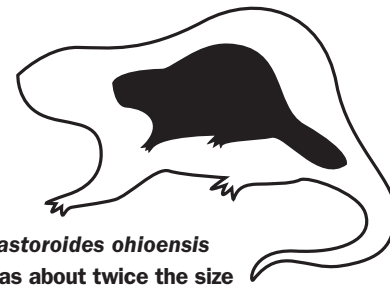
Behemoth beavers were no threat to trees during the last ice age.

The giant beaver *Castoroides ohioensis* roamed North America near the end of the last ice age. Fossils indicate that it weighed between 60 and 100 kilograms, says Catherine Yansa of Michigan State University in East Lansing.

Yansa and University of Wisconsin–


Whitewater colleague Peter Jacobs analyzed material from a giant beaver’s jawbone, which was unearthed in southeastern Wisconsin. Carbon dating analysis showed that the creature lived around 14,500 years ago, Yansa reported October 19. Pollen and plant fossils at the site suggest that the environment then was cold and marshy with relatively few trees.

Modern beavers eat mainly tree bark and the underlying tissue called cambium. But when Yansa and Jacobs analyzed the composition of an ancient beaver tooth, the ratio of carbon-13 to carbon-12 isotopes fell well outside the range expected for a creature eating trees. The ratio suggests the beaver



Castoroides ohioensis was about twice the size of modern beavers in North America.

ate mainly aquatic plants. “Ecologically, the giant beavers were like little hippos,” Yansa said.

Younger fossils at the site show that forests crowded out wetlands as the ice age lifted, creating prime habitat for modern beavers. 

Genes & Cells



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Gene implicated in speech evolution

Duplicated DNA aided vocal cord flexibility, study suggests

By Tina Hesman Saey

Humans may owe the gift of gab to a newly discovered gene that helps keep vocal pipes limber.

Researchers discovered the gene, dubbed *tospeak*, in an Australian family with a speaking disorder. Many of the women in the family have weak, husky voices, while several of their male relatives cannot speak above a whisper, Raymond Clarke of the University of New South Wales' St. George Hospital in Kogarah, Australia, reported October 21.

Clarke and colleagues traced the family's disorder to chromosome 8. Part of that chromosome had been rearranged, causing a break in the *tospeak* gene. *Tospeak* probably doesn't code for a protein, Clarke says. And though the RNA produced from the gene doesn't resemble RNAs known to have specific cell functions, *tospeak* RNA seems important for proper development of the larynx.

Family members with the speaking problem have short, thick vocal cords that don't vibrate properly. Some family members also have fused carpal and tarsal bones (in the wrists and feet) and fused vertebrae. All of the defects may be linked to a breakdown in relations between *tospeak* and a neighboring gene known as *GDF6*, the researchers reported.

GDF6 helps control bone and eye development. Loss of the gene leads to fusion of tarsals and carpals in mice. And mutations in *GDF6* lead to fusion of neck vertebrae in people with a genetic disorder known as Klippel-Feil syndrome, the researchers found. Those discoveries indicate that *GDF6* helps keep joints flexible, Clarke says. The new study suggests that *GDF6* may also allow humans to stretch their vocal cords and create a range of sounds necessary for speech.

Clarke's group found that the *tospeak* gene overlaps a DNA region that regu-

lates *GDF6*'s activity in the carpals and tarsals. Disrupting *tospeak* also appears to interfere with *GDF6* activity.

By looking for the gene in various species, the researchers discovered that *tospeak* first appeared in primates. In humans, part of the genetic control panel that governs *tospeak* activity was duplicated, resulting in higher activity of the gene in humans than in chimpanzees or other primates. Revved-up *tospeak* activ-

ity probably tweaks *GDF6* levels as well, giving humans more flexible voice boxes than other primates, Clarke said. That advantage could have allowed humans to develop language, he said.

Other experts say changes in the brain were more important than alterations of the larynx for the evolution of language. "It is reasonable to expect that anatomical and physical changes have expanded our vocal repertoire," says geneticist Simon Fisher of the Wellcome Trust Centre for Human Genetics in Oxford, England, but "the idea that it's the larynx that underlies speech is overly simplistic."

Slow healing in diabetics linked to bacterial mix

Mouse study finds difference in skin wound microbe types

By Tina Hesman Saey

Too much of the wrong type of skin bacteria may explain slow wound healing in people with diabetes.

A study of bacterial diversity on the skin of diabetic and normal mice suggests that bacteria normally present on healthy skin may play a role in wound healing, Elizabeth Grice of the National Human Genome Research Institute in Bethesda, Md., reported on October 23.

The new work aims to find out how bacteria and other microorganisms on the skin — known collectively as the skin microbiome — affect health.

People with diabetes have a notoriously hard time healing from skin wounds. At any given time, about 15 percent of patients with diabetes have a slow-healing wound, Grice said. Previous work revealed that such wounds contain *Staphylococcus*, *Streptococcus*, *Pseudomonas*, *Enterococcus* and *Corynebacterium*. But a survey of healthy skin

showed that those bacteria are also a normal part of the skin microbiome.

Grice and her colleagues compared bacteria from the skin of diabetic mice with those from the mice's healthy siblings. Diabetic mice had 40 times more bacteria on their skin than healthy mice, but fewer types of microbes. The researchers used a skin punch, like those used by dermatologists to take skin samples, to make a small wound on the mice's backs. Wounds in normal mice healed in about two weeks, but healing took nearly a month for the wounds on diabetic mice.

Diabetic mice had higher levels of *Staphylococcus* and certain other bacteria, such as *Aerococcus* and *Weissella*, in their wounds. Injury sites in normal mice had increased levels of *Clostridium* and *Streptococcus*.

Grice doesn't know whether the shifts in microbes impair wound healing or are a result of slow healing or other differences in the skin of diabetics. She hasn't yet sampled bacteria in people with diabetes, but the work may lead to improved ways to treat wounds in those patients.

It is "an important step towards linking the diversity of microbial distribution in diabetic wounds and their role in healing, thus providing a potential therapeutic target," says immunologist John Lambris of the University of Pennsylvania School of Medicine in Philadelphia.



In European robins, eyes beat out beaks for sensing magnetic fields

Migratory compass relies on light-processing brain area

By Laura Sanders

A cell in the eye may be worth two in the beak, at least when it comes to a migratory bird's magnetic compass. In European robins, a visual center in the brain and light-sensing cells in the eye — not magnetic sensing cells in the beak — allow the songbirds to detect which direction is north and migrate correctly, scientists report in the Oct. 29 *Nature*.

"This is really fascinating science," says biophysicist Klaus Schulten of the University of Illinois at Urbana-Champaign, one of the first to suggest that migrating birds could sense magnetic fields.

Researchers have known that built-in biological compasses tell migrating birds which way to fly, but exactly how birds detect magnetic fields has been unclear.

"This is basically the sixth sense of biology, but no one knows how it works," says study coauthor Henrik Mouritsen of the University of Oldenburg in Germany. "The magnetic sense is by far the least understood sense in the natural world."

Some researchers had proposed that

iron-based receptors in cells in the upper beaks of some migratory birds sense the magnetic field and send that information along a nerve to the brain. Other scientists have favored the hypothesis that light-sensitive cells in birds' eyes sense the magnetic field and send the information along a different route to a light-processing part of the brain called cluster N.

Proteins called cryptochromes in the birds' eyes may mediate this light-dependent magnetic sensing, Mouritsen says. Light hitting the proteins produces a pair of free radicals, highly reactive molecules with unpaired electrons. These electrons have a property called spin that may be sensitive to Earth's magnetic field. If so, Mouritsen thinks the free radicals could signal nerve cells in cluster N, ultimately telling the birds where north is.

To find the location of the magnetic compass, Mouritsen and colleagues caught 36 migratory European robins and made sure that the birds could all orient correctly under natural and induced magnetic fields. Next, the researchers severed the nerve that connects the




For migratory navigation, European robins appear to use light-sensing cells to detect the Earth's magnetic field.

beak cells to the brain or, in other birds, damaged the brain cells in cluster N that receive light signals from the eye.

Birds with the severed beak-to-brain nerve — called the trigeminal nerve — still oriented perfectly, Mouritsen says. "No information from those iron crystals could get to the brain, but the birds oriented just as well," he says.


On the other hand, birds with damaged cluster N regions could no longer sense and orient to magnetic fields.

The study "nicely confirms that the trigeminal nerve is not involved in this direction sensing," says John Phillips of Virginia Tech in Blacksburg.

Mouritsen thinks beak cells might play a different role in magnetic sensing, such as picking up minor changes in magnetic field strength along a north-south axis. 



Blood perfume lures spiders

For the jumping spider *Evarcha culicivora*, shown dining here, the scent of a recent meal of blood-fed mosquitoes enhances mating allure. Engorged-mosquito breath proves attractive to both males and females among *E. culicivora*, says spider biologist Fiona Cross of the University of Canterbury in Christchurch, New Zealand. She and colleagues tested the preferences of both spider sexes by timing how long they lingered in a stream of air wafting over potential mates that had different dining histories. This species, native to East Africa, is the only animal known to feed on vertebrate blood indirectly. The spiders don't do blood sucking themselves but seek out mosquitoes that have bitten vertebrates. A spider's food odors may give clues to its potential quality as a mate, the researchers speculate online November 3 in *Proceedings of the National Academy of Sciences*. A question raised by the allure of blood perfume is whether an indirect blood diet enhances egg or sperm production. — Susan Milius 

“The magnetic sense is by far the least understood sense in the natural world.” — HENRIK MOURITSEN

Three dino ages, not dino types

Fossils may show one group at different growth stages

By Lisa Grossman

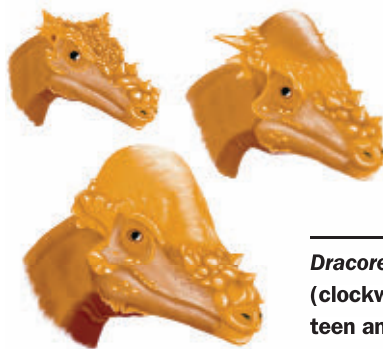
Three dinosaurs thought to belong to different groups are actually kids, teens and adults of the same genus, researchers report October 27 in *PLoS ONE*.

“I made a brand new dinosaur hall at the museum three years ago, and now I have to change it,” says study coauthor Jack Horner of the Museum of the Rockies in Bozeman, Mont. “We’ve named twice as many dinosaurs as there probably are.”

Pachycephalosaurus wyomingensis had

a large domed skull that some argue was used to butt heads in dominance displays. *Stygimoloch spinifer* had a smaller dome and menacing spikes protruding from the back of its head, while *Dracorex hogwartsia* had horns dotting its flat, long snout.

These distinctive bumps and knobs were thought to differentiate related genera. But Horner and his colleagues



had doubts and so cut open bones and skull fragments from fossil specimens to see how old the individual dinosaurs had been when they died.

Bones from *Pachycephalosaurus* were dense and canal-free, suggesting that it was an adult. *Stygimoloch* and *Dracorex* both had spongy, porous bones characteristic of youth. “We haven’t found anything that would be called a *Pachycephalosaurus* that has juvenile bones, and we haven’t found anything that anyone would call a *Stygimoloch* or a *Dracorex* that has mature bones,” Horner says. “Using bone ... we can probably reduce the number of species by a third.”

***Dracorex*, *Stygimoloch* and *Pachycephalosaurus* (clockwise from top left) may actually be the juvenile, teen and adult forms of the same dinosaur genus.**

Pheromone is a turnoff for bed bugs

Males find mates by trial and error and avoiding scent of alarm

By Susan Milius

Male bed bugs get confused in bed. Now a scientist has found a bug chemical signal that says, “Whoa, buddy. I’m a guy too.”

Male bed bugs grasp and try to mate with any other member of their *Cimex lectularius* species that has had a full meal of blood recently, says chemical ecologist Camilla Ryne of Lund University in Sweden. Single-minded males don’t seem inclined, or even able, to distinguish other males from females at first.

Initial recognition of a potential mate works largely by trial and error, Ryne says. What corrects those errors, she finds, is a chemical blend previously described as an alarm pheromone. “This is the first time to my knowledge that anyone has shown that alarm pheromones are used for sexual recognition,” Ryne says.

Females can release the substance when disturbed but typically don’t when grasped by a male, Ryne says. But males do exude the scent when grabbed by

another male. After a whiff of the stuff, misguided suitors back off, Ryne reports online October 24 in *Animal Behaviour*.

Considering that bed bugs are making a comeback as a pest in the industrialized world, “knowing how they mate is important,” says entomologist Joshua Benoit of Ohio State University in Columbus. His studies of the pheromone also suggest that the bugs use it in several ways.

Pheromones may have achieved fame as dizzying lures for the opposite sex, but biologists have discovered plenty of other kinds: Compounds can fuel aggression among male mice or urge baby rabbits to search for a nipple.

When disturbed, bed bugs release a blend of (*E*)-2-octenal and (*E*)-2-hexenal, Ryne says. A mating attempt might indeed be disturbing, since males deliver their sperm by

what’s called traumatic insemination. They ignore the opening to the female reproductive tract and inject sperm with a needlelike appendage directly through the outer covering of a mate’s body. In the abdominal area most commonly pierced, female bed bugs grow a mass of the kinds of cells associated with immune defense. Males, though, have no extra protection there.

To test the idea that the alarm pheromone helps mistakenly targeted males free themselves, Ryne painted nail polish over the glands that produce the substance, thus blocking its release. Males that couldn’t signal chemically ended up in longer embraces than males dabbed elsewhere with nail polish.

In another test, Ryne collected the substance by washing disturbed males with a solvent. When she wafted the extract over mating pairs of males and females, the males backed off. Even with a suitable mate, the signal disturbed the males.



Not so alarming: A male bed bug mates with a female.

Atom & Cosmos



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Photons' photo finish puts limits on grainy space

Light-speed result challenges theories of quantum gravity

By Ron Cowen

Smaller dots Georges, please.

In their efforts to unify quantum theory and gravity, theoretical physicists have likened spacetime to a Georges Seurat painting, composed of tiny dots or lumps that meld to form a seemingly smooth picture. But if spacetime really does have a grainy structure on the smallest scales, the cosmic painter may need to get finer brushes, new observations reveal.

A report published online October 28 in *Nature* suggests that the dots that may make up spacetime must be smaller than a hundred-millionth of a trillionth the size of a proton, one-thousandth the size indicated by less sensitive experiments.

Sylvain Guiriec of NASA's Marshall Space Flight Center and colleagues measured the relative difference in the speed



Photons emanating from a gamma-ray burst (illustrated) travel at about the same speed regardless of their energies.

of two particles of light, or photons, of widely different energies. Both were emitted by a cosmic explosion known as a short-lived gamma-ray burst.


Many theories of gravity at subatomic distances view space as lumpy or foamy on tiny scales. Such theories suggest that the lumps would alter the speed of light by an amount that depends on the photon's energy: The more energetic a photon, the slower its speed. This slight slowdown

could in principle be detectable over a journey of several billion light-years.

This possibility led Guiriec and colleagues to examine photons from a gamma-ray burst that erupted 7.3 billion light-years from Earth. Recorded by the Fermi Gamma-ray Space Telescope on May 10, the burst produced an assortment of gamma-ray photons, including one with an energy of 31 billion electron volts and another about one-tenth as energetic.

After traveling for 7.3 billion years, the photons arrived at the Fermi telescope less than 0.9 seconds apart, a speed difference of no more than one part in 100 million billion, notes study coauthor Peter Michelson of Stanford University.

Speed differences would violate Lorentz invariance, which requires identical laws of physics regardless of observers' relative uniform motion, a tenet of Einstein's theory of special relativity. The Fermi result upholds special relativity, ruling out quantum gravity theories that violate Lorentz invariance substantially.

John Ellis of CERN in Geneva cautions that effects of spacetime graininess on photon speed can't easily be distinguished from other effects, such as light scattering in the intergalactic medium. 

Extrasolar planet population grows

Roster tops 400 with 32 additions, including 6 superEarths

By Ron Cowen

About half of all sunlike stars host light-weight planets less than three times Neptune's mass — some perhaps only a few times heavier than Earth, a team of European astronomers concludes.

The team's assessment accompanies the discovery of 32 more planets beyond the solar system, extending the list of known extrasolar planets to over 400.

"These low-mass planets are everywhere," team member Stéphane Udry of Geneva Observatory in Sauverny, Switzerland, notes. "Models are pre-

dicting them and we are finding them."

The new mother lode increases by about 30 percent the number of low-mass planets — those with a mass of less than 20 Earth masses — Udry says.

He and his colleagues reported the findings October 19 during a conference at the University of Porto in Portugal. Udry says his team expects to announce the discovery of another 30 or so extrasolar planets within the next six months.


"All I can say is, 'Wow, what a bonanza of planets,'" says theorist Sara Seager of MIT, who was not on the discovery team.

The new roster of planets includes six

superEarths, so classified because their masses are five to 10 times that of Earth.

"This proves that [superEarths] are very common. Even if you are not looking for them, you are finding them," Udry says. SuperEarths — at least those with short-period orbits — appear to be at least three times more common than giant, Jupiter-like planets, he adds.

That dovetails with a finding reported last year by Udry and colleagues, using a smaller data set, that as many as 30 percent of all sunlike stars may harbor short-period superEarths (*SN*: 7/5/08, p. 7).

His team is trying to extract from the numbers how common Earth-mass planets and superEarths are, a task for which NASA's Kepler mission, launched this year, may provide the best results. 

16.637 billion
kilometers

Voyager 1's distance
from the sun as
of September 25

13.493 billion
kilometers

Voyager 2's distance
from the sun as
of September 25

At solar system's edge, astronomers find a surprise wrapped in a ribbon

IBEX results raise questions about heliosphere's boundary

By Ron Cowen

The first global map of the solar system reveals that its edge is tied up with a ribbon — nothing like what had been predicted, astronomers have discovered.

NASA's Interstellar Boundary Explorer satellite, or IBEX, found the narrow ribbon, which completes nearly a full circle across the sky. IBEX records neutral atoms — the only way to image the fringes of the solar system — and found the atoms densely packed into a narrow ribbon rather than evenly distributed.

"Our maps show structure and energy spectra that are completely different from what any model has predicted," says study coauthor Herbert Funsten of the Los Alamos National Laboratory in New Mexico.

The ribbon and related findings, reported online in six papers October 15 in *Science*, will not only send theorists back to the drawing board, but also may provide new insight on the interaction between the heliosphere — the vast bubble in which the solar system resides — and surrounding space.

The bubble is inflated by the solar wind, the high-speed stream of charged particles blowing out from the sun. For 48 years, researchers have assumed that the solar wind sculpted the structure at the heliosphere's boundary with interstellar space, says Tom Krimigis of Johns Hopkins University's Applied Physics Laboratory in Laurel, Md. But the newly found ribbon's orientation suggests that the galaxy's magnetic field is the chief organizer of structure at the edge of the heliosphere, says theorist Nathan Schwadron of Boston University, a lead author of one of the studies.

"First and foremost, this is a big surprise because we thought we knew a lot about this region, the edge of the heliosphere," says David McComas of the Southwest Research Institute in San Antonio. The Voyager 1 craft in 2004 (*SN*: 1/3/04, p. 7) and Voyager 2 in 2007 (*SN*: 8/2/08, p. 7) crossed the termination shock — where the solar wind encounters the influx of particles from interstellar space — on opposite sides of the solar system. Both craft recorded the density of particles and the strength of the magnetic fields.


Voyagers 1 and 2 missed seeing the ribbon because it spans a region between their flight paths, McComas says.

It's not known whether the ribbon is permanent. Also puzzling are observations of the same boundary region with an instrument on the Cassini spacecraft, which recorded the atoms at higher energies than IBEX did. From its vantage point at Saturn, Cassini sees a belt rather than a ribbon, Krimigis' team reports in *Science*. The belt is substantially broader than the ribbon seen by IBEX but is in the same area.

The heliosphere shields the solar system from 90 percent of energetic cosmic rays — high-speed charged particles that would otherwise bombard the planets and harm life. Understanding more about the heliosphere and its ability to filter out galactic cosmic rays could be critical for assessing the safety of human space travel, Schwadron notes. The findings may also help predict how the heliosphere varies in shape and size as it moves through the galaxy and encounters space with different densities and magnetic field strengths.

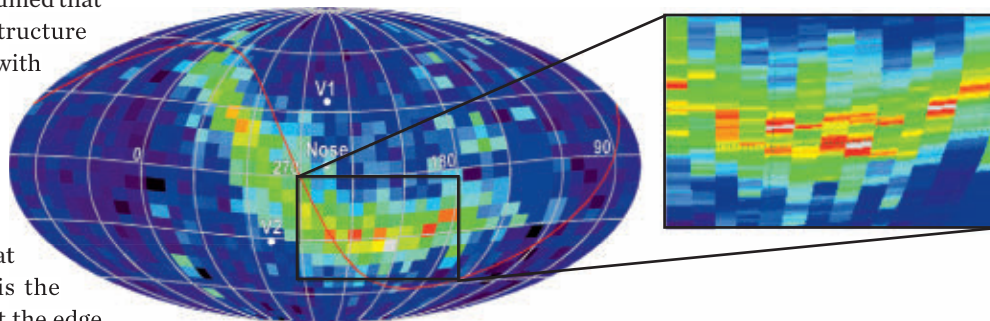
The IBEX ribbon, which was recorded at energies from 200 to 6,000 electron volts, lies between about 100 and 125 astronomical units from the sun, McComas notes. (An astronomical unit is the average distance from Earth to the sun.)

The ribbon runs perpendicular to the direction of the galaxy's magnetic field at the interstellar boundary, indicating that the field has a stronger than expected influence on the sun's environs, report Schwadron and colleagues. One possibility is that pressure from the magnetic field forced particles inside the heliosphere to bunch together into the ribbon.

IBEX also generated the first maps of neutral hydrogen and oxygen atoms entering the solar system from interstellar space. 

"This is a big surprise because we thought we knew a lot about this region."

DAVID MCCOMAS



A map of neutral atoms, generated by IBEX, shows a ribbonlike structure near the heliosphere's edge, the boundary between the solar system and interstellar space. Blue denotes the lowest intensity of atoms, and red denotes the highest.

Body & Brain



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Psychiatric meds for kids can bring on weight gain

Antipsychotic drugs may create metabolic trade-offs


By Nathan Seppa

Many children and adolescents taking drugs for severe psychiatric problems gain substantial weight, researchers report in the Oct. 28 *Journal of the American Medical Association*. But the drugs often benefit children who have schizophrenia, autism, tics, severe bipolar disorder or aggressive behavior.

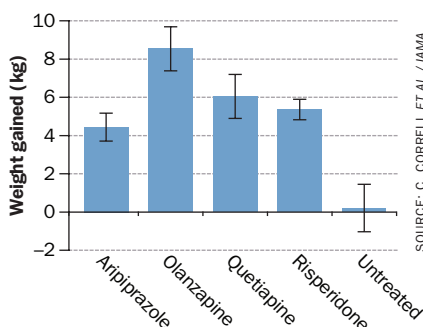
“We are between a rock and a hard place here,” study coauthor Christoph Correll of the Zucker Hillside Hospital in Glen Oaks, N.Y., says. Correll and his colleagues monitored 257 children, ages 4 to 19, who were taking olanzapine, quetiapine, risperidone or aripiprazole. After about 11 weeks, patients had gained 4.4 to 8.5 kilograms (10 to 19 pounds) on average, depending on the drug.

Longer-term data are needed, says Christopher Varley, a child psychiatrist at the Seattle Children’s Hospital. “You never really treat a kid with one of these conditions for only 12 weeks.”

The biological mechanism causing the weight gain is unclear, Varley says, but patients do experience carbohydrate cravings and a mild sedative effect.

Patients on olanzapine showed increased LDL cholesterol, and patients on olanzapine or quetiapine had higher triglycerides. All four drugs used in the study are cleared for adults, but the U.S. Food and Drug Administration has approved only aripiprazole and risperidone for pediatric use. 

Average weight gain over 11 weeks, by drug



Flu shots can benefit moms-to-be

Vaccination may help prevent premature birth, low weight


By Nathan Seppa

PHILADELPHIA — By getting flu shots, pregnant women can reduce the risks of premature birth or low birth weight, two studies show. Researchers working in the United States and Bangladesh presented the data October 29 at a meeting of the Infectious Diseases Society of America.

Flu infection can pose health risks to a fetus even if the infection doesn’t make the pregnant woman outwardly sick.

In the U.S. study, Saad Omer of Emory University in Atlanta and his colleagues found that children born to Georgia women getting the shot were 40 percent


less likely to be born prematurely during flu season. In months when the most flu cases were reported, babies born to vaccinated moms were 70 percent less likely to be born prematurely.

In the other study, pediatrician Mark Steinhoff of Cincinnati Children’s Hospital Medical Center and colleagues found that, on average, babies born to women who didn’t get flu shots weighed about half of a pound less than babies of women getting the shot. In the off-season for flu in Bangladesh, the difference disappeared. “This is a fairly specific effect only seen when the virus is around,” Steinhoff says. 


MEETING NOTES

Infectious Diseases Society of America, October 29–November 1, Philadelphia

Cholesterol drugs may fight flu

Statin drugs, prescribed to keep high cholesterol in check, may also offer partial protection against influenza, a study suggests. Researchers reviewed the records of roughly 2,800 adult patients from 10 states who came down with flu during the 2007–08 season. About 30 percent were taking a statin drug. During that season, there were 17 deaths in the statin group and 64 deaths among people not using statins. After accounting for differences in age, race and cardiovascular health, the researchers found that people getting statins were about half as likely to die from the flu, Meredith Vandermeer of Oregon’s Public Health Division in Portland reported October 29. —Nathan Seppa 

Bacteria strike last-resort drug

Little-known antibiotics often used in the 1960s have recently been useful against stubborn bacterial infections, but bacteria are starting to show resistance to the drugs, a study finds. The antibiotics, called polymyxins, fell out of favor because of kidney toxicity. But the drugs are back in use against antibiotic-resistant infections, says Jason Kessler of Columbia University Medical Center. Kessler and his colleagues analyzed samples from more than 1,000 infected patients and found that 6 percent of infections were resistant to polymyxin B, one of two polymyxins approved for use. Incidence of resistance to polymyxin B doubled from 2006 to 2008, Kessler reported October 30. —Nathan Seppa 



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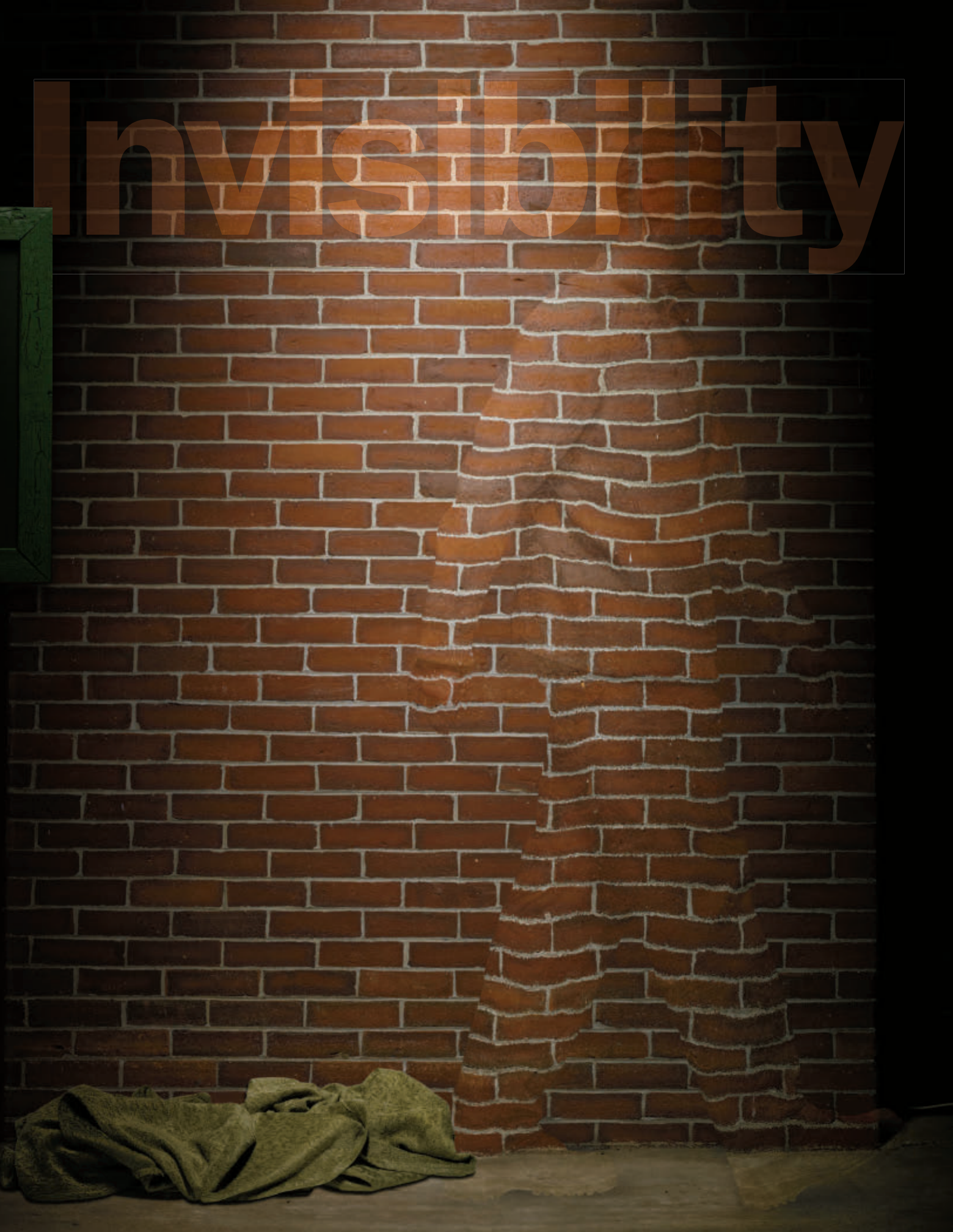
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Invisibility



Uncloaked

In race to make things disappear, scientists gain ground on science fiction

By Charles Petit • Photo illustration by Cary Wolinsky and Rick Kyle

UIf Leonhardt is riding high these days, with a new award from the Royal Society of Great Britain to further develop his ideas on how to make things in plain sight disappear.

Born in East Germany and now occupying the theoretical physics chair at Scotland's University of St. Andrews, Leonhardt is among the leaders of the worldwide race to realize an old dream of science fiction: cloaking devices. They would steer light or other electromagnetic waves around them like water around a stone in a smooth stream, leaving nary a ripple of difference in the flow. Such things, letting light swish past like a boxer ducking every punch, would be invisible.

Cloaking device is a common term in technical literature. It also deliberately evokes myth and popular fiction. Allusions include the Romulan technology that first amazed TV viewers of the old *Star Trek* in the episode "Balance of Terror," when hostile Bird of Prey fighting vessels just disappeared, poof. One finds cloaking in J.K. Rowling's novels about the young wizard Harry Potter with his invisibility cape. Farther back, H.G. Wells' novel *The Invisible Man* (and the movie of the same name, along with its sequel *The Invisible Woman*) toyed with much the same idea. J.R.R. Tolkien assigned similar power to The One Ring in his tales of hobbits. Inspiration for the ring apparently came from way back—the magical ring that the shepherd Gyges recovered from an earthquake-spawned chasm in Plato's *The Republic*.

Leonhardt's role in the cloaking field's rise to respectability did not get off to an encouraging start. The details of his initial frustration and eventual triumph illustrate the swiftness with which the field entered the mainstream—even surprising some experts. "I began my work at a time when invisibility was not fashionable at all," he says. That was about a decade ago. After years of quiet work with a few colleagues, he wrote a paper titled "Optical conformal mapping." The abstract's first

words come right to the point: "An invisibility device should guide light around an object as if nothing were there."

In 2005 he sent the paper to *Nature*, which rejected it, and to *Nature Physics*. Editors at *Nature Physics*, Leonhardt recalls, took just two days to reject the paper as well. So, he says, he sent it to *Science*. There, it lasted two weeks before the heave-ho. In early 2006 he tried again, this time with *Physical Review Letters*, or *PRL*. Another no-go. One reviewer said the mathematics, while classical (the calculations refer to Maxwell's and Newton's

equations of light and to other mathematical constructs credited to such titans as Fermat, Lagrange, Euler, Descartes, Euclid, Kepler, Einstein and Feynman), did not offer enough new physics. Ouch.

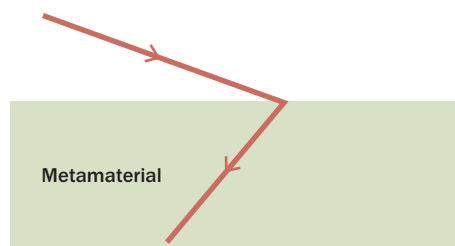
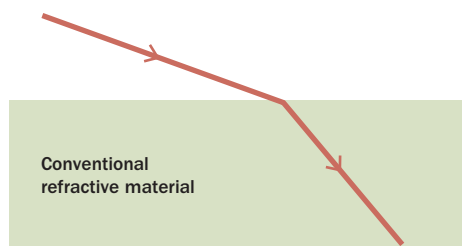
But it was another *PRL* reviewer's rebuke that opened Leonhardt's eyes wide. It said he was not alone. The assessment, routinely shared with Leonhardt, indicated that the reviewer had been to two meetings in the previous months "in which John Pendry discussed his group's efforts on the same issue, calling it a cloaking device or their Hogwarts project in reference to the cloak of invisibility associated with the Harry Potter series." Pendry and his colleagues, the assessment added, "supposedly have filed a patent related to this work."

Hence, the anonymous reviewer declared, the

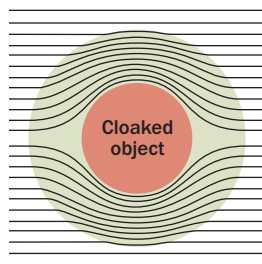
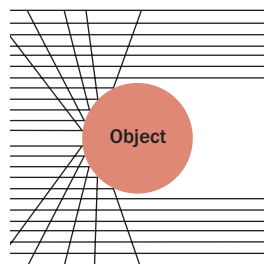
work was not new and did not merit publication in *PRL*.

It came as a surprise to Leonhardt that he had been in unwitting competition with Pendry, one of the most distinguished scientists in Britain. Pendry is not merely professor of theoretical physics at Imperial College London—he is *Sir* John. The queen knighted him in 2004 for his services to science. Much of his reputation is based upon achievements in optical theory and in metamaterials that refract light in a fashion—even backward—not found in natural substances. Leonhardt was pleased to have a rival of such eminence but furious over his paper's treatment. Because Pendry's team had not published its work, Leonhardt argued in a letter to *PRL*, the journal

**Cloaking devices
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Typical behavior When light waves hit an object, they are reflected (right), allowing the object to be seen. Transparent materials also refract, or bend, light (above). The amount of bending depends on a property called the refractive index. Because air has a lower index than water, refraction causes a straw to look split where it enters a glass of water. But conventional materials don't bend light in a way useful for cloaking.



Negative refraction Conventional materials have refractive indices greater than 1, the index for a vacuum. But some materials exhibit negative refraction, meaning they can make light bend backward on itself. This could lead to a straw that seems to defy reality (illustrated), but also offers cloaking possibilities. Carefully designed metamaterials (doughnut, left) can steer light around a solid object.

should publish promptly — not reject — his own paper. Further, Leonhardt averred that a pending patent provides no ethical reason to reject independent work by an outsider.

Then, abruptly, his fortunes took a 180-degree turn.

Science, he recalls, wanted to publish his paper after all. The journal had just received a paper from Pendry's team, which includes his close collaborator David Smith, an electrical and computer engineer at Duke University in Durham, N.C. Titled "Controlling electromagnetic fields," the work was strikingly similar in its overall message to what Leonhardt had already offered. In late May 2006 the two papers came out (*SN*: 7/15/06, p. 42). They were sensations. Dozens of groups around the world set to work to build devices that, however crudely, tested the elegant new mathematical prescriptions.

Later that year *Science* named the papers and cloaking as among the world's top science breakthroughs of 2006. *Scientific American* named Pendry, Smith and Leonhardt to its list of top 50 research leaders of the year. Leonhardt recently won a prestigious Theo Murphy Blue Skies award from the Royal Society with two years' full funding to pursue invisibility by manipulating light and other electromagnetic waves, and to follow indications that even sea waves might be steered around small islands or drilling platforms by altering the water nearby. Pendry this year won the UNESCO-Niels Bohr gold medal for his work in the field.

Stabs at disappearance

During the past four years headlines have been reporting the baby-step progress by Leonhardt and a dozen or so other teams toward not only cloaking devices, but also supersharp lenses, omnidirectional reflectors (a specialty of Leonhardt's) and artificial black holes that would swallow light much like a

collapsed star in deep space would (*SN*: 10/10/09, p. 10). All such seeming trickery is born of the same underlying optical sleights of hand. On the physics website arXiv.org, more than 30 papers have appeared in the past year with variants of "cloak" or "cloaking" in their titles.

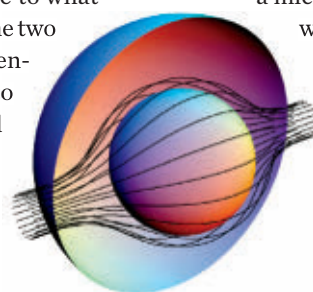
So far the devices have all been tests of the concept, with nothing close to practical. Furthermore, the small gadgets don't yet cloak anything perfectly, or cloak anything very large. Some regions that have been made invisible are hard to see without a microscope. And because cloaks that shield longer

wavelengths of light are easier to make, first successes came with microwaves — whose radiation can be measured in inches. Some devices work in the infrared with pinhead-sized or smaller wavelengths, with even shorter light waves just now showing up on the agenda.

Leonhardt and Pendry remain in the thick of it — and remain rivals. Each is easily goaded to murmurings that the other takes more than his fair share of credit for coaxing invisibility from obscurity.

While Pendry says Leonhardt's first published paper "had a good scheme," he adds that Leonhardt makes more of it than he should. "Ulf is not being straightforward, for his was not a full cloak, but an approximation" — because his approach did not have a full treatment of light as waves but handled it as a collection of rays. Leonhardt in turn says of Pendry: "He has done very important work, but he has not done everything. In particular the connection of this research area to general relativity, that is what we have done.... He makes the impression that this whole field is due to him, and he used results that I developed without referencing them."

Sharp elbows are not uncommon in highly competitive, new fields of science. But the researchers agree on one thing: Progress has been fast. "The field has amazed me," Pendry says.



A metamaterial cloak (outer ring) steers light.

"People have jumped onto the theme, and how successful they have been. There are some wonderful ideas out there." Says Leonhardt: "It has gotten more interesting than I expected. The theoretical side of the field was over very quickly. Now it is being turned into reality."

A few examples:

- Xiang Zhang of the University of California, Berkeley and the Lawrence Berkeley National Laboratory says he and a few others in the field have their eyes on a cloaking material that ought to work at visible wavelengths — but it's a secret for now, so he can't say what it is. "You could trip on it, and feel it, but you wouldn't see it," he predicts. The secret recipe needs more work, he says, and ought to be ready for publication in a year ... or more.
- At Purdue University in West Lafayette, Ind., physicist Vladimir Shalaev is pretty sure he can do it, too, and is happy to describe the material (basically, mirrors and air), but he isn't yet sure how to shape it for practical use.
- Physicist Michal Lipson of Cornell University and her group have demonstrated a microscopic "carpet cloak," a miniature flat, reflective surface with a lump in it to hide the goods. The lumpy part looks as flat as the rest of the "rug," the team reports in the August *Nature Photonics*. Zhang's Berkeley group, led by grad student Jason Valentine, did the same thing, reporting the results in the July *Nature Materials*. "It's like we ripped a hole in the fabric of space," Valentine says. "Light won't go there."
- This year in *PRL*, a team led by Che Ting Chan, a Berkeley-trained physicist at the Hong Kong University of Science and Technology, describes an approach called "remote cloaking." It not only (in theory) renders an object invisible, but also does so with a device sitting next to rather than surrounding the thing to be hidden. Invisibility, says one of the team's papers, is merely the process of altering the light so an object "looks like air." Even better, the group claims, it may be possible to make one thing look like another — for example "change an apple optically to [a] banana." The researchers call this offshoot "illusion optics."

Some of these methods work only within a narrow range of wavelengths, often in flat, two-dimensional settings. It's difficult to find anybody in the know who expects there will ever be a device that hides itself and its contents at all wavelengths — if you can't see it in visible light, then perhaps radar, infrared, ultraviolet or X-rays would reveal it. But optimism for practical uses is growing. So are the sources of money to propel research.

In the United States, National Science Foundation program officer Robert Trew says that the main division supporting such work — Electrical, Communications and Cyber Systems — has about \$15 million worth of contracts now out, shared among 16 awards. The Pentagon's Defense Advanced Research Projects Agency, or DARPA, has been supporting such research —

initially behind a cloak of semisecrecy (not quite classified, but not published in open media either) for most of this decade. While precise figures are hard to come by, DARPA has spent about \$50 million in the last 10 years on metamaterials, including cloaking research.

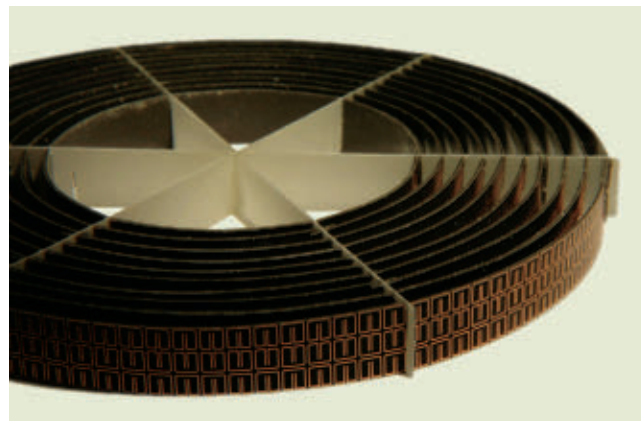
In an allusion to the cloaking process, Pendry now thinks "much of this work will soon go dark" as military money in the United States, and in other nations, drops a cape on sensitive applications.

A hidey-hole in stretched space

While *cloaking* is the term that has caught the public's eye, the broader field is known as transformation optics. Its power comes from a remarkable property of Maxwell's classic equations describing the behavior of light and other electromagnetic radiation. The equations are invariant, meaning that they work the same in different coordinate systems. Thus physicists can keep track of how light will behave if a real object is mathematically warped into something shaped quite different — or, vice versa. A dimensionless point in one mathematical realm, unaffected by passing light waves, can be expanded into a 3-D void in another coordinate system. But light or other radiation remains oblivious to the void.

Leonhardt, in his seminal paper in *Science*, described this as conformal mapping. Just as a mapmaker drapes the geographic points on the Earth's globe onto a flat sheet — such as for a Mercator projection — mathematicians can map, or conform, the surface of one object onto something else. And Maxwell's equations still work there.

Pendry, in a review in the July 30 *Nature*, explained the concept clearly: "Imagine that the optical system in question ... is embedded in a rubber medium. We then stretch and pull the rubber, taking with it all the rays of light passing ... until the rays are traveling in the desired directions." The same transformations that "stretched the rubber" also describe how the



This 1-centimeter-tall invisibility device uses metamaterials to bend microwaves around its center area so that they reemerge on their original paths on the other side. David Smith of Duke University and his colleagues reported cloaking a tiny copper ring using this device in 2006.

newly made cloak's properties must change — how its refractive index at every point must be altered — to permit Maxwell's equations to exert themselves as desired and steer the waves around the hiding place.

It is for this reason that papers on cloaking are often littered with the symbols ϵ and μ . These are epsilon and mu, the electrical permittivity and the magnetic permeability of a material. The values describe the way a substance reacts to the oscillating electrical and magnetic fields of electromagnetic radiation. Changes in these values can make light slow down, speed up and thus refract, or bend. (Wave fronts swerve when one portion slows compared with the others.) While other qualities determine how transparent a material is to a given wavelength, ϵ and μ work pretty much the same at all wavelengths. They are the components of the refractive index.

And metamaterials, whose refractive index can be engineered far more flexibly than can natural substances (even to the point of a negative index that bends light more than halfway back on its original direction), are the medium of choice.

Unlike the atoms and molecules that nature provides, which are limited in the combinations of electrical and magnetic permittivity and permeability, the novel metamaterials can mix and match ϵ and μ to provide exactly the radical refractive index variations that make light do loop-de-loops around a

cloaked void, while obeying rules that would otherwise produce a straight route.

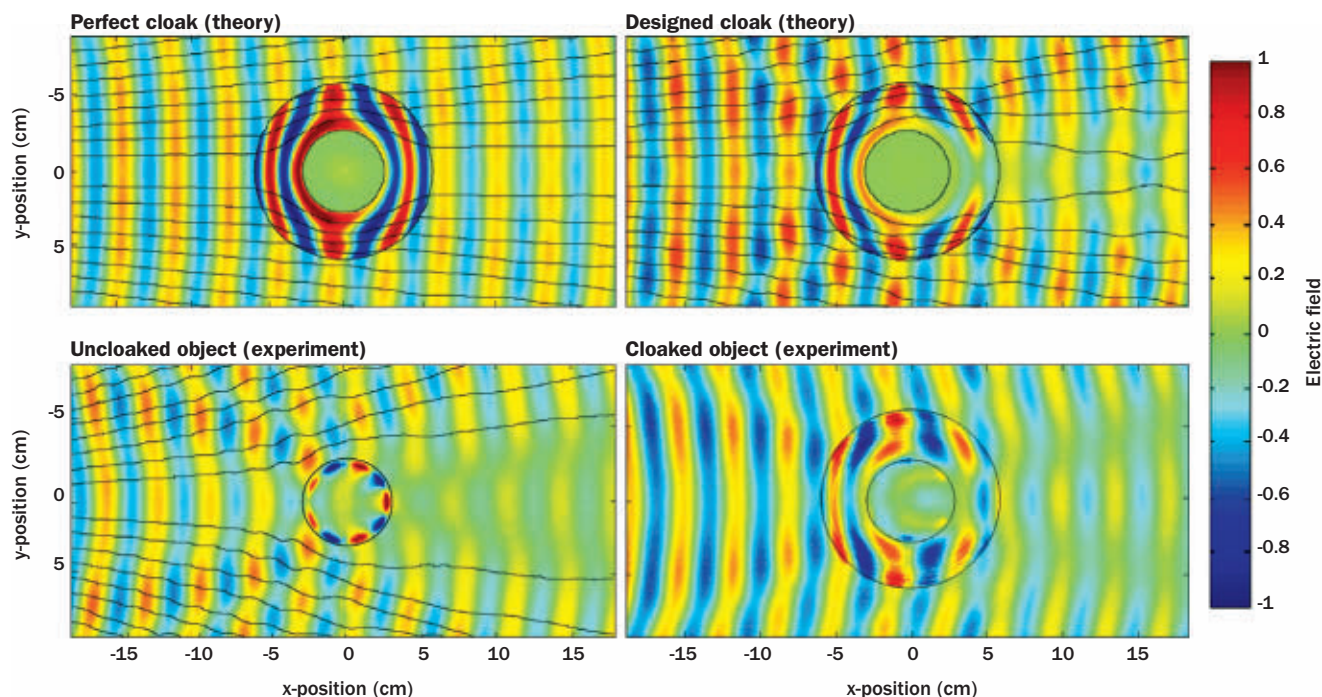
The shorter the wavelength passing through, the tinier must be the bits of matter whose combined optical behavior yields a metamaterial. So it is no surprise that the first working cloak, about the diameter of a CD but much thicker, functioned only with microwaves at wavelengths of about an inch in air. The device, made by Smith's group at Duke in 2006, has antenna-like copper wires embedded in concentric rings of fiberglass easily visible to the eye (*SN*: 10/21/06, p. 261).

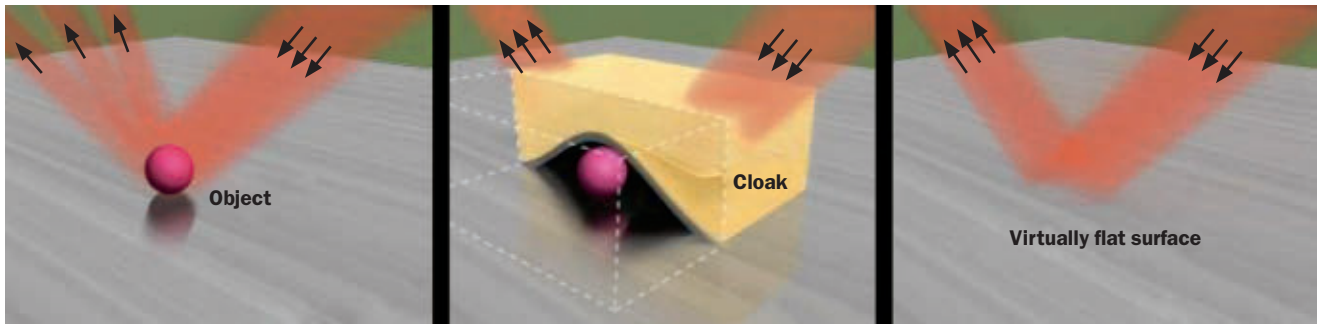
Earlier this year, Zhang's lab at Berkeley steered infrared waves, which have much shorter wavelengths, around a hiding place. Grad student Valentine and colleagues used a focused beam of ions to drill varying arrays of holes in silicon-based semiconductors to make the carpet cloak. Similarly, delicately patterned forests of tiny pegs, planted on a silicon wafer by Lipson's team at Cornell, altered the electrical permittivity so that infrared waves bouncing off a mirrored surface didn't notice a lump. They reflected as though the surface were flat — the lump and anything beneath were cloaked.

"It's not good for anything, now," says Valentine of the carpet cloak. For one thing, it works only in two dimensions. And for another, it has a special but not very useful geometry that lets the researchers manipulate permittivity, ϵ , alone, allowing use of ordinary materials that are poor conductors but are

Metamaterials can mix and match epsilon and mu to make light do loop-de-loops around a cloaked void.

Visible results The microwave cloak designed by David Smith's team (doughnut shape, bottom right) altered light's path just as the team expected (top right). Note the changes in the electric field (color in both images at right) as the wave fronts moved through the cloak and reconvened on the other side. Results from an uncloaked object (bottom left) show that the object blocks and disrupts waves directly surrounding it.





Beneath the rug Xiang Zhang of UC Berkeley and colleagues have designed a cloak made of nanostructured silicon that can hide objects from view in the infrared. Light hitting an object normally scatters, giving away the object's presence (left). But with the new "carpet cloak" (middle), the light reflects as if it were bouncing off a flat surface (right). The cloak hid an area that measured 3.8 micrometers by 400 nanometers.

friendly to electric fields. The holes and pegs simply change the material's gross density, hence its electrical response. "But it works, and that's a start." And it works at a broad range of infrared wavelengths, from about 1,400 to 1,800 nanometers. The scheme will not work, however, at visible wavelengths, which range from 700 down to 400 nanometers, at least not with any fabrication method clear to the researchers. And wavelengths shorter than that — from ultraviolet to X-rays and below — remain pure science fiction for now.

Asked how to make metamaterials whose simulated "atoms" of unnatural material are small enough to smoothly steer visible light, Valentine's boss Zhang is a bit evasive. He and several teams, he says, have something in mind. What is it? "I cannot tell you," he says. "It will take more work." Until it is tested and published, Zhang will say no more.

Remarkably, the mathematics of metamaterials and transformation optics have led researchers to think freshly about other ways to manipulate electromagnetic radiation. At Purdue University, for example, a group led by Shalaev has found that the equations for how light is channeled down a waveguide — basically a mirrored conduit — are similar to those that describe how variable refractive indices smoothly steer light's path. It turns out that when such a waveguide gets so narrow that its walls are about as far apart as the wavelength of radiation between them, the radiation slows down. If the conduit is too tight, then the radiation can go no further. But if a path just a little wider is available, the radiation swerves down that. Shalaev has come up

with a system of gold-plated convex mirrors stacked with similarly mirrored flat, gold-plated sheets. As radiation enters from the side, the gaps between the gently curved surfaces and flat sheets squeeze down. When the gap between the central portion of the convex mirror and the flat sheet becomes too small for the light to pass through, it scoots around the protruding dome of the mirror, converges on the opposite side and keeps going. In May in *Physical Review Letters*, Shalaev and colleagues report that a one-layer cloak of this tapered waveguide device shielded a tiny area about 50 micrometers across. As he said: "I can cloak a human hair. It's a good start. If I could answer how to cloak a human, I have Nobel Prize."

For all the excitement now, says Smith, "the basic ideas behind this have been around a long time, some of them from Maxwell's time." A paper written in 1961 in an obscure, Russian journal by an optics specialist named Lev Dolin used almost the exact same manipulation of Maxwell's equations, coordinate transformations and alterations of permeability and permittivity that Pendry and Leonhardt have been using within the last decade.

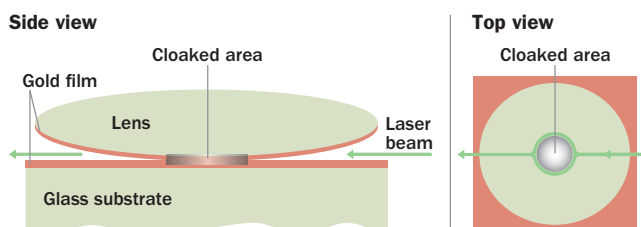
But whether cloaking in the sense of science fiction's dreams ever occurs or not, the dam has burst. New ways to focus and project light and other radiation seem certain. "There is a whole new class of optics waiting for us," Smith says.

Nobody expects cloaking to make things invisible to all detectors. But even here, fiction has anticipated things with a spooky parallel. Recall the Romulan warships? Their cloaking didn't work perfectly either — and the *Enterprise* crew learned to track them, cloaked or not.

And one more thing to remember. If a cloak were to make an object fully invisible to the outside world, then the outside world would be invisible to the object within the cloak. A thing (or person) inside a perfect cloak is not only invisible. It is blind. ■

Charles Petit is a freelance writer based in Berkeley, Calif.

No metamaterials needed Instead of using metamaterials, Vladimir Shalaev of Purdue University and colleagues employ a sheet and lens, both with gold film, to direct light (side view). When the mirrored space between the sheet and lens becomes too tight, light scoots around the center of the lens, cloaking an area just below its dome (top view).



Explore more

- Ulf Leonhardt's discussion of invisibility: www.st-andrews.ac.uk/~ulf/invisibility.html
- John Pendry on metamaterials and refraction: www.cmth.ph.ic.ac.uk/photonic/Newphotonic/research.html

A close-up photograph of a chimpanzee sitting on the ground, which is covered with dry leaves and twigs. The chimpanzee is holding a large, flat, grey stone in its right hand and using it to strike another stone on the ground. The chimpanzee's face is visible, showing its eyes and mouth. The text "Aping the Stone Age" is overlaid on the image in a large, bold font. The word "Aping" is in a brown color, and "the Stone Age" is in white.

Aping the Stone Age

Chimp chasers join artifact extractors to probe the roots of stone tools **By Bruce Bower**

For chimpanzees living in a forest surrounding the village of Bossou in Guinea, cracking nuts is a serious task with important steps. They are: First, lug large rocks to a spot near a nut-bearing tree, such as an oil palm. Next, gather the nuts and place them on the rocks. Then, obtain a smaller, graspable rock. Finally, smash the armored treats and let the shells fly. As clutches of apes pound away with devastating precision, these nut bashers create an unholy din akin to a human rock band.

In fact, these West African chimps rock out in a surprising way. In this corner of the jungle, chimps appear to think more carefully about implements and how to assemble them than many scientists had assumed. A team led by anthropologist Susana Carvalho set up a nut-cracking lab in the forest near Bossou by placing seven piles of nuts and several dozen stones of various sizes, shapes and types inside a clearing. Over five field seasons, 14 of 17 chimps that regularly visited the clearing consistently reused the same pairs of stones, the scientists report in a special October issue of *Animal Cognition*. Most chimps, Carvalho says, used the stones together as one tool, a nutcracker.

Carvalho suspects that watching the Bossou chimps at work will provide clues to the origins of the Stone Age, the 2.6 million years during which members of the human evolutionary family are known to have used and made stone tools of increasing complexity. She is one researcher participating in a scientific movement to merge strains of archaeology, anthropology, primatology and psychology into a hybrid field dubbed primate archaeology: the study of current and past material culture among apes and perhaps other nonhuman animals.

“Very few archaeologists and paleoanthropologists have seen a wild ape, and very few primatologists have done any excavation or analysis of artifacts and fossils,” says Cambridge primatologist William McGrew, who has studied wild chimps for more than 40 years. “We have much to offer one another.”

If, for example, the modern chimps’ pounding leaves signature damage on the stones, then sites holding remains from ancient African hominids — now-extinct members of the human evolutionary family — could be probed for similarly marked stones. Such markings could reveal tools that may

Chimpanzees in Tai National Park in Ivory Coast use stones for cracking nuts, and older chimps pass these skills on. Studies of the ways modern chimps use tools may provide clues for piecing together aspects of human prehistory.

have preceded the earliest known stone tools, known collectively as the Oldowan industry, named for Olduvai Gorge in Tanzania. These single-edged cutting implements date from around 2.6 million years ago. Researchers could also search the modern chimps' nut-cracking site for sharp stone fragments produced during pounding. Such accidentally sharpened fragments may have stimulated the invention of Oldowan tools.

Early hominids possessed chimp-sized brains and some other chimplike traits, making living chimps a reasonable group to compare with hominids, Carvalho contends. (That view is controversial; *SN*: 10/24/09, p. 9).

Carvalho, a graduate student at the University of Cambridge in England, and 17 other scientists set out the case for primate archaeology in the July 16 *Nature*. New investigations inspired by this perspective are set to appear in an upcoming *Journal of Human Evolution*.

For now, primate archaeology focuses on chimps, though gorillas and orangutans, capuchins (*SN*: 2/14/09, p. 12), crows (*SN*: 8/29/09, p. 5), dolphins (*SN*: 1/3/09, p. 13) and other animals also make and use tools. One line of research explores how cultural traditions in tool use and other behaviors spread among African chimp communities, with possible implications for understanding cultural links among ancient hominid groups. Another project combines chimp, hominid and modern human data to explore the mystery of why most people are right-handed. And new finds in Africa reveal the possibility of a chimp stone age.

Chips off the old block

Primatologist Andrew Whiten of the University of St. Andrews in Scotland also suspects that primate archaeology will provide a glimpse into the way tool-making evolved and spread among both chimps and hominids.

Researchers disagree about whether chimps display cultural conventions, such as styles of making stone tools, that resemble the long-standing behavioral traditions — from pottery patterns to religious rituals — that demarcate different human cultures (*SN*: 6/19/99, p. 388). But converging lines of evidence indicate that wild chimps indeed invent distinctive types of tools within communities, and these tools get passed from one generation to the next as a kind of cultural legacy, Whiten says. He and his colleagues Kathy Schick and Nicholas Toth, both archaeologists at Indiana University in Bloomington, agree that modern chimps' stone tools offer a framework for identifying precursors of Oldowan tools at ancient hominid sites and the beginnings of the spread of tool-based cultural traditions among hominids.

"The nature of chimp culture has become one of our best indicators of the likely forms of hominid culture during at least the earliest phase of the Oldowan," Whiten says. The Oldowan period of toolmaking lasted for 1 million years, until double-edged hand axes appeared in Africa around 1.6 million years ago.

A new analysis of artifacts previously unearthed at 20 Oldowan sites in East Africa reveals considerable evidence of stone-on-stone pounding that was

probably a legacy of earlier hominids, the researchers say. Stones pounded to crack nuts contain smooth pits, Schick and Toth note. Stones pounded to break off sharp-edged Oldowan flakes, which are also used as tools, display rough pits. Further research will attempt to distinguish between these two tool varieties at Oldowan sites.

For roughly 50,000 generations, Oldowan toolmaking techniques got passed from hominid experts to novices. In recent experiments, Whiten has found that captive chimps display a similar capacity for learning how to use tools by observing more experienced comrades.

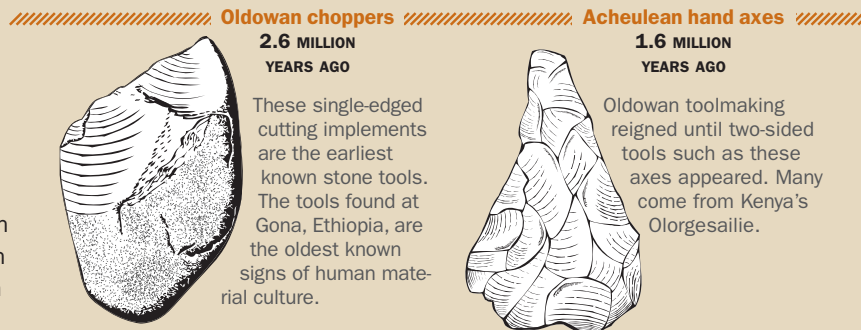
A vivid demonstration was reported in 2008. Whiten and a colleague studied 12 wild-born, juvenile chimps living in an African sanctuary. The experimenters supplied stones, and one 5-year-old chimp named Mawa immediately started using the stones to crack palm nuts, a talent he had apparently learned in his native community. The other chimps showed no sign of knowing anything about nut cracking, reflecting an absence of this activity in their home groups.

Nine of those chimps — all at least 3 years old — cracked nuts with stones after watching Mawa demonstrate his skills for a few days. The same animals had previously been clueless when given nuts and stones but no access to Mawa.

Schick and Toth have observed a comparable learning process in a family of captive pygmy chimps that has never lived in the wild. In 1990, Toth began teaching one of the male chimps, Kanzi, to strike one stone against another to produce a sharp-edged implement.

Evolving complexity through the Stone Age

A timeline of major tool industries in the human family tree shows how stone tools became smaller and more specific in shape and function over time. The earliest known stone tools are Oldowan choppers. The new field of primate archaeology seeks to extend the known timeline back further. Signatures of tool use by modern chimps could offer clues for finding evidence of human tool use dating to before the Oldowan.



Kanzi soon learned to make and use an adequately sharpened stone to cut a cord and gain entry to a box containing food.

Over the past several years, Kanzi's younger sister Panbanisha has developed her own stone-sharpening proficiency by watching Kanzi and humans make stone tools. Panbanisha's two children, Nyota and Nathan, have now begun to experiment at pounding stones together.

Hints from chimp culture

What happened in Kanzi's family apparently gets magnified in the wild, where many chimp families live together, says biological anthropologist Stephen Lycett of the University of Kent in Canterbury, England. A new investigation led by Lycett suggests that chimps, like people, have evolved a strong preference to copy behaviors exhibited by a majority of those in their home groups.

Lycett's team used data on the number of shared traditions—including types of tool use and social grooming rituals—in different African chimp communities to construct a tree of branching social relationships among these groups.

The team was surprised to find that the chimps' cultural ties stretched to distances similar to those documented among human hunter-gatherer groups.

Chimp groups in close proximity display more behaviors in common than do chimp groups living far from each other. Consider that the use of stone hammers and anvils for nut cracking extends through only a limited number of neighboring chimp communities in West Africa. Groups in East and West Africa share virtually no behaviors in



After a juvenile Bossou chimp grooms a dominant male, the adult gives the juvenile access to cracking tools and a stash of *Coula* nuts. Learned behaviors, such as this exchange, often spread through chimp communities that live close together.

common, supporting the chimps' assignment to separate species. Overall, the findings suggest that cultural traditions regularly get passed from one generation to the next in chimp communities, but that these traditions typically get passed from one community to only a few neighboring groups, Lycett says. This group-to-group sharing usually happens via migration of females when they reach sexual maturity.

Whiten estimates that chimp groups share cultural traits across a distance of no more than 700 kilometers.

As it turns out, seven Oldowan sites in East Africa lie within 700 kilometers of a major Oldowan location called Koobi Fora. If the chimp model of cultural spread applies to ancient hominids, then a common tradition for making stone tools may have spread from Koobi Fora to some or all of its surrounding sites, Whiten suggests. Scientists have

yet to test his hypothesis.

"Stone-flaking technology is one of the best candidates for examining the possibility of shared cultural traits in the prehistoric record," Whiten says.

Evolution's right hand

Stone tools, both chimp and human, can also be used to pry into the enduring mystery of why most people are right-handed, says archaeologist Natalie Uomini of the University of Liverpool in England.

By at least 120,000 years ago, right-handedness frequently occurred among Neandertals, Uomini asserts. Neandertals' cutting tools tended to get resharpened on one side in a way that was most likely done using the right hand. Neandertal fossils have larger attachment areas for muscles on the right arm than on the left arm, indicating a preference for using the right arm.

The archaeological record from ancient *Homo sapiens* that lived during the same time as Neandertals shows similar signs of a right-handed skew, Uomini notes. In addition, European cave art from more than 20,000 years ago contains a preponderance of left-hand stencils made by individuals who apparently liked to hold paint-blowing tubes in their right hands.

Indiana University's Toth has reported that most Oldowan toolmakers from nearly 2 million years ago



were probably right-handed, based on the direction in which they sharpened stones. But that evidence remains preliminary, Uomini holds.

Primatologists have established that wild chimp communities display a variety of hand preferences. Groups can be right-handed, left-handed, evenly divided between right- and left-handed or can contain ambidextrous individuals.

But a trend of relatively stronger right- and left-handedness does appear in chimp groups that regularly use tools, such as nut-cracking stones or sticks for poking into termite mounds to remove the edible insects. Making and using tools requires a division of labor between the hands, Uomini says. Pressure to learn increasingly complex techniques pushed hominids toward a right-sided bias, she hypothesizes.

Many researchers suspect that specific genes contribute to human hand preferences. Uomini hypothesizes that people and chimps share a genetic propensity to use one hand more than another on tasks that demand dexterity. Genes for right-handedness, though, have evolved in humans alone, she proposes.

Uomini favors a hypothesis advanced by French researchers to explain the retention of left-handedness in about 15 percent of the human population. In this scenario, minority left-handers have enjoyed a long-standing advantage over majority right-handers in face-offs and combat because lefties are more used to facing righties than vice versa. The result: Preservation of a genetic tilt to the left in some people.

"The question of left-handedness is still open, although we know that there was a small minority of Neandertal left-handers," Uomini says.

Preliminary evidence from visitors to a Dutch archaeological center supports the idea that increasingly complex tool operations elicit a right-handed preference. A nut-cracking station included three stone anvils, 21 hammer stones and an assortment of nuts. Another station had puzzles: four to nine flint pieces that could be fit together into a single unit.

Among 14 people who tried to crack

nuts at least six times, 12 exclusively held the hammer with their right hands, just as they had signed up for the game with their right hands. Another two right-handed signers used the hammer ambidextrously. In contrast, 34 of 38 people who gave the puzzle at least six tries manipulated flint pieces ambidextrously.

Uomini's finding of greater right-handedness on the more complex nut-cracking task recalls a 1995 study led by anthropologist Linda Marchant of Miami University in Oxford, Ohio. Marchant's team found that members of three modern-day hunter-gatherer groups preferred to use their right hands when holding tools, such as cutting implements, that require a precision grip. Ambidexterity characterized other hand actions, such as waving at insects and poking at objects.

Marchant, who regards predominant right-handedness as an evolved trait in hominids, is intrigued by Uomini's ideas about the impact of complex tool use on hand preferences. Other than Marchant's 1995 paper, little is known about handedness in hunter-gatherer populations. "A full-scale project really needs to be done," Marchant says.

Stone Age for chimps

Even greater uncertainty surrounds a category of stone artifacts that no one knew about until a few years ago. In 2007, researchers working in a West African forest were the first to report the discovery of chimp archaeological sites (*SN*: 2/17/07, p. 99).

Three excavations in Taï National Park in Ivory Coast yielded more than 200 stone pounding implements that chimps used to crack nuts at least 4,300 years ago. A team led by archaeologist Julio Mercader of the University of Calgary in Canada and primatologist Christophe Boesch of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, noted that the prehistoric stones looked like the nut-cracking rocks today's chimps employ in the same forest.

This discovery raised questions about how far back in time chimps began to use



Many cave stencils are of left hands, so stencilers probably used their right hands to paint. Shown are finds from Borneo (top) and Papua New Guinea.

stones as pounding tools and whether there is any way to distinguish prehistoric chimp implements from those of ancient hominids.

Further insights should come from a new chimp archaeological site that Cambridge University's Carvalho discovered in 2006.

She came upon an abandoned nut-cracking site while surveying an area inhabited by chimps in Guinea. Initial excavations revealed hammer and anvil stones, along with pieces of nut shells, buried in soil layers.

Next year Carvalho will conduct studies of microscopic damage, wear marks and organic residue on the Guinea stones. Burned bits of wood from the site will provide radiocarbon age estimates for the finds. Then the results will be submitted for publication.

"We hope for some exciting news and plan to compare the new stone assemblage with Mercader's," says Carvalho.

Like Bossou chimps today, their long-gone predecessors, it seems, can still make a rock-solid racket. ■

Explore more

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Slumber science

Your October 24 issue featuring sleep research was very interesting and helpful. However, it did not cover any research being done — there may be none — relating to the human brain and modern changes to the nighttime environment. For most of human history, not much activity could take place at night. The diurnal cycle of light and darkness and the yearly seasons north and south of the equator must have had great influences on our development, response, brain activity and sleep. Man and the other biota with brains all developed when these cycles of inactivity dominated their lives.

It has only been relatively recently that the human environment has had light for the entire 24-hour day. Being able to be awake for long durations allows human activities such as 24 hours of essentially instantaneous worldwide communications, global business activities and many pleasures of life. It seems to me that all of these are now probably contributing to the medical problems discussed. There is no time to sleep!

However, these are unique to man. Are other living things having similar problems with sleep? This would seem to be a fruitful area for comparative sleep research.

Warren L. Dowler, Brookings, Ore.

Your recent discussion of the need for sleep (“The why of sleep,” *SN*: 10/24/09, p. 16) cited Robert Stickgold as saying that the benefits for memory are, to date, the only explanation as to why consciousness has to be shut down during sleep. I propose that a key psychological benefit is the extinction of the emotional potency of the relatively intense and less worked-through moments from the preceding day. Matthew Wilson talked about sleep replaying the day’s events. Recycling these strongly emotional moments would reduce their intensity, enabling them to move into longer-term memory with a reduced potential for restimulating images that would activate upsetting emotional arousal. They move

toward becoming “my history.” In contrast, sleep deprivation leads to a lower threshold for emotional arousal (irritability) that increasingly interferes with the next day’s functioning. The tangential and symbolic or “distorted” qualities of dream content would be necessary to sustain sleep: Direct recapitulations of whole events would likely keep awakening the sleeper. My hypothesis is that to do all this, the system must shut down consciousness.

Alex Caldwell, Los Angeles, Calif.

Dreaming during sleep was evidence something was going on in the brain long before EEGs were invented. Now that we know brain activity during sleep is comparable to, but different from, the awake state, we understand why body mobility must be shut down during sleep. It would not enhance survival if man followed the dictates of an active brain that had no attendant sensory inputs. It’s better to be immobile inside your cave than sleepwalking out of it.

Bernard Leitner, Palo Alto, Calif.

Your special issue on sleep is very interesting. I wonder whether a re-orientation of our viewpoint might be productive — that is, to consider the sleep state as the normal condition of living things, and consciousness as a periodic interruption to enable feeding and reproduction.

Walter Weller, Wakefield, La.

I am outraged by the casual description of a sleep experiment performed on laboratory rats: “A lab rat perishes when marooned for weeks on a disk that tips it into water when the rat dozes off.” What sentient creature would not perish after weeks of torture? If something was learned about sleep deprivation from this “experiment,” it was not worth the moral cost.

Anthony Weaver, New York, N.Y.

Virus appreciation

Your article “Enter the virosphere” (*SN*: 10/10/09, p. 22) was excellent. I had to read it three times to understand it,

but it looks like viruses are the “order-keepers” of life, the “check and balance” of existence. They can change at will, are almost indestructible and can transfer genes from creature to creature.

If they could think, they could destroy a species that got out of whack. And if they could communicate, they would be devastating: Give somebody a flu shot, then the virus in their body figures out the change to protect itself, it could tell all the viruses in other bodies, and the flu shot no longer works.

John Carlton Hagerhorst, Frederick, Md.

One-way ticket to Mars

The “Scientific Observation” from Lawrence Krauss (*SN*: 10/10/09, p. 4) illustrates the decline of moral reasoning. Comparing an astronaut’s one-way trip to Mars to the voyages of Pilgrims and settlers to the New World centuries ago is quite specious. Certainly the Pilgrims and settlers generally did not intend to return to Europe, but they certainly did not intend simply to go to the New World and die. The Pilgrims sought to spread Christianity to the peoples of the New World and the settlers expected to leave descendants there. Astronauts have no reasonable expectation of doing either on Mars for quite some time.

John F. Fay, Mary Esther, Fla.

Lawrence Krauss (if quoted correctly) does not make a distinction between explorers and immigrants, and seems to make a false distinction between the safety measures required for a one-way trip to Mars versus a round-trip back to Earth. The planet to which the Pilgrims traveled had all the same properties as the planet on which they lived, and on which their ancestors had evolved. Before setting sail, the Pilgrims knew that the American environment was capable of sustaining human life because explorers had safely traveled there and returned.

Jeffrey D. Mueller, Eldersburg, Md.

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Charles Darwin's *On the Origin of Species*: A Graphic Adaptation

Michael Keller

Illustrated by Nicolle Rager Fuller

The first edition of Charles Darwin's *On the Origin of Species* laid out the case for evolution by natural selection with nearly 500 pages of dense prose and a single diagram. Now, writer Michael Keller and illustrator Nicolle Rager Fuller have artfully transformed this important book into a highly readable and copiously illustrated page-turner, available in hardcover and paperback.

Each of the chapters in this graphic adaptation presents a condensed version of a theme from the original book, explaining basic principles of evolution such as how variations among a creature's offspring provide the raw material upon which natural selection operates.

Also included is an introductory chapter detailing the research and ruminations that led Darwin to con-

ceive his theory. The book is further strengthened by an afterword that describes the public's response to the book's initial publication in 1859 and a



timeline that shows post-Darwin breakthroughs in evolution-related topics such as genetics, population biology and paleontology.

The text accompanying this book's marvelous, full-color illustrations draws directly from Darwin's own words, including letters he exchanged with friends and scientists about the details and the implications of his nascent theory. The result is a powerful adaptation that offers a new generation of readers — and, indeed, readers of all ages — an engaging introduction to one of the most important books ever written. — *Sid Perkins*
Rodale Books, 2009, 192 p., \$19.99.

Smallpox — The Death of a Disease: The Inside Story of Eradicating a Worldwide Killer

D.A. Henderson

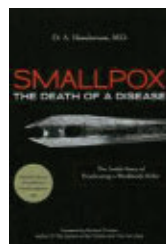
The defeat of smallpox was a public health tour de force that remains the sole example of humans wiping out a disease. The knockout blow arrived through a World Health Organization eradication campaign lasting from 1967 to 1977. In this thorough and compelling book, Henderson describes how that effort unfolded, going country-by-country to highlight challenges and successes. He ought to know: He directed the program.

After a brief history of smallpox, Henderson draws from his insider perspective to detail the WHO strategy. Plenty of vaccine was available from the outset, he writes, but attempting to reach every at-risk person invited futility. Rather, Henderson and his team

used an approach built on surveillance, containment and targeted vaccination. The book details, through anecdotes, how delivering vaccine to infected villages stopped the spread of outbreaks.

Africa posed a particular challenge with dozens of countries, hundreds of local languages and few paved roads. WHO teams there were prepped in foreign languages and even in auto repair for the inevitable breakdowns. These experiences come to life through striking photographs that put a human face on this monumental effort.

Thanks to the WHO effort, whole generations now refer to smallpox only in the past tense — with one caveat: In the book's final section, Henderson describes the use of live smallpox in bioweapons research in the Soviet Union even after the disease was eradicated. The virus still exists in Russian and American labs. With the passion of one who has spent his life fighting the disease, Henderson advocates destroying these stocks. — *Nathan Seppa*
Prometheus Books, 2009, 334 p., \$27.98.



National Geographic Concise History of Science and Invention: An Illustrated Time Line

Jolyon Goddard, ed.

Photos, illustrations and essays trace the progress of discovery from ancient times to modern days. *National Geographic*, 2009, 352 p., \$40.



The SharpBrains Guide to Brain Fitness

Alvaro Fernandez and Elkhonon Goldberg

Interviews with scientists offer practical advice and tips for maintaining brain function. *SharpBrains*, 2009, 166 p., \$24.95.



Mathematical Amaze-ments and Surprises: Fascinating Figures and Noteworthy Numbers

Alfred S. Posamentier and Ingmar Lehmann

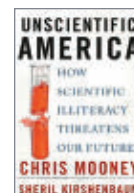
A book by two math professors presents number trivia that highlights math's "gee, wow!" factor. *Prometheus Books*, 2009, 269 p., \$20.98.



Botanical Medicine: From Bench to Bedside

Raymond Cooper and Fredi Kronenberg, eds.

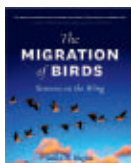
Researchers are looking to plants to treat ailments from diabetes to dermatological problems. *Mary Ann Liebert Inc.*, 2009, 237 p., \$99.



Unscientific America: How Scientific Illiteracy Threatens Our Future

Chris Mooney and Sheril Kirshenbaum

A journalist and a scientist lament ignorance of science and propose ways to fix the problem. *Basic Books*, 2009, 209 p., \$24.



The Migration of Birds: Seasons on the Wing

Janice M. Hughes

A biologist reviews the latest research on bird migration and includes

high-quality photos of discussed species. *Firefly Books*, 2009, 207 p., \$40.



How NASA Builds Teams

Charles J. Pellerin

A former NASA scientist describes how the agency puts together the teams on which

lives and budgets depend and relates tips for team management. *John Wiley & Sons*, 2009, 261 p., \$39.95.



No Small Matter: Science on the Nanoscale

Felice C. Frankel and George M. Whitesides

Seemingly invis-

ible objects such as viruses and molecules are imaged in rich detail through high-powered microscopes and photography. *Belknap Press*, 2009, 182 p., \$35.



Quantum Mechanics in a Nutshell

Gerald D. Mahan

A physicist presents an introduction to quantum mechanics for college and grad-

uate-level readers. *Princeton Univ. Press*, 2009, 399 p., \$65.



The Rising Sea

Orrin H. Pilkey and Rob Young

Coastal scientists describe the threat that higher sea levels pose to people around

the world and what can be done. *Island Press*, 2009, 203 p., \$25.95.

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SCIENCE BOOKS FOR YOUNG READERS

Dinosaurs (Book series)

Matteo Bacchin and Marco Signore

Translated by Marguerite Shore

Graphic novels — formerly known as comic books — are getting more respect these days. That may explain why Abbeville Kids has published the first four of what will be a six-part graphic series grounded in science facts but told partially through fiction. Although the large-format books are aimed at young dino aficionados — especially those 9 to 14 years old — the text won't bore adults.

Each book begins with an introduction by an unconventional narrator: the sun. Explains Sol: "The eons have turned these beings into mute stones and have emptied their chests of breath and warmth, but I bring you testimony of their ancestral time." Who knew old Sol was so poetic?

Books three and four, released this year, describe the life and times of an *Allosaurus* and a *Scipionyx*, a small

theropod of the early Cretaceous period. *Plateosaurus* and *Archaeopteryx* anchored the first two books, published in 2008.

The sun's narration breathes life into dino adventures such as hunting, nesting and migration. Roars, rumbles and the occasional "grooooooagh"

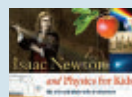
punctuate the storytelling.

The rest of each volume is more conventional, with amply illustrated text describing dinosaurs and their ecosystems,

how the creatures fossilize and places they've been unearthed. The first book comes with a 22-by-29-inch poster illustrating the dinosaur timeline.

Expect books five and six some time next year. — *Janet Raloff*

Abbeville Kids, 2008 and 2009, 61 p., \$15.95.

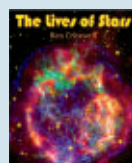


Isaac Newton and Physics for Kids

Kerrie Logan Hollihan

A guide to demonstra-

tions of basic physics accompanies this story of a great scientist and his famous discoveries. *Chicago Review Press*, 2009, 131 p., \$16.95.

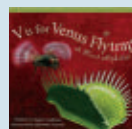


The Lives of Stars

Ken Croswell

Brilliant images and comprehensive text present the basics of stellar astronomy in an

engaging fashion. *Boyd's Mills Press*, 2009, 72 p., \$19.95.



V is for Venus Flytrap: A Plant Alphabet

Eugene Gagliano

Young readers can explore the botanical

world by browsing a plant type, feature or characteristic for each letter of the alphabet. *Sleeping Bear Press*, 2009, 40 p., \$17.95.



Ornamental Origami: Exploring 3D Geometric Designs

Meenakshi Mukerji

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Jen Green

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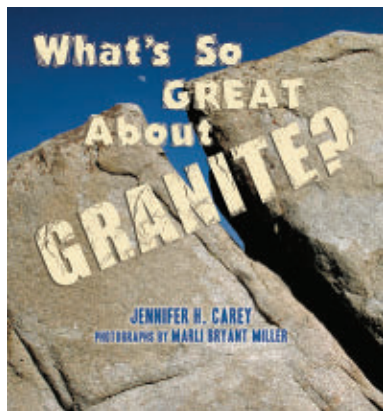
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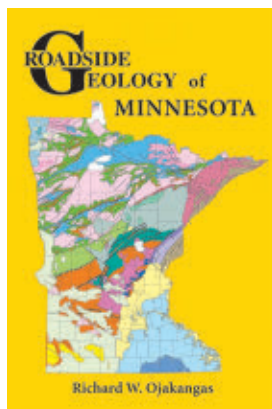
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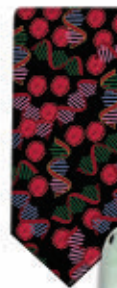
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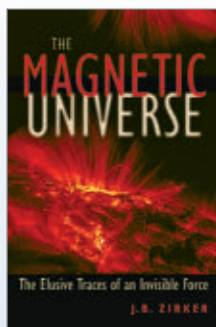
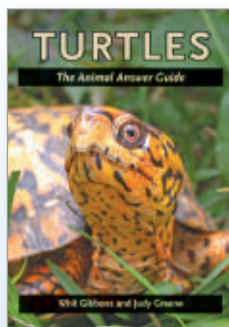
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Chelonian Research Institute



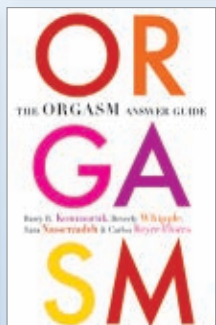
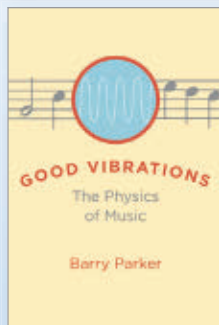
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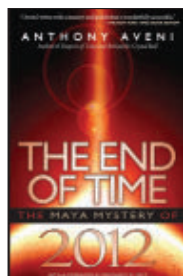
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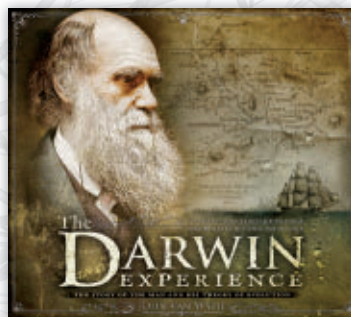
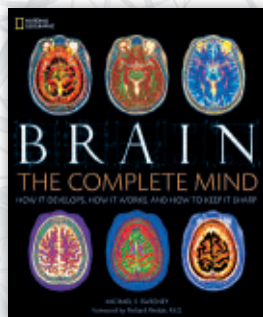
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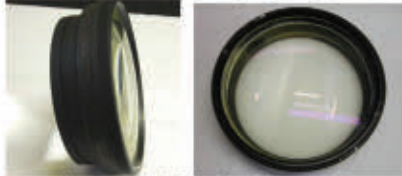
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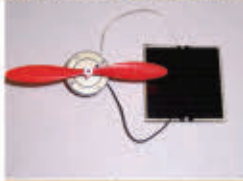
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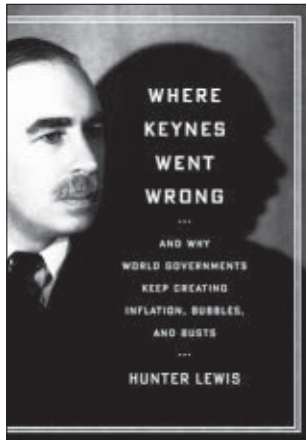
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NATO committee fosters science's role in security

Not everyone knows about Science for Peace and Security, a NATO committee with a small budget that focuses on funding civil science projects with applications to countering threats. The committee's goal is developing high-quality knowledge in various areas relevant to antiterrorism, to other threats to security or to the priorities of the Partner Countries of Eastern Europe and the former Soviet Union and of the Mediterranean Dialogue countries.

Among current SPS projects is Virtual Silk Highway, or SILK-2, a multi-year NATO computer networking project which began early this millennium to bring connectivity to the eight countries of the Caucasus and Central Asia. SILK-2 provides universities and civil research institutions in participating countries with state-of-the-art satellite technology. As part of NATO assistance to Afghanistan, SILK-2 was extended to 14 institutions in Kabul (SILK-K). SILK-K will transition to SILK-Afghanistan, bringing improved connectivity to seven provincial Afghan cities.

Over a million people will make use of the new capabilities, and millions will benefit from the connection between the receiving countries and the West.

Another program, of high priority in defense against terrorism, is STANDEX — for Standoff Detection of Explosives. STANDEX's objective is to create a prototype multiple technology system for remote (standoff) detection of suicide bombers and to demonstrate it successfully under real conditions. Details of that project emerged from workshops held by SPS with the NATO (military) Research and Technology Organization. Seven leading institutions from France, Germany, the Netherlands and Russia will collaborate on

the prototype. The combination of cutting-edge technologies could lead to a breakthrough in detecting improvised explosive devices, or IEDs, in a crowd. Russia has announced that it will contribute financially to the project as France, Turkey and the United States have.

STANDEX will develop new laser spectroscopic and active microwave devices and create new computer programming to control and coordinate these components. It marks the first cooperation of SPS with the U.S. Department of Homeland Security.

SPS efforts have produced immense benefits while attracting little publicity — the destruction of mélange in Azerbaijan and Uzbekistan, for example. The Soviets used mélange, a highly toxic substance, as a rocket fuel oxidizer. When the Cold War ended, 1,300 tons were left in Azerbaijan in metal barrels that began to corrode and leak. In 2005, SPS procured equipment and began rendering the mélange harmless. It finished in three years, and the mobile treatment plant is being transported to Uzbekistan to convert 1,100 tons of mélange beginning this fall. A July 2008 video on the mélange conversion is available on the SPS website.

In another SPS project, scientists from Azerbaijan, Armenia and Georgia worked for seven years to assess pollutants and radionuclides in their shared rivers, the Kura and Araks. This South Caucasus River Monitoring project, conducted in cooperation with the Organization for Security and Cooperation in Europe, or OSCE, provided laboratory facilities, consultant

support and training to build capacity in the three countries.

Another successful short-term project on environmental aspects of military compounds was conducted by the Netherlands, Germany and the United States from 2006 to 2008. Environ-

mental factors, such as safe drinking water, waste management, soil protection, storage of hazardous material and energy supply are vital in compound life cycles. The Netherlands and Austria organized a workshop in 2006 to establish how participating countries have covered environmental aspects of military compound procedures and techniques. Those countries shared experience and established a network of experts and considered follow-up activities.

In a Phase II, Germany, the Netherlands and the United States organized three workshops and an editorial meeting, resulting in three handbooks on environmental aspects of military operations. In March 2009, the NATO Standardization Agency and the Military Committee's Joint Standardization Board endorsed the development of the three SPS products into NATO-agreed documents.

These projects are just the tip of the iceberg of SPS's many efforts both to help counter threats to security and to help Partner Countries become prosperous, modern, democratic technological societies. ■



SPS efforts have produced immense benefits while attracting little publicity.

Physicist Vigdor Teplitz is the U.S. Department of State's representative to NATO's SPS committee. For more information, visit www.nato.int/science



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