SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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old spine, modern form

antimicrobial: soap to sludge

flycatcher food funk

weighing nanotech's risks

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cold faithful

ERUPTIONS ON ENCELADUS

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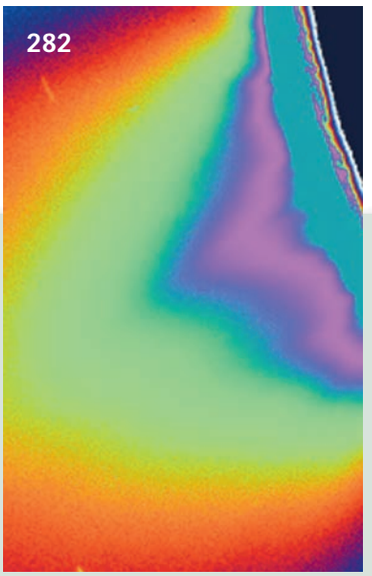

Features

This Week

Of Note

Departments

Cover Researchers last year discovered a geyser of water vapor and ice on Saturn's moon Enceladus. The finding spotlights this small moon as a new place to look for liquid water and other signs of life in the outer solar system. (JPL/NASA, Space Science Institute) Page 282

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Tainted by Cleanser

Antimicrobial agent persists in sludge

About 76 percent of a commonly used antimicrobial agent exits sewage-treatment plants as a component of the sludge that's often used as a farm fertilizer, according to the first study to track the chemical through a typical plant. The finding raises questions as to the ultimate fate of the antimicrobial in the environment, the study's authors say.

U.S. manufacturers add 500,000 to 1 million pounds of the chemical triclocarban each year to personal-care products, such as antimicrobial soaps. Past toxicological studies have linked the chemical to decreases in birthweight and survival in rats and rabbits, says Rolf U. Halden of Johns Hopkins University in Baltimore.

Halden and his colleagues followed triclocarban through a treatment plant that takes in 680 million liters of wastewater per day produced by 1.3 million residents of a city in the mid-Atlantic region. The plant separates the sewage into liquid and solid streams, and microbes break down much of the organic content of those flows.

According to the National Academies in Washington, D.C., U.S. treatment plants send about 60 percent of the solid sludge that they generate to agricultural fields and other land as fertilizer. Liquids leaving the plants typically flow into streams or other bodies of water.

The group determined the quantity of triclocarban in samples of the incoming sewage and outgoing liquid and sludge. "It's difficult analyzing the sludge," says Halden. "In the past decade, the appropriate instrumentation has become available."

In an upcoming *Environmental Science & Technology*, the team reports that microbes broke down only about 21 percent of the triclocarban entering the treatment plant. About 76 percent accumulated in the sludge, and another 3 percent remained in the liquid stream.

"If a consumer goes to the supermarket and buys a bar of soap, three-quarters of the active ingredient could end up in agriculture because the sludge is being recycled," says Halden.

The researchers estimate that from sludge released solely by the plant that they studied, more than 1,000 kilograms of triclocarban enter the environment each year. Scientists haven't yet discerned whether the chemical degrades or accumulates in soils or what its effects are on natural soil microbes, says Halden. "We don't know if it's being taken up by plants and migrating into the food supply," he adds.

QUOTE

"If a consumer ... buys a bar of soap, three-quarters of the active ingredient could end up in agriculture."
ROLF U. HALDEN, Johns Hopkins University

"This finding suggests potential problems due to the high usage rate of triclocarban in the U.S.," says Craig D. Adams, an environmental engineer at the University of Missouri–Rolla.

With the new insight on what quantities can be expected in the environment, researchers can now turn to assessing the chemical's risk, says chemist Diana Aga of the State University of New York at Buffalo.

Although the Environment Protection Agency hasn't endorsed a method for detecting triclocarban in sludge, Rick Stevens, EPA's national biosolids coordinator, says that the results "are the kind of thing that raises interest." —A. CUNNINGHAM

Evolutionary Back Story

Thoroughly modern spine supported human ancestor

Bones from a spinal column discovered at a nearly 1.8-million-year-old site in central Asia support the controversial possibility that ancient human ancestors spoke to one another.

Excavations in 2005 at Dmanisi, Georgia, yielded five vertebrae from a *Homo erectus* individual, says anthropologist Marc R. Meyer of the University of Pennsylvania in Philadelphia. The finds occurred in previously dated sediment that has yielded several skulls now attributed to *H. erectus* (*SN: 5/13/00, p. 308*).

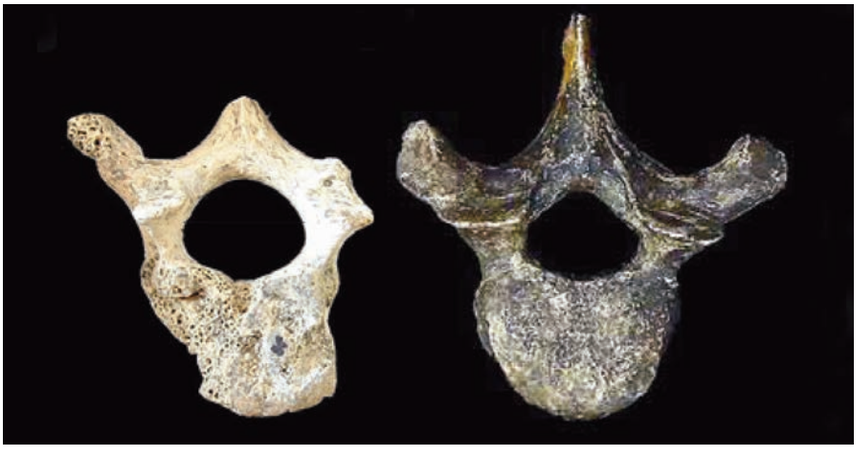
The new discoveries represent the oldest known vertebrae for the genus *Homo*, Meyer announced last week at the annual meeting of the Paleoanthropology Society in San Juan, Puerto Rico. The fossils consist of one lumbar, two thoracic, and two cervical vertebrae.

Meyer and his colleagues—David Lordkipanidze and Abesalom Vekua, both of the Georgian State Museum in Tbilisi—compared the size, shape, and volume of the Dmanisi vertebrae with more than 2,200 corresponding bones from people, chimpanzees, and gorillas.

"The Dmanisi spinal column falls within the human range and would have comfortably accommodated a modern human spinal cord," Meyer says.

Moreover, the fossil vertebrae would have provided ample structural support for the respiratory muscles needed to articulate words, he asserts. Although it's impossible to confirm that our prehistoric ancestors talked, Meyer notes, *H. erectus* at Dmanisi faced no respiratory limitations on speech.

In contrast, the 1984 discovery in Kenya of a boy's 1.6-million-year-old skeleton, identified by some researchers as *H. erectus* and by others as *Homo ergaster*, yielded small, chimplike vertebrae. Researchers initially suspected that the ancient youth and his presumably small-spined com-



MEYER

WIDE OPEN **A recently discovered *Homo erectus* vertebra from central Asia (left) displays a larger spinal cord canal than does a corresponding bone (right) from a skeleton that had been found in Kenya.**

rades lacked the respiratory control to talk as people do today.

In the past 5 years, investigators including Bruce Latimer of the Cleveland Museum of Natural History have suggested that the prehistoric boy offers a misleading view of *H. erectus*' backbone. They contend that growth of the bony canal encasing his spinal cord had been stunted, and spinal cord compression would have impeded his movement and caused limb weakness.

Finding ancient, humanlike vertebrae at Dmanisi fits with Latimer's view, Meyer says. Infant malnutrition, which often arrests growth of the human vertebral canal, may have affected the *H. erectus* youth, Meyer suggests.

The ancient boy, who died at age 10 or so, would have required intensive protection and provisioning, Meyer asserts. "Both altruism and spoken language may have been part of the behavioral repertoire of early *Homo*," the Pennsylvania researcher says.

The modern-looking vertebrae at Dmanisi, remarks David Frayer of the University of Kansas in Lawrence, comport with earlier fossil-skull studies indicating that early *Homo* possessed a speech-ready vocal tract.

Robert C. McCarthy of Florida Atlantic University in Boca Raton disagrees. At the Paleoanthropology Society meeting, he presented vocal-tract reconstructions for various ancient *Homo* species suggesting that the capacity to articulate speech as well as people do now emerged exclusively in *Homo sapiens* around 50,000 years ago.

Before then, all members of the *Homo* genus—including *H. sapiens*—possessed a short set of neck vertebrae, resulting in a vocal tract with a restricted range of speech sounds, McCarthy and his coworkers argue.

Many populations today, including Australian aborigines, possess neck vertebrae comparable in length to those that McCarthy's team considered inadequate for modern speech, Meyer responds. —B. BOWER

No Early Birds

Migrators can't catch advancing caterpillars

Pied flycatcher numbers are crashing in places where climate change has knocked the birds' spring migration out of sync with the food bonanza on the breeding ground.

That's the conclusion from a study of nine breeding areas in the Netherlands, says Christiaan Both of the Netherlands Institute of Ecology in Heteren. Each spring, the pied flycatchers arrive there after traveling 4,500 kilometers from Africa, cued mostly by day length.

AIR TRAFFIC CONTROL A pied flycatcher relies largely on day length to time its flight to its breeding grounds in northern Europe. Unfortunately, day length doesn't reflect changes in climate.

Unfortunately for these birds, late-April weather in the Netherlands has warmed some 4°C during the past 20 years. In some places, that warmth has moved up the timing of a short-lived banquet of caterpillars, which adult flycatchers feed to their ravenous chicks. The flycatcher numbers in those locations have dropped by about 90 percent, Both and his colleagues report in the May 4 *Nature*.

"This is the first time that people have shown the population consequences of climate change [in a report] that also incorporates the mechanism," says Both.

Dozens of other bird species make long-distance treks from Africa to Europe each spring. Earlier studies had indicated that numbers of other migrants have decreased as winter temperatures have risen.

The flycatchers offer an unusual opportunity to study the effects of global warming, Both says, because he has decades of data on their breeding success.

Previously, Both and his colleagues found that flycatchers tended to arrive at the same time each spring but, in recent years, were breeding more hurriedly than before. Over the past 2 decades, the birds shifted their nesting 10 days earlier. However, in those years, the big peak in caterpillar abundance advanced by 16 days. The profusion of caterpillars lasts only 3 weeks, so a 6-day mismatch can matter to the birds, says Both.

To study the effects of this timing, he and his colleagues examined sites across a range of more than 100 km. In some of the forests, leaves don't sprout early, and the burst of caterpillars that munch on them hasn't advanced. Both speculates that poor, sandy soil there may prevent early leafing out.

Both's team tracked caterpillar abundance through one spring by monitoring the insects' droppings under trees. The researchers used their previously collected data to work backward through the years. For example, they identified late-caterpillar areas for some years by seeing where European birds called great tits had raised second clutches of eggs.

Both and his colleagues found a correlation between declines in flycatcher numbers and the timing of the peak in food for their chicks. In the forests where the caterpillar peak was latest, flycatcher numbers had dropped by only 10 percent.

The scenario of migration miscues "very likely could apply to other birds," says ornithologist David Winkler of Cornell University. He notes that many European migrants, including the flycatcher, winter south of the Sahara Desert, so far from their breeding grounds that they lack information about spring weather there.

Ornithologist Scott Sillett calls the mismatch between migration itineraries and food availability "a very plausible mechanism" for climate effects on migrants. Based at the Smithsonian Institution's Migratory Bird Center in Washington, D.C., he tracks black-throated blue warblers.

He suspects that migration miscues might affect northern forests in North America. In summer, most of the birds there are migrants, some from South America, he says. —S. MILIUS

Boyish Brains

Plastic chemical alters behavior of female mice

Exposure to the main ingredient of polycarbonate plastics can modify brain formation in female mouse fetuses and make the lab animals, later in life, display a typically male behavior pattern, scientists have announced.

The chemical, bisphenol-A, is measura-

BOTH

ble in 95 percent of U.S. residents, according to past research. The chemical mimics the hormone estrogen, which in mammalian fetuses affects anatomical development that distinguishes male and female brains.

Neuroendocrinologist Beverly S. Rubin and her colleagues at Tufts University School of Medicine in Boston pumped bisphenol-A into the bodies of female mice while they were pregnant and while they were nursing their offspring. Some of the mice received 250 nanograms of bisphenol-A daily per kilogram of body weight (ng/kg/day); others received 25 ng/kg/day. Another group of mice wasn't given any bisphenol-A.

The researchers then examined the brains of some of the male and female offspring, and they placed other offspring into an empty arena to monitor their behavior.

In offspring that had not been exposed to bisphenol-A during development, a brain structure that influences fertility-related hormone cycles was larger in females than in males. However, that sex difference was not evident among animals receiving either dose of bisphenol-A, Rubin's group found.

Compared with unexposed female offspring, those given 250 ng/kg/day of bisphenol-A had fewer neurons of a type critical to the function of the fertility-controlling brain structure. The results will appear in an upcoming *Endocrinology*.

"Exposure to very low doses of bisphenol-A results in masculinization of the female brain," says coauthor Ana M. Soto.

Furthermore, the team reports, females exposed to either dose were less distinguishable from males on the basis of their behavior. Female mice normally explore more avidly than do males in an open environment.

Several scientists have estimated that the average person's daily exposure to bisphenol-A is similar to the lower dose given to animals in this study. That dose is the lowest that's been shown to affect the sexual differentiation of a mammalian brain, Soto says.

"This study is a strong addition to a series of recent reports on the long-term effects of bisphenol-A on sexual differentiation," says John G. Vandenbergh, a zoologist emeritus at North Carolina State University in Raleigh. "It shows significant effects at remarkably low doses that are well within the range of known human exposures."

But Steve Hentges, a chemist with the American Plastics Council in Arlington, Va., says that effects observed in these animals aren't relevant to people because food that's been in contact with polycarbonate is the main source of human exposure to bisphenol-A. The body metabolizes the chemical into a non-estrogenic form when it's ingested, says Hentges, whose organization represents plastics manufacturers.

Researchers "would have to confirm this kind of result with an oral exposure to make it relevant for people," Hentges says.

Frederick vom Saal of the University of Missouri–Columbia counters that the Tufts researchers, by exposing animals continuously day after day, "are mimicking to the best degree possible the human exposure to bisphenol-A."

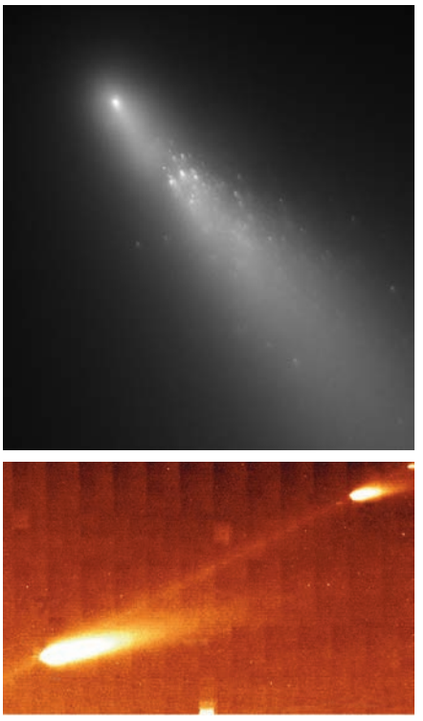
The bisphenol-A concentrations used were "so staggeringly low" that people will inevitably be exposed to similar amounts as long as polycarbonate remains in commerce, vom Saal says. —B. HARDER

Big Breakup

That's the way the comet crumbles

Scores of telescopes are watching a comet fall apart, and the main show may be only beginning. The comet has already fragmented into at least 59 pieces and may continue to break up as it reaches its position closest to the sun on June 6. In mid-May, the chunks will venture within 11.7 million kilometers of Earth—the closest any comet has come to our planet in 20 years—and the largest fragments should be visible with binoculars.

Called Comet 73P/Schwassman-Wachmann 3, this body passes near the sun every 5.4 years and has been breaking up for years. But over the past month, the Hubble Space Telescope and other instruments have documented that a few of the 36-or-so biggest chunks have each split into several dozen smaller bits 20 to 30 meters across.



COMETARY SPLIT Hubble Space Telescope image (top) homes in on a large fragment of Comet 73P/Schwassman-Wachmann 3. Some 30 subunits that recently broke off this fragment, dubbed B, trail behind it. Infrared image (bottom) taken by the Spitzer Space Telescope shows dust connecting the fragments C (left) and B (upper right).

WEAVER ET AL./NASA; REACH ET AL., JPL/NASA

The ongoing breakup attests that the cores of comets "are as fragile as the meringue in lemon-meringue pie," says Casey Lisse of the Johns Hopkins Applied Physics Laboratory in Laurel, Md.

Many short-period comets—those that orbit the sun at least once every 200 years—may end their lives by splitting up, says Hal Weaver of Johns Hopkins.

Infrared images of the comet taken with the Spitzer Space Telescope and released this week show large amounts of millimeter-to-centimeter–diameter dust particles bridging the large fragments. The ejection of millimeter-size dust might be the primary way in which comets lose material and disintegrate, says Spitzer scientist Bill Reach of the California Institute of Technology in Pasadena.

Spectra from Spitzer also reveal that the largest fragment, dubbed C, contains a higher abundance of micrometer-size silicate grains than is typically seen in intact short-period comets, says Cincinnati-based Spitzer scientist Michael Sitko of the Space Science Institute. "The breakup has cracked the comet open like an egg," revealing its interior composition, Sitko says.

Recent Hubble images show that several house-size fragments generated by the breakup of one of the larger chunks, dubbed B, are being pushed in the direction opposite to the sun. Weaver and his colleagues suggest that solar heating has vaporized icy patches on the chunks, jetting them toward the comet's tail.

Solar heating may also be responsible for the comet's breakup. Although this heat isn't likely to penetrate more than a meter beneath a comet's surface, notes Lisse, that might be deep enough if the heat encounters a large crack within a highly porous comet.

Nevertheless, Lisse says that a "great mystery" remains: "How can a body as weak as meringue come together on a kilometer scale, then fall apart?" —R. COWEN

Defending against a Deadly Foe

Vaccine forestalls fearsome virus

A single injection of an experimental vaccine prevents infection by the lethal Marburg virus in monkeys, a study finds. The

test is the first to show that a vaccine given after exposure to the virus can stop it. People infected with Marburg, a cousin of the Ebola virus, develop high fever, nausea, and internal bleeding and often die.

Scientists had previously demonstrated that the vaccine could avert Marburg virus when administered a month before exposure (*SN: 7/16/05, p. 45*). The new research comes closer to simulating real-world conditions, in which exposure to Marburg virus arises unpredictably in natural outbreaks or in laboratory accidents.

The virus is named for Marburg, Germany, where it was first identified in 1967 after infected monkeys shipped there from Uganda spread the virus to people. Since then, sporadic outbreaks have occurred in Africa.

Using extreme biosafety precautions, researchers injected eight rhesus macaque monkeys with Marburg virus. Within 30 minutes, they gave five of the animals a single shot of the vaccine. The three others got an inert substance.

The immunized animals survived the 80-day test and showed no sign of the virus in their blood, says Thomas W. Geisbert, a virologist at the U.S. Army Medical Research Institute of Infectious Diseases at Fort Detrick in Frederick, Md. The three unvaccinated monkeys died within 12 days of exposure to Marburg, Geisbert and his colleagues report in the April 29 *Lancet*.

Scientists made the vaccine by replacing a gene in an innocuous livestock virus with a gene that encodes a glycoprotein on the surface of the Marburg virus. This recombinant virus attracts the attention of a mammal's immune system, which then makes antibodies that foster immunity against the Marburg virus, says study coauthor Heinz Feldmann, a virologist at the National Microbiology Laboratory of Canada in Winnipeg.

"It's incredible that they are able to show that the [vaccinated] monkeys stayed healthy after such a high dose" of Marburg virus, says Luciana Borio, an infectious-disease physician at the Baltimore, Md., office of the Center for Biosecurity of the University of Pittsburgh Medical Center.

STATS

88%

Death rate among the 374 people infected by Marburg virus in an outbreak in Angola last year

Feldmann and Geisbert envision that the vaccine would be given as a precaution to health workers during an outbreak and to family members of infected people. It could also rescue lab workers exposed to the virus by needlesticks or other accidents, Geisbert says.

Pharmaceutical companies might find this vaccine difficult to get approved and ultimately unprofitable because the disease is uncommon, Borio says. She considers distribution of a Marburg vaccine, beyond a cache for lab safety, "a long shot."

However, the former Soviet Union had developed bioterror weapons based on Marburg and other viruses. If there were a bioterror attack using Marburg, previous assumptions about the economics of vaccine production would "go out the window," Borio says. —N. SEPPA

Blood Sucker

Like the adult heart, the developing heart takes advantage of suction

The embryonic heart, though only a simple tube, uses the same basic mechanism to move blood as an adult heart does, new observations in zebrafish suggest.

Adult hearts in vertebrates, such as zebrafish and people, pump blood using valves and muscle contractions to create suction, but the early heart in these animals is a valveless tube.

Nevertheless, this simple organ begins pumping blood when an embryo is just a few days old. Because of its austere anatomy, researchers long assumed that the developing heart uses a mechanism called peristalsis, in which a series of muscle contractions move material from one end of a tube to the other.

"Peristalsis is like squeezing toothpaste out of a tube—if you hold one end and run your fingers down it, the contents will come out," says bioengineer Morteza Gharib of the California Institute of Technology in Pasadena. Peristalsis commonly moves fluids in other parts of the body. For example, in the esophagus, it moves food from the throat to the stomach.

Peristalsis has certain defining characteristics, Gharib says. For one, increasing the frequency of muscle contractions increases the flow rate of contents leaving the tube. Moreover, all contents in the tube head in one direction with no material backing up.

While studying embryonic zebrafish hearts, Gharib and his colleagues noticed that neither of these conditions was satisfied all the time. "That put the whole claim of peristalsis in doubt," he says.

To investigate what pumping mechanism the early heart might be using, Gharib's team used a powerful microscope to view the beating hearts of zebrafish embryos. The researchers got a good look at their target by using fish genetically modified so that their hearts glowed red and their blood glowed green.

The studies revealed that the hearts move fluid much as does a device called an impedance pump, which creates a low-pressure area within a tube by squeezing and quickly releasing one end. Gharib explains that in response to the pressure drop, new fluid flows in. This process continues in a wave down the length of the tube.

The researchers report in the May 5 *Science* that they noticed a similar phenomenon when a small group of cells contracted and relaxed at one end of each fish's tubular heart. With each cycle, blood rushed into the tube and continued out the other end.

The finding that embryos have impedance pumps indicates that both embryonic and adult hearts use the basic mechanism—suction—for pumping blood, Gharib notes. Previously, he adds, researchers were at a loss to explain how the embryonic heart transitions away from peristalsis as valves develop. "It was as if two different designers made the embryonic and adult hearts," he says. "Our paper suggests that suction is really the way the heart does pumping."

Steven Vogel of Duke University in Durham, N.C., who has studied the mechanics of a variety of other natural pumps in animals and plants, notes that a similar mechanism might be lying undiscovered in the hearts of other organisms, such as insects. "I have a strong feeling this [mechanism] will turn up elsewhere," he says. —C. BROWNLEE

Renewing Our Commitment To Promoting Sustainability

Once again this year at the Intel ISEF 2006, we are proud to be sponsoring the special Ricoh Sustainable Development Award - for ideas that balance the economic and social needs of today with the environmental needs of tomorrow.

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Our virtual host at The Ricoh Sustainabilty Portal will be Maximus Green, a teen-age science fair finalist from the year 2036. His future science fair project is (or will be) a successful time travel device. This technology enables Max to travel back in time to visit with fair attendees at this year's Intel ISEF and congratulate them on the many ways their projects have (or will have) helped establish a more sustainable future world.

For those of you unable to attend the 2006 Intel ISEF, we invite you to visit the Ricoh Sustainability Portal online at:

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PARTICULAR PROBLEMS

Assessing risks of nanotechnology

BY AIMEE CUNNINGHAM

On March 10, an unusual product inventory went live on the Web. The items, which include wrinkle-banishing creams and reinforced tennis rackets and hockey sticks, don't look out of the ordinary. The shared feature of these 200-or-so seemingly disparate products hides within them. The products represent the initial attempts to take advantage of the special properties ascribed to nanotechnology. For instance, carbon nanotubes purported to be up to 100 times as strong as steel are being used to toughen sports equipment.

The inventory's items are only "the first wave of a product tsunami," says David Rejeski, director of the Project on Emerging Nanotechnologies in Washington, D.C., which compiled the inventory. The National Science Foundation has predicted that a decade from now, nanotechnology will have a $1 trillion impact on the world's economy.

Nanotechnology is the engineering and study of particles that have at least one dimension less than 100 nanometers. Along with tempting opportunities, the new field has brought safety concerns. Right now, the government approaches safety assessments of items that include engineered nanoparticles much as it does items that contain larger chunks of the same materials. Yet the tremendous interest in nanotechnology centers on novel features of the nanoparticles: Their small size, large surface area, and unusual structures endow them with electronic, optical, and catalytic properties not found in their parent materials.

SMALL IMPROVEMENTS — These everyday products are some of the first to incorporate nanotechnology into their designs.

The unusual qualities of engineered nanoparticles imply that they may have "unusual toxicity," says molecular toxicologist Valerian Kagan of the University of Pittsburgh.

The differences between engineered nanoparticles and other materials, as well as distinctions among nanoparticles, add to the challenge of assessing their toxicity. The engineered items come in many shapes and, within their tiny realm, various sizes. Their effects on cells are different when they clump than when they act individually, and it's often unclear how cells in the body would encounter them. Pinpointing the factors responsible for a toxic response is a needle-in-a-haystack task.

To address these challenges, toxicologists and chemists are working to establish protocols for what they have begun to call nanotoxicology. Their work will not only influence safety standards for the production and use of engineered nanoparticles but will also shape how the public perceives the new materials. "If we get it wrong, we can turn people and attitudes against a technology which is potentially useful and powerful," says Andrew D. Maynard, chief science advisor for the Project on Emerging Nanotechnologies, which is funded by the Pew Charitable Trusts.

ENGINEERED ENTITIES Nanotoxicology deals with the safety of engineered nanoparticles. These purposefully made particles come in shapes ranging from spheres and dots to tubes and wires. Researchers control size and shape when designing nanoparticles to exploit specific properties that "give you something useful, in an engineering sense," says chemist Kevin D. Ausman of Rice University in Houston.

Engineered nanoparticles share a size range with some by-products of natural or human activity: for example, nanoparticles that arise in clouds of volcanic ash and smoke or as pollutants from engines and factories.

These pollutants gave toxicologists the first indication that nanosize particles can be more toxic than larger particles are. Late–20th-century studies of particulate matter in air pollution and of carbon black, a nanoscale product used in tire manufacturing, suggested that the smaller the particle, the greater the chance of harm to the lung, says Ken Donaldson of the University of Edinburgh Centre for Inflammation Research.

Other work has uncovered how the body responds to inhaled particles. When a particle lodges in a lung, it activates inflammatory cells that generate highly reactive oxygen molecules, which damage other cells, says Kagan. At exposures that overwhelm the body's defenses, inflammation and cell death can cause airway-obstructing diseases.

With this knowledge, Kagan says, the question regarding engineered nanoparticles' effects on cells isn't so much whether they provoke an inflammatory response but whether researchers "are going to find anything unique in the interactions." New electrical and catalytic properties engineered into the particles might make them damaging at lower-than-usual concentrations or in unexpected ways.

MULTIPLE PERSONALITIES A variety of factors need to be considered to evaluate the toxicity of engineered nanoparticles. The size, chemical composition, and structure can affect how toxic the particle is, says Donaldson, "and these things can vary dramatically for what's supposed to be the same material."

This is different from the situation for other chemicals. "If you

PROJECT ON EMERGING TECHNOLOGIES

open a bottle of benzene in Tokyo and a bottle in Edinburgh, you are going to see the same thing," says Donaldson. But two engineered nanoparticles that are similarly named but made in different places "are likely to be totally different."

Consider carbon nanotubes. "Right now, you can buy dozens, if not hundreds, of different samples of carbon nanotubes," says Ausman. Most tubes are made by one of four techniques, each of which introduces differing amounts of metallic impurities and defects into the walls of the tubes. And some laboratories add their own touches to a production method.

These details matter when it comes to toxicity. Kagan and his colleagues reported in 2003 that single-walled carbon nanotubes riddled with iron impurities are more toxic to cultured cells than purified nanotubes are. In an upcoming *Toxicology Letters*, they examine the responses of cultured macrophages, the cells responsible for clearing pathogens from the lung and regulating the inflammatory response. They report that the iron-rich tubes led to an abundance of reactive-oxygen molecules that hampered the macrophages' response, which could lead to early onset of lung scarring.

Findings such as these emphasize the need for nanotoxicologists to adequately characterize their starting materials, says Ausman. Right now, there is a "severe lack of standards in the materials and the terminology used in describing those materials," he says.

DANGER WITHIN? — Two compartments within a cultured human-skin cell reveal the presence of multiwalled carbon nanotubes (arrows).

MONTEIRO-RIVIERE

ENTRY WAYS The toxicity of engineered nanoparticles on cells growing in a laboratory provides only half the story. A useful assessment of dangers from these particles also requires knowledge of the exposure: the amount of material and the way in which it enters a person's body.

One stumbling block to predicting true exposures is that engineered nanoparticles, especially carbon nanotubes, tend to aggregate, forming globs of material that behave differently than individual particles. In a manufacturing facility, for example, it's unclear whether workers are more likely to inhale carbon nanotubes individually or in clumps. That would affect where the particles end up in the body and how damaging they might be.

In the lab tests so far, carbon nanotubes are often treated with a soap to spread them out to contact cells in a dish. This "raises another question of whether or not these studies are measuring anything that models a real-world exposure," Ausman says.

The same question arises for animal studies. In the November 2005 *American Journal of Physiology*, Anna A. Shvedova of the National Institute for Occupational Safety and Health in Morgantown, W. Va., and her colleagues report the effects of single-walled carbon nanotubes on the lungs of mice. The volume of material, delivered in one dose, matched the current permissible exposures in volume for graphite, another form of carbon, over 20 workdays. Unlike graphite, however, the tubes caused a rapid inflammatory response that progressed to scarring of the lung within 7 days, says Shvedova.

The findings suggest that workplace exposures may need to be lower for carbon nanotubes than for graphite, Shvedova says. But she and her coworkers note that a more realistic inhalation exposure needs to be studied. In their work, the material was inserted into the throats of the animals, which then breathed it in. The group is working on a method that more closely mimics inhalation through the nose and mouth.

Skin is another likely route of exposure. Nancy A. Monteiro-Riviere of North Carolina State University in Raleigh and her colleagues tested the effect of multiwalled carbon nanotubes on human-skin cells growing on laboratory plates. The team reports in the March 15, 2005 *Toxicology Letters* that the nanotubes entered the cells and initiated the release of a protein that induces inflammation.

Many questions, however, remain about how nanotubes would affect the skin of a person, Monteiro-Riviere notes. Would the tubes lodge in the tough, outermost layer of dead cells? Or would they pass through to the next layer, where they could gain access to the circulatory system and travel throughout the body?

Nanotoxicologists also have to consider how engineered nanoparticles might affect the brain. In 2004, Günter Oberdörster of the University of Rochester in New York and his colleagues reported that carbon-13 nanoparticles inhaled through a rat's nose can travel along the olfactory nerve to the brain's olfactory bulb, a group of neurons located at the top of the nasal cavity (*SN: 1/24/04, p. 54*). Viruses also use this pathway, which isn't well known to toxicologists, Oberdörster says.

"What we don't know is the quantities that are translocated," he says. "It may not mean much if hardly anything gets there, but we need to be aware [of this pathway]."

PARTICLE PLANS As nanotoxicologists address these challenges, they're also attempting to figure out the most appropriate strategy for testing engineered nanoparticles' safety. Putting every particle through animal studies—the classic toxicology approach—"would take a lifetime," says Andre Nel of the University of California, Los Angeles. "And each of those full-toxicity tests would cost within the range of several million dollars."

Instead, researchers are advocating a tiered approach. Oberdörster and a multi-institute roster of toxicologists and chemists described such a strategy in the October 2005 *Particle and Fibre Toxicology*. Nel and his colleagues advocated a similar approach in the Feb. 3 *Science*.

Screening would begin with noncellular tests to "get an idea of how reactive the particle might be," says Oberdörster. The more-reactive particles would be the first to proceed to longer-term cellular and then animal studies.

Researchers would also like to see standards implemented in nanotoxicology studies. Scientists should agree upon comparison materials, Oberdörster says, so that "you can express your unknown particles against the activity of well-characterized references."

Studies must also include detailed information on the samples themselves. "Characterization, characterization, characterization," says Ausman. "That's the hurdle."

Maynard agrees, adding that only with accurate characterization of samples can people "have an intelligent conversation about what is the same and what is different about their studies."

He is also concerned that safety assessments could fall behind nanotechnology advances. "If we don't act fast," he says, "we will be in that position."

But Ausman is encouraged. "If you look at the development of other technologies, we are way ahead of the curve," he says. "We are actually trying to evaluate the risk, exposure, and health and safety issues before there are observed problems, rather than after." ■

THE WHOLE ENCELADUS

A new place to search for life in the outer solar system

BY RON COWEN

Step aside, Europa. Make way, Titan. Saturn's small moon Enceladus is becoming one of the hottest places to look for signs of life in the chilly outer solar system. NASA's Cassini spacecraft recently discovered that a giant plume of water vapor, dust, and small ice crystals shoots out from a crack-lined region in the southern hemisphere of this 500-kilometer-wide moon. Observations of the plume and surrounding material on the moon's surface suggest that Enceladus harbors the basic ingredients necessary for life as we know it.

An internal heat source probably drives the geyser, which looks like Yellowstone's Old Faithful. The source might heat pockets of liquid water at the bottoms of the cracks, driving it out as hot water or steam. The mix of inorganic compounds and hydrocarbons found in the plume, as well as organic compounds detected on nearby regions of the moon, suggest that a rich, warm organic soup lies beneath the surface. Such a soup would be a prime place for finding amino acids, building blocks of life, says Cassini scientist Dennis Matson of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

He and his colleagues report the basic findings about Enceladus in nine articles in the March 10 *Science*.

A water-bearing zone on Enceladus might be more easily explored than other promising sites in the outer solar system could, some planetary scientists now argue. Although Jupiter's moon Europa may harbor a vast, briny ocean, it would lie beneath an icy shell estimated to be tens of km thick. And if Titan, the largest Saturnian moon, contains liquid water, the reserves are probably well beneath its hydrocarbon-shrouded surface, which is cold enough to freeze even methane. In contrast, the exposed crevasses on Enceladus that may hold liquid water are only about a half-kilometer deep.

"I'm not saying we're going to find bugs on Enceladus, but I am saying that whatever the incipient conditions are for life, they are readily accessible there," says Cassini researcher Christopher Parkinson of the University of Michigan in Ann Arbor. "And it's worth taking a look."

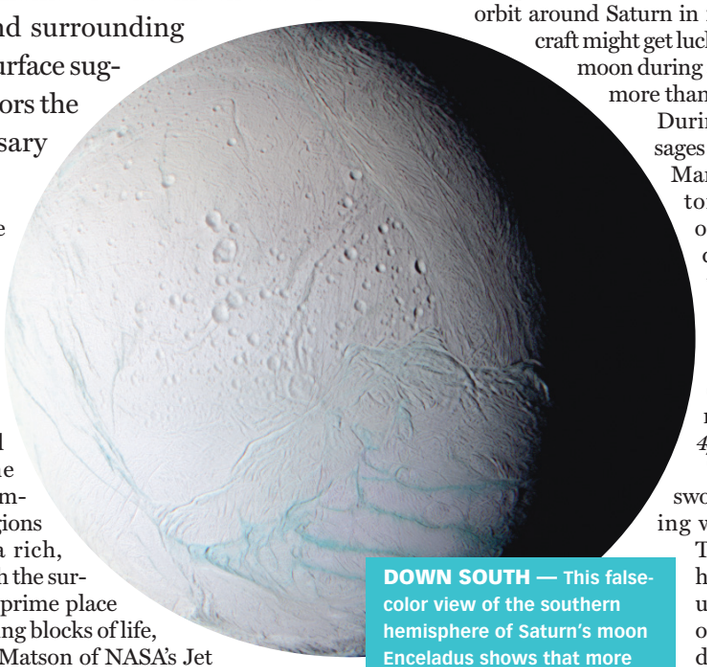
VOLATILE FINDINGS Enceladus, a tiny moon whose area is smaller than that of New Mexico, first captured the attention of planetary scientists a quarter-century ago. That's when the two Voyager spacecraft revealed ancient, pockmarked terrain on the moon lying adjacent to much younger, smoother regions. The smooth areas suggested that parts of the moon had recently undergone a facelift in which upheavals erased old craters.

Those and later Earth-based observations showed a diffuse ring of ice particles residing around the moon, another indication that Enceladus is geologically active and venting material.

Researchers planning the Cassini mission, which settled into orbit around Saturn in 2004, hoped that the robotic craft might get lucky and record a snapshot of the moon during an eruption. The scientists got more than they bargained for.

During the first two Cassini passages of Enceladus, in February and March 2005, the craft's magnetometer detected radio-wave oscillations at the exact frequency expected when ionized water molecules gyrate along magnetic field lines. The ions were probably created when sunlight struck water vapor emanating from the moon, researchers concluded (*SN: 4/16/05, p. 253*).

Then, on July 14, Cassini swooped in for a closer look, coming within 172 km of the moon. That's the nearest that the craft has come to a satellite of Saturn. Images revealed a terrain of faults, folds, and ridges devoid of craters, further evidence that Enceladus is one of the most geologically active places in the solar system. The images also showed fresh-looking deposits of amorphous and crystalline ice that could be just hours to decades old.



DOWN SOUTH — This false-color view of the southern hemisphere of Saturn's moon Enceladus shows that more heavily cratered, presumably older terrain lies next to smoother, younger terrain. The smooth patches indicate that the south-polar area has undergone recent fracturing or upheavals.

JPL/NASA, SPACE SCIENCE INSTITUTE

Then, to the astonishment of planetary scientists, "Cassini saw this great big, wonking thing," recalls Parkinson. A giant geyser of water vapor was erupting from the vicinity of 100-meter-wide linear cracks, dubbed tiger stripes, at the south pole. The plume soared 175 km above the moon (*SN: 1/7/06, p. 13*).

"This was a heart stopper," says Carolyn Porco, Cassini imaging scientist at the Space Science Institute in Boulder, Colo.

Spectra revealed that the geyser contained compounds tentatively identified as carbon dioxide, methane, propane, acetylene,

and molecular nitrogen. Molecular nitrogen requires a relatively warm temperature, notes Matson. For a crucial 24 seconds during this flyby, instruments on Cassini observed the southern hemisphere of Enceladus while a background star, Bellatrix, dipped behind the moon. Just before the star vanished, some of its light filtered through the tenuous gases surrounding Enceladus.

Viewing this stellar occultation, an ultraviolet detector on Cassini measured the amount of water vapor expelled by the plume. It also revealed in the plume and on the nearby surface, a mixture of organic and inorganic compounds that might support life. Because that material probably came from the cracks, the vents would seem to be a hospitable place for life, says Parkinson.

Completing the picture, Cassini revealed an infrared glow—a hint of heat. Though it's still a frigid 157 kelvins, the region around the plume is 25 kelvins warmer than other areas on the moon.

Solar heating isn't enough to explain the high temperature, Parkinson says. Instead, the moon must have some inner source of heat. If the temperature at the base of the plume at the bottom of the crack is higher than that of the moon's surface, as several models suggest, it means that the crack may hold liquid water.

TIGER TALES — Enceladus shows a pattern of roughly parallel crevasses, dubbed tiger stripes, in the moon's south-polar latitudes. The same internal heat source suggested to power Enceladus' geyser might have created pockets of liquid water at the crevasses' bottoms, which lie only about a half-kilometer below the moon's frigid surface.

JPL/NASA, SPACE SCIENCE INSTITUTE

Other evidence hints that Enceladus' plume isn't a one-shot event but has persisted for years. The longer the moon has been belching water vapor, the more likely it is to have retained liquid water beneath its surface, says Parkinson. Assuming that the geyser continues erupting, Cassini might get another chance to study it when the craft passes the moon again in spring 2008.

Enceladus was first detected in 1789. In the early 1980s, ground-based observations revealed that the moon inhabits an interesting neighborhood. It lies in the middle of Saturn's E ring, a tenuous outer circle of fine ice particles. Scientists immediately suspected that Enceladus both created and replenishes the ring.

Computer models indicate that the largest chunks of ice in the plumes probably follow paths that send them hurtling back toward Enceladus. But some of the smaller plume particles disperse into orbits that make up the E ring.

The ring requires constant replenishing because its particles are only loosely bound by gravity and escape after about 1,000 or so years of orbiting Saturn, says Parkinson. If Enceladus weren't belching new ice particles, the E ring would probably have vanished long ago.

LIVELY SPECULATION The mix of short-chain organic compounds found in the plumes, Parkinson and his colleagues say, suggests that if there is a heat source beneath the surface of the moon, amino acids could have been synthesized there.

Inside Enceladus, water moving through the rocky material near the moon's core could have created iron-rich clays. Models indicate that such clays could foster the formation of amino acids and even bacteria, Parkinson says.

Another source of these clays could be micrometeorites, which deliver organic compounds and metals. The micrometeorites would pound the surface and ultimately become incorporated into deeper layers of the moon.

Other features also favor formation of biological materials, Parkinson notes. For instance, spectra of the surface of the moon show several compounds that could dissolve in water and trigger energy-releasing chemical reactions. Known as redox reactions, they break down compounds by taking away or adding electrons—reducing or oxidizing the compounds respectively, in the chemical parlance. The rusting of metal, which gives Mars its reddish color, is one example of an oxidation reaction.

The geothermal activity, liquid water, and redox reactions "give favorable conditions for life on Enceladus," says Parkinson.

"These conditions are not duplicated anywhere in our solar system [today] except our planet," he asserts. Mars might have had flowing water at or just beneath its surface, but only in the distant past. Titan is a frozen repository of chemicals that could become part of a biological brew, but other conditions on that moon don't appear to be favorable for making life.

Some of the water from Europa's vast underground ocean could have oozed up through cracks in the overlying ice, refrozen, and then reacted with charged particles from surrounding space. However, Parkinson says, most of it would remain isolated beneath a thick layer of ice. Without contact with an atmosphere, redox reactions are unlikely to have occurred there.

Given these conditions elsewhere, Parkinson concludes, "Enceladus is the most exciting object in the solar system for the search of extant life."

Some other scientists disagree. For Ralph Lorenz of the University of Arizona in Tucson, Enceladus and Europa are mere "side-shows" compared with the intriguing landscape and potential lessons about the development of life offered by Titan. He says that he's not all that impressed by the shallow "Perrier water" that Enceladus may harbor.

Although they have their favorites, Parkinson, Lorenz, and other planetary scientists support explorations of all three places. But with limited funding for space missions in general, and astrobiology in particular, "everyone is protecting their own turf," says Parkinson.

HOT DEBATE Eighteen months ago, a probe carried by Cassini landed on Titan, revealing a surprisingly Earthlike terrain of shorelines and river valleys. These had been sculpted not by water but by liquid methane or ethane and by moving pebbles apparently rounded by the flow of the same hydrocarbon. Heat stored and gradually released by this mammoth moon, which is nearly as big as Mercury, can account for the complex landscape, notes Jeff Kargel of the University of Arizona in Tucson.

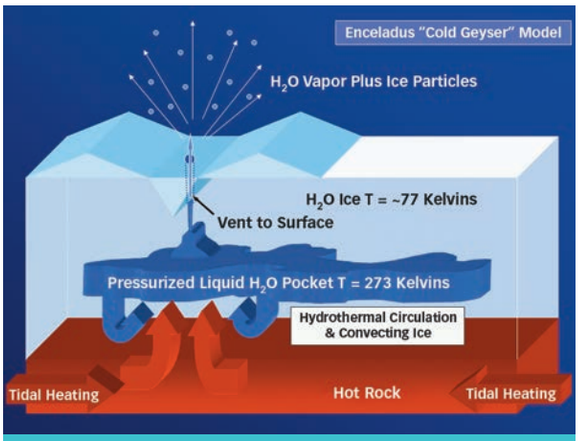
Enceladus, by contrast, remains an enigma. The moon is one of the tiniest of Saturn's retinue of satellites that orbit the planet in the same direction that the planet orbits the sun. Scientists had expected that a moon this small in the frigid outer solar system

would be an inactive ball of ice and rock. Indeed, a similar-size Saturnian moon called Mimas shows no geological activity.

Yet Enceladus' plume flouts that expectation. Researchers are debating what kind of heat source powers the moon's geysers.

Theorists generally agree that the energy that generates enough heat to liquefy some of the moon's ice comes from within the moon. In March, at NASA's annual astrobiology meeting in Washington, D.C., Julie Castillo of NASA's JPL presented one of the models for that energy.

The key to Enceladus, her team proposes, is that it has a relatively rocky, much larger core than the inactive Mimas does. Coalescing about 3 million years after the birth of the solar system, the rocky material began to undergo radioactive decay, which generates heat. Short-lived radioisotopes, such as aluminum-26, jump-started the heating. Once these isotopes decayed, long-lived ones, such as uranium and thorium, took over and produced enough heat to melt the core, the team suggests.



MODEL BEHAVIOR — Schematic of how radioactive decay and gravitational flexing could have created enough heat at the moon's rocky core to produce reservoirs of liquid water under pressure beneath the surface.

A liquid core can easily absorb energy from the gravitational stresses generated by variations in the tug of a neighboring body. As Enceladus travels on its oblong path, which the model suggests was even more elongated in the past, the moon responds to variations in Saturn's gravitational pull. This produces tidal forces that flex the core of the moon and sustain its interior heat, even after the short-lived isotopes have decayed.

Tidal energy would keep the rocky core molten. Heat transferred from the molten core to surrounding ice could then liquefy water and produce a plume, Castillo's team says.

FUTURE SEARCH While many scientists are enthusiastic about planning a mission to Enceladus, they'll need much more information from Cassini, other craft, and from ground-based telescopes, says Parkinson. Planetary scientists want to determine whether the plumes are generated steadily or sporadically. They also want to confirm hints in spectra that there are compounds of biological significance, such as ammonia and oxidants, on the moon's surface and to look for chlorophyll and other harbingers of life.

To encounter liquid water, a probe might not have to descend to the bottom of the cracks. Data in hand indicate that a mist of water may lie just 7 m down the vents.

Cassini is scheduled to fly past Enceladus in 2 years. "If a wet domain exists at the bottom of Enceladus' icy crust ... Cassini may help to confirm it," says Kargel. But learning whether the moon hosts life is beyond Cassini's ken, he adds.

In the March 10 *Science*, he wrote, "Any life that existed could not be luxuriant and would have to deal with low temperatures, feeble metabolic energy, and perhaps a severe chemical environment. Nevertheless, we cannot discount the possibility that Enceladus might be life's distant outpost." ■

JPL/NASA, SPACE SCIENCE INSTITUTE

OF NOTE

ZOOLOGY

Bird hormone cuts noise distractions

A jolt of springtime hormones makes a female sparrow's brain more responsive to song, say researchers.

The female hormone estradiol doesn't do this by boosting the tissue's response to song, though. Instead, it dulls the reaction to junk noise, says Donna Maney of Emory University in Atlanta. Songs might thus stand out against a background of unromantic environmental sounds.

MANEY

COME HITHER A female white-throated sparrow reacts favorably to a male's courtship song.

Scientists have learned that one of the ways hormones affect animals' behavior is by changing the ways in which their brains process smells and sounds.

Maney and her colleagues explored such hormonal tuning in captive female white-throated sparrows. The researchers gave half the birds tiny implants that released estradiol, which normally abounds in females during breeding season. The other half received empty implants. After several days, the researchers played recordings of either male songs or a string of beeps at frequencies in the songs.

The researchers then dissected the birds' brains and checked the activity of the gene *zenk*, which turns on during processing of important sounds. The females with the hormone implants showed more *zenk* activity if they'd listened to real song than if they'd heard just beeps. Females with the empty implants showed about the same *zenk* activity after either recording, Maney and her colleagues report in the March *European Journal of Neuroscience*. —S.M.

SCIENCE & SOCIETY

Study finds bias in peer review

Researchers have found evidence of bias when scientists review data and the researcher's name and affiliation are available to the reviewers.

The survey focused on some 67,000 research abstracts submitted to the American Heart Association (AHA) between 2000 and 2004. Experts in the field annually review the abstracts and deem about 30 percent of them acceptable for presentation at the organization's annual meeting.

Beginning in 2002, AHA changed its review process so that authors' names and affiliations were stripped from abstracts before they were sent out for peer review. Joseph S. Ross of the Yale University School of Medicine and his colleagues now report that the change triggered major shifts in which categories of authors were most likely to have their abstracts accepted.

For instance, during 2000 and 2001, abstracts from U.S. authors were 80 percent more likely to be accepted than were those from non–U.S. authors. After blinding, the U.S.–based papers were only 41 percent more likely to be accepted, Ross' team reports in the April 12 *Journal of the American Medical Association*. Similarly, the share of abstracts from faculty at highly regarded U.S. research universities dropped by about 20 percent, after blinding. For authors in government agencies, the acceptance rate fell by 30 percent.

Although the study focused on abstract acceptance at one organization's scientific meeting, there's no reason to assume the same thing doesn't happen at other meetings or in other disciplines, the authors say. —J.R.

BIOMEDICINE

Two drugs are equal in preventing breast cancer

A commonly prescribed anti-osteoporosis drug works as well at preventing breast cancer in postmenopausal women as the sole drug currently prescribed for the task, a head-to-head trial shows.

Scientists designed the study to compare oral doses of the osteoporosis drug raloxifene (Evista) with tamoxifen (Nolvadex) taken for 5 years. Roughly half of the nearly 20,000 women received raloxifene; the others got tamoxifen. All the women were at high risk of breast cancer.

Researchers report that roughly the same number of women—167 and 163—developed breast cancer while taking raloxifene and tamoxifen, respectively.

However, 36 women getting tamoxifen developed uterine cancer, compared with only 23 taking raloxifene. Also, more women getting tamoxifen developed blood clots than did women taking raloxifene.

Researchers stopped the trial after 4 years of average follow-up when the study established the drugs' equal effect on breast cancer development. The National Cancer Institute, which funded the trial, released the results in mid-April.

Research has shown that the hormone estrogen binds to cells and stimulates their proliferation in about 70 percent of breast cancers. Both tamoxifen and raloxifene block the hormone from binding to breast cells.

"It's clear that raloxifene is the winner" in the new study, says Lawrence Wickerham, an oncologist at Allegheny General Hospital in Pittsburgh. —N.S.

MICROBIOLOGY

Liver regeneration tied to bile acids

Bile plays an integral role in the regeneration of damaged liver tissue, a study finds.

The liver manufactures bile, which is then stored in the gall bladder. From there, it moves into the small intestine where it helps digest fats. Up to 95 percent of bile is then recycled via the blood and pumped back to the liver. It's a highly efficient system, says molecular biologist David D. Moore of the Baylor College of Medicine in Houston.

Earlier work had hinted that bile might influence the liver's capacity to repair itself. To investigate, Moore and his colleagues fed mice chow that contained a bile component. Within a week, the animals' livers grew by 30 percent.

In a separate experiment, the scientists removed parts of the livers of normal mice, which within days showed signs of regrowth. Because the gall bladder continued to release a normal amount of bile into the gut, more bile is available per gram of the undersize liver. This suggests that bile stimulated the liver regeneration, Moore says.

After similar surgery, mice lacking a gene called *FXR* didn't regrow liver tissue as well, the researchers report in the April 14 *Science*. The researchers focused on *FXR* because they knew that bile binds to and activates the protein encoded by the gene. Within a liver cell, this protein then switches on various genes that influence cell replication and other processes.

The finding indicates that the protein from *FXR* acts as a bile sensor, he says. Combined, the experiments suggest a

OF NOTE

mechanism by which the liver senses and responds to tissue loss. Further research may clarify which genes the protein switches on and how that influences cell replication, he says. —N.S.

ZOOLOGY

Just turn your back, Mom

A female in a species of legless amphibians called caecilians nourishes her youngsters by letting them eat the skin off her back, says an international research team.

Caecilians, which look like worms or snakes, burrow through the soil in the tropics. Some species lay eggs, and quirks of several of these species got Mark Wilkinson of the Natural History Museum in London and other researchers wondering whether these moms fed their young. The hatchlings had scraperlike teeth, for example, and they hung around their mother for their first weeks of life.

Now studying the egg-laying African species *Boulengerula taitanus*, Wilkinson and his colleagues have found the missing baby food. They dug up and observed 21 nesting females and their broods.

The researchers saw skinny, pink youngsters poke their lower jaws against their mother's' backs and peel off the dark outer layer of her skin, leaving her bluish white. Also, females with young develop an especially thick outer layer of skin with morsels of fat in it, the researchers report in the April 13 *Nature*.

The scraper teeth in these young resemble teeth of fetal caecilians in live-birth species. Scientists speculate that those youngsters use them to graze on the linings of their mothers' oviducts as they slide by. Since the skin feeders have the same kind of scraper teeth, researchers speculate they come from a lineage intermediate between ancient, egg-laying lineages of caecilians and more-recent lineages bearing live young. —S.M.

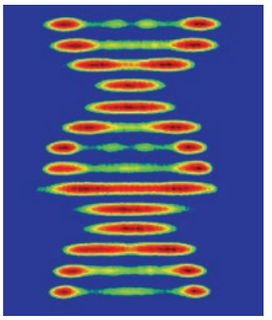
PHYSICS

Confined gas rejects compromise

Imagine pouring cold milk into a cup of hot coffee and finding that the milk stays cold while the coffee stays hot. Physicists have now achieved a similarly strange result by restricting atoms of an ultracold gas to motion in just one dimension.

In the new system, atoms of different energies collide but don't share energy in the usual way that, for example, equal amounts of hot and cold liquids make a lukewarm mix, notes David S. Weiss of Pennsylvania State University in University Park. He says that his team has devised an experimental means to investigate what causes and controls the energy-distribution process, called thermalization.

To do so the researchers first created a quantum state known as a Bose-Einstein condensate (*SN: 9/18/04, p. 186*) by trapping and cooling rubidium-87 atoms. Then, by crossing two laser beams to form thousands of light tubes capable of confining atoms, the team divvied up the atom cloud into a hundred-or-so atoms per tube. Finally, a third laser's pulse split each tube's contents into two portions and imparted unequal doses of momentum to each—the rough equivalent of creating hot and cold parts of each sample.



IN A RUT Confined to narrow tubes, oscillating atom clouds of unequal energies collide without attaining a happy energy medium. This image shows clouds' motions (from top) at 1-millisecond intervals.

This set the portions in motion in one dimension within their tubes. The atoms repeatedly mixed, but their energy profiles didn't change, even after an estimated thousands of collisions, report Weiss and his Penn State colleagues Toshiya Kinoshita and Trevor Wenger in the April 13 *Nature*.

The system forestalls thermalization because the one-dimensional motion prevents the kind of momentum transfers that generate a broad distribution of energies, Weiss says. —P.W.

SCIENCE & SOCIETY

Clinical trials really pay off

A new study finds that large-scale human trials of new treatments in medicine have the potential to pay rich dividends—huge economic benefits from improved quality of life.

S. Claiborne Johnston and his colleagues at the University of California, San Francisco evaluated all 28 trials that the National Institute of Neurological Diseases and Stroke (NINDS) in Bethesda, Md. had ever funded to test the efficacy of new drugs or procedures. They focused on the eight trials for which there were data on a therapy's use and impact. Adding the ensuing years' cost of the therapies in this group boosted their cumulative total cost to $3.6 billion.

The estimated return on that investment was an additional 470,000 years of improved quality of life for people receiving these treatments, the neurologists report in the April 22 *Lancet*. At $40,000 per year of improved quality of life—a low figure for such estimates by economists—net benefits from just eight trials yielded dividends worth more than $15 billion. The researchers note that the cost of all 28 NINDS trials totaled only $335 million.

"I had assumed there would be some benefit, but I was shocked at how great it was," Johnston says. Indeed, his team found that NINDS' average investment in a trial "was returned through health benefits within 1.2 years" of its completion. —J.R.

NEUROSCIENCE

Wired for math

The same neural circuits that adults use to perform complex calculations are already at work in preschoolers doing basic math, a new study finds. This result suggests that the brain is set up to process numbers early in life.

How the brain graduates from simple counting to more-advanced mathematics, which uses symbols and requires reasoning, isn't clear, says Jessica Cantlon of Duke University in Durham, N.C. One important question has been whether the same region of the brain, called the intraparietal sulcus (IPS), that's active when adults do sophisticated sums also controls basic math skills.

"Intuitively, it would seem that those [skills] are really separate," Cantlon says.

To test IPS' role, she and her colleagues used magnetic resonance imaging to measure changes in blood flow in the brains of 4-year-old children and young adults performing numerical tasks. The subjects watched a stream of computer images of different numbers of squares, circles, and triangles. During repeated shape changes for the objects, IPS activity declined in both adults and children. But the IPS kicked into gear in both groups when the number of objects was changed, the researchers report in the May *PLoS Biology*.

"The take-home message is that by at least 4 years [of age], your brain is learning how to deal with quantitative information," Cantlon says. "The same brain circuits appear to be important for doing mathematical tasks your whole life." —C.G.

WEISS

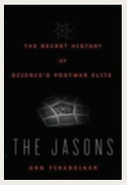
Books

A selection of new and notable books of scientific interest

THE JASONS: The Secret History of Science's Postwar Elite

ANN FINKBEINER

The Jasons, as silly as the name might sound nowadays, was an elite and deadly serious group of scientists that advised the U.S. government on defense strategies during the Cold War and on other science topics. The academics were outed during the Vietnam War and briefly vilified. But since then, little about the nature of their classified work had been revealed to the public. Science writer Finkbeiner gives the first inside look at this illustrious but secretive group, named for the hero of the Greek tale *Jason and the Argonauts*. Among the group's ranks were such physics legends as Freeman Dyson and Murray Gell-Mann as well as numerous leaders from other scientific disciplines. These men and women met for a few weeks each year to develop scientifically sound ideas for various government agencies. Among their sponsors were the Defense Advanced Research Projects Agency, the CIA, the Navy, NASA, and the Department of Energy. Finkbeiner examines moral dilemmas that Jasons members faced in helping the government develop nuclear bombs and battlefield technologies. She also reveals the groundbreaking discoveries that stemmed from these meetings, including electronic battlefield technologies for the Vietnam War, climate-research systems, and astronomy technology that has extended scientists' view into space. This book looks at the consequences of an unusual interplay of science and government. ***Penguin, 2006, 336 p., hardcover, $27.95.***



THE FIRST HUMAN: The Race to Discover Our Earliest Ancestors

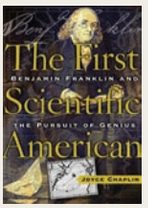
ANN GIBBONS

Anthropologists face a variety of obstacles as they search for fossils in Africa, the cradle of humanity: sandstorms, relentless heat, and the occasional landmine. They also face interpersonal challenges, as researchers vie to locate the anthropological Holy Grail: the fossil that will definitively identify humanity's earliest ancestor. Gibbons writes about human evolution for *Science* magazine. In her exciting narrative, she chronicles the work of four international teams in a sometimes-dangerous race to identify the clues to how humans diverged evolutionarily from chimpanzees some 5 million to 7 million years ago. The cast of characters includes paleoanthropologists Tim White of the United States and Michel Brunet of France, African zoologist Meave Leakey, and British geologists Martin Pickford and Brigitte Senut. In recent years, these groups have vied to claim discovery of the oldest human ancestor, starting with White's find of a 4-million-year-old partial skeleton in Ethiopia in 1992. Gibbons provides a firsthand account of the challenges faced by these groups, including not only the competition but also the bureaucracy of getting permits for digs, the logistics of survival in remote places, and ego clashes among the fossil hunters. ***Random House, 2006, 336 p., b&w plates, hardcover, $26.00.***

THE FIRST SCIENTIFIC AMERICAN: Benjamin Franklin and the Pursuit of Genius

JOYCE E. CHAPLIN

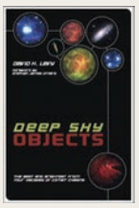
From childhood, most people in the United States remember the iconic image of founding father Benjamin Franklin flying a kite during a thunderstorm. However, many of the facts implied by this picture are misleading. For one, Franklin discovered the electricity in lightning before he did the kite experiment. Also, his scientific achievements went far beyond kite flying and even the understanding of electricity. He was the first scientist to reach international celebrity status, acclaim that paved the way to his successful political career. Chaplin's biography is unusual in that it focuses on the man's scientific career and his attempts to understand and control nature. Franklin began his intellectual life as a printer, publishing his famous *Poor Richard's Almanac*. His interests soon extended to the physical systems of equilibrium, including those of the human body, which were first described by other scientists of the 18th century. Franklin drew a connection between the body's systems and the systems of society, specifically the need for checks and balances. This is just one way in which Franklin's scientific interest influenced his political views. Chaplin describes in detail Franklin's other achievements, including charting the Gulf Stream and describing the aurora borealis, and argues that if not for his foray into U.S. politics, Franklin might have a body of scientific discoveries the likes of that accomplished by Isaac Newton. ***Basic, 2006, 421 p., b&w images, hardcover, $27.50.***



DEEP SKY OBJECTS: The Best and Brightest from Four Decades of Comet Chasing

DAVID H. LEVY

In this book, Levy offers budding astronomers an introduction to deep-sky objects, objects beyond the solar system. These celestial wonders include red stars, double and triple stars, nebulae, quasars, and comets. Using his own experiences as a comet hunter, Levy has identified 378 bright objects that can be seen even in a light-polluted night sky. The book presents these objects in order of their distance from Earth. Each entry lists an object's name, date of its discovery, position in the sky, best viewing season and conditions, and magnitude of brightness. Levy includes tips for how the amateur astronomer should use a telescope and record his or her observations. The book also details the history of many deep-sky objects' discoveries, starting with observations made by Charles Messier in the late 1770s. Levy includes anecdotes from his own work in charting the cosmos as well as a series of constellation charts, forming a sky atlas. ***Prometheus, 2005, 362 p., b&w images, paperback, $20.00.***



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LETTERS

Same old grind

"Ancient Andean Maize Makers: Finds push back farming, trade in highland Peru" (*SN: 3/4/06, p. 132*) remarks on maize starch granules being "consistent with" stone grinding. The presence of lowland arrowroot on one tool is consistent with trade, but it is equally consistent with a wandering hunter grabbing a root in the midlands and bringing it home.

JAMES REICHLE, QUINCY, CALIF.

It's my decision

"Do Over: New MS drug may be safe after all" (*SN: 3/4/06, p. 131*) contained a very disturbing comment: "Neurologist Annette Langer-Gould of Stanford University says that even the 1-in-1,000 risk of PML [leukemia] 'seems to outweigh the benefits' that natalizumab would provide many patients." Having a genetic mutation for which there is no treatment or cure and having (and having had) friends with MS, I am very concerned that some entity would withhold a beneficial treatment because of an identified risk. First and foremost, the choice is that of the recipient, not the administrator. When the risks are high—e.g., greater than 50-50—then sufficient counseling should be made available to help the patient consider the quality of life versus the trade-offs.

DAVID SWEETMAN, DYER, NEV.

The party's over?

Light pollution (*"Light All Night," SN: 3/18/06, p. 170*) is a side effect of cheap fossil fuels. As such, we may be closer to the end of this problem than most people think. Electricity is still the best bargain in the civilized world, but blowing it off into the night sky has always been folly. When energy prices reach a high-enough level, streetlights, commercial signage, and private-yard lights will begin to wink out. I eagerly await that day.

TOM NESS, GRANTS PASS, ORE.

The study by Chad Moore and Dan Driscoe quantifying light pollution is valuable. However, like most similar studies, it does not address the deleterious effects light pollution is already having on humans. The notion persists that the electric destruction of night is nothing more that a minor nuisance. Nothing could be farther from the truth. One has only to survey a few people to see how abysmally ignorant they are about the stars in the night sky—which they have basically never seen—to understand the pernicious effects of light pollution on our very nature as intelligent beings.

PATRICK L. LILLY, COLORADO SPRINGS, COLO.

Science Mall shopping

sciencemall-usa.com

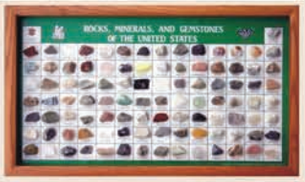
Deluxe Dinosaur Panorama Poster

The Deluxe Dinosaur Panorama poster - A colossal wall poster that embodies the elegance and power of dinosaurs. Painted by Haruo Takino. Size: 64.375"L X 22.75"H and comes laminated. Order #JPT-dinopan cost: $38.00

Dino Panorama Floor Puzzle - 70 piece - NEW!
Puzzle size: 39"W X 14"H
#JPT-dinofloor, Cost: $16.95

Dino Panorama Puzzle - 1,000 piece - Puzzle size: 37"W X 13"H #JPT-1000 Cost $19.95,

Rocks, Minerals and Gemstones



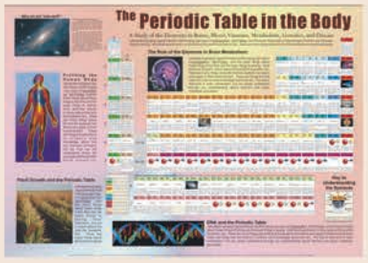
Rocks, Minerals and Gemstones of the U.S. 100 piece set, size: 20"L X 12"W X 1"D, Oak casing. Great for classrooms, collectors or young scientists. Suitable for wall hanging. Order #JPT-1888, Cost: $85.00 *Meteorite included!*

NASA Solar System Poster - Size: 26.75" X 38.5" JPT-System laminated - $15.95 Simply beautiful!

Earthrise over the Moon - This poster represents the classic beauty of outer space! Size: 15.75" X 19.75" Order#JPT-5515, Cost: $15.95 Laminated

Medicinal Plants poster - This poster represents about 50 different medicinal plants. Great refence and learning poster! Size: 26.75" X 38.5" Order#JPT-1112, Cost: $15.95 Laminated

The Periodic Table in the Body - 2006 copyright



The Periodic Table in the Body - poster discusses each of the elements on the Periodic Table in relation to how the body uses them. It helps us understand how the elements are used by bones, blood, metabolism, genetics, and disease. Also, there are five sections to this periodic table poster. One section examines why we are indeed "star stuff" and our chemical ties to the universe; others profile the chemical makeup of the human body, plant growth, DNA, and the role of the elements in brain metabolism. Full color, laminated, 28"W X 38"H poster, Copyright 2005.....#JPT-4191.... Cost $28.95

Vitamins poster - Covers all the major vitamins. This poster would make a great match with the "Periodic Table in the Body" poster for health information. Size: 26.75" X 38.5" Order #JPT-vita, Cost: $15.95, Laminated

FREE Human Genome Poster with every order over $45 - Jewelry - there is still time for Mother's Day!

Aromatic Herbs - (above) Covers over 50 different types, Size:26.75" X 38.5" Order JPT-aroma, Cost: $15.95, Laminated

Red Eye Frogs poster Size: 24"W X 36"H, laminated, Order #JPT-frogs, Cost $15.95 *They are just adorable!*

Mammoth Ivory Rose Pendant
This exquisite, delicately carved Ivory Rose Pendant is wrapped in 14K gold. Comes with 20" braided gold chain. The pendant comes with certificate of authenticity and its history. It is the perfect gift for Mother's Day or other special occasions. Rose pendant size 1" diameter, rose earrings size 3/8" diameter. Order #JPT- rose..$185 Order jewelry set - with earrings, pierced ears or clips, #JPT-1733...$360 for the set.

Attractive Ammonite Pendant wrapped in 14K gold with *braided,* beautiful gold 14K chain. These are the best quality in the world, from Madagascar.
Comes in attractive jewelry box with information and authenticity. Size: 1 1/2" W x 2 1/4" L Chain is 20"
Order: #JPT-1719 $120

Pewter Ankh Pendant Jewelry - This figurative symbol has come to mean life or "zoe." An interesting and beautiful gift. Sterling Silver; Ankh size: 1 1/8" X 2 1/8"L, Comes with 22" SS chain in an attractive jewelry case with info. Order # JPT-ankh, Cost: $75

"Mother and Child" mammoth ivory pendant - This delicately carved pendant is wrapped in 14K gold and comes with 20" braided gold chain. This rare, beautiful cameo was made from ancient fossil Mammoth Ivory that remained buried in the snows of Alaska for over 50,000 years. This would be a keepsake for generations to come! Cameo size: 35mm, JPT-cameo135....$165, Pendant set with earrings: # JPT-cameoset135 - $320 ***Also available on our website:*** *Mammoth Ivory Rose Pendant, Victorian Woman Ivory Pendant and Hooded Woman Ivory Pendant, as well as many other new items!*

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