SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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ocean eddies' far-flung effects

superior threads spun

the pox from prairie dogs

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wild sphere

TAMING A MATHEMATICAL CONJECTURE

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This Week

Of Note

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Cover This bronze sculpture of what mathematicians call a wild sphere illustrates how complicated an object can be and still belong to the family of shapes known topologically as two-dimensional spheres. A Russian mathematician seems to have finally proved the famous Poincaré conjecture, which concerns spheres and the shapes of three-dimensional spaces. (Sculpture: Helaman Ferguson; photo: Dick Barbieri) Page 378

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African Legacy

Fossils plug gap in human origins

Three partial skulls excavated in eastern Africa, dating to between 154,000 and 160,000 years ago, represent the oldest known fossils of modern people, according to the ancient skulls' discoverers.

The new finds of *Homo sapiens* fossils, unearthed near an Ethiopian village called Herto, fill a major gap in the record of our direct ancestors. Modern *H. sapiens* fossils previously found in Africa and Israel date to about 100,000 years ago. A skull excavated in Ethiopia of a not-yet-modern, so-called archaic *H. sapiens* is roughly 500,000 years old.

The Herto fossils show that *H. sapiens* evolved in Africa independently of European Neandertals, says project director Tim D. White, an anthropologist at the University of California, Berkeley. The finds thus bolster the out-of-Africa theory of human evolution (*SN: 5/17/03, p. 307*). In this view, people originated in Africa between 200,000 and 150,000 years ago and subsequently replaced Neandertals and other closely related groups.

In contrast, supporters of multiregional evolution argue that *H. sapiens* evolved over the past 2 million years with at least some interbreeding of African, Asian, and European populations.

"Only in the African fossil record can we now see a progression of specimens leading to modern humans," White says.

At Herto in 1997, White's team found the partial skulls of two adults, one of which retained its facial bones, and of a 6-to-7-year-old child. Removal of sediment from the fossils and their reconstruction, including the assembly of more than 200 pieces of the child's cranium, occurred over the next 3 years. Measurements of argon gas trapped in volcanic ash above and below the finds were used to generate an age estimate. The group describes the Herto discoveries in the June 12 *Nature*.

The investigators classify the skulls as members of a "near-human" *H. sapiens* subspecies. The face of the more complete adult specimen looked much like that of people today, they say. However, the braincase volume of the two Herto adults is smaller than that of archaic *H. sapiens* skulls and slightly larger than that of current populations.

At Herto, White's team also unearthed skull pieces and teeth from seven other *H. sapiens* individuals, more than 600 stone artifacts, and hippopotamus bones bearing stone-tool incisions made by humans either killing the animals or scavenging their carcasses. Geological analyses indicate that ancient Herto residents lived along the shores of a shallow lake inhabited by hippos, crocodiles, and catfish.

Stone-tool incisions on the Herto skulls probably resulted from removal of flesh after death and from other mortuary practices, White says. The smoothed edges of the child's skull indicate that it was repeatedly handled.

"At last, we have well-dated evidence for the emergence of modern *Homo sapiens* in Africa," remarks anthropologist G. Philip Rightmire of the State University of New York at Binghamton.

The only question remaining now is whether modern *H. sapiens* evolved first in eastern Africa or resulted from the mixing of archaic populations across Africa, adds anthropologist Christopher Stringer of the Natural History Museum in London, a backer of the out-of-Africa theory.

FRESH OLD FACE **A nearly 160,000-year-old skull found in Ethiopia looks much like that of a person living today.**

Multiregional-evolution proponent Milford Wolpoff of the University of Michigan in Ann Arbor disagrees. Human fossils from later in the Stone Age exhibit signs of interbreeding among Africans and non-Africans, even if *H. sapiens* got its start in Africa, Wolpoff contends. —B. BOWER

Full-Length Pregnancy

Progesterone product may reduce premature births

A therapy first tried in the 1960s can both extend a pregnancy in a woman who is at risk of giving birth prematurely and reduce a newborn's risk of complications, a new study finds. The drug, 17-alpha-hydroxyprogesterone caproate (17P), is a natural metabolic product of the female hormone progesterone. In previous small-scale tests, it showed mixed results.

For the new study, researchers enrolled 463 pregnant women who had delivered a previous child prematurely—after an average of 31 weeks. A full-term pregnancy lasts 40 weeks, and a delivery is considered premature if it occurs before 37 weeks. Being born even a few weeks ahead of schedule can slow a child's development.

The researchers randomly assigned two-thirds of the women to receive weekly injections of 17P beginning in the second trimester and the other women to get inert shots.

Of the women receiving the drug, 36 percent gave birth prematurely, compared with 55 percent of those receiving the placebo shots, says Paul J. Meis of Wake Forest University School of Medicine in Winston-Salem, N.C. Also, babies of mothers getting 17P weighed more and averaged fewer complications, such as brain hemorrhages and serious intestinal problems, than babies of the placebo group did, Meis and his colleagues report in the June 12 *New England Journal of Medicine*. It's still unclear how supplements of this first cousin of progesterone can keep a risky pregnancy on an even keel, Meis says.

"This is a very exciting study," says Peter S. Bernstein of the Albert Einstein College of Medicine in New York. Currently, physicians have no way to stop premature labor once it starts, so a drug to avoid it may represent "one magic bullet," he says. However, only further study will reveal which at-risk women are most likely to benefit from 17P injections, Bernstein says.

Study coauthor Alan M. Peaceman of Northwestern University School of Medicine in Chicago agrees that researchers now need to "hone down the population of women" whom 17P will benefit.

Toward that end, Meis' team plans to test the drug on women pregnant with twins, a group prone to premature births. Meanwhile, Meis and Peaceman both say

that they would be willing to prescribe 17P for women with a history of premature births. However, although the drug is approved for fertility treatment, it isn't commercially available.

Others are less sure about giving 17P. Jeffrey C. King of New York Medical College in New York says that although the new research is well done, it needs to be replicated. "I would hate to see [17P] blindly adopted by lots of practitioners because they have nothing else to offer patients," he says.

"Obstetrics has a somewhat dark history of rapidly adopting technologies and treatments that are subsequently shown to be not effective and in some cases dangerous," says King.

Consider the synthetic estrogen called diethylstilbestrol (DES). It was prescribed from 1940 to 1971 to prevent complications in pregnancies but turned out to increase cancer risk. Meis acknowledges that this outcome may have discouraged research into 17P over the past 3 decades, even though the hormones differ chemically. —N. SEPPA

Super Fibers

Nanotubes make tough threads

The superior mechanical and electrical properties of carbon nanotubes have intrigued materials scientists for a decade. But they've struggled to take advantage of the hollow tubes, just nanometers wide, for macroscopic projects.

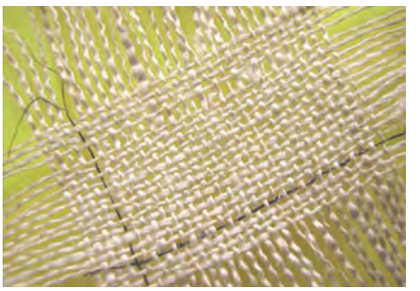
Now, researchers have spun the tubes into composite fibers that are tougher than steel, Kevlar, or spider silk. The new fibers appear to be tougher than any other synthetic or natural material, says Ray Baughman of the University of Texas at Dallas in Richardson. Toughness indicates how much energy a material can absorb before breaking.

By modifying a process developed by French researchers (*SN: 12/16/00, p. 398*), Baughman's team spins fibers made of carbon nanotubes and polyvinyl alcohol, a common industrial polymer. In the June 12 *Nature*, Baughman and his colleagues describe the finished threads, which are the width of a human hair and 100 to 200 meters long.

The achievement is "very good news for the field of nanotubes," says Philippe Poulin of the Paul Pascal Research Center in Passac, France, one of the researchers who developed the technique that Baughman's team modified.

The Texas researchers tested their fibers' mechanical properties and compared them with known values for 3,000 other materials. The fibers are 20 times as tough as steel wire, 17 times as tough as the Kevlar used in bulletproof vests, and 4 times as tough as spider silk—a natural material whose renowned toughness researchers have long tried to mimic (*SN: 08/17/02, p. 100*). The nanotube fibers are also stronger than spider silk and Kevlar, meaning they can support more weight.

"The results are the best I have seen from nanotube-composite materials," comments Otto Zhou of the University of North Carolina at Chapel Hill. "This is a big step toward eventual utilization of carbon nanotubes . . . in composites, which has been envisioned since the discovery of carbon nanotubes more than 10 years ago."



FUTURISTIC FIBERS Materials scientists used carbon nanotubes to make two electricity-storing supercapacitors (black threads) that they inserted into cloth. The woven area is a little more than 2 centimeters long.

"This fiber will provide for a new generation of high-strength fabrics and energy-absorbing materials, such as vehicle armor," suggests Ken Smith of Carbon Nanotechnologies, a Houston company that supplies Baughman with carbon nanotubes.

The fibers' extraordinary properties could also make them candidates for safety harnesses, explosion-proof blankets, or bulletproof vests, suggests Baughman. He cautions, however, that the fibers haven't yet been tested for antiballistic capabilities.

Baughman and his coworkers have already fashioned the fibers into electricity-storage devices called supercapacitors, which they incorporated into ordinary cloth. This exercise demonstrates the fibers' potential for electronic textiles, such as military uniforms with built-in antennas, sensors, or tiny batteries for powering communications equipment, he says.

The most exciting thing about the new nanotube work is that the supertough fibers can now be made available to many researchers, says James Von Ehr, the founder of Zyvex, a firm based in Richardson, Texas, that's developing carbon nanotube composites and other nanotechnology products. Ehr personally donated the seed money that established the NanoTech Institute at the University of Texas where Baughman and his colleagues work.

Right now, nanotube researchers agree, the biggest hurdle to exploiting the new fibers is the cost and limited availability of the nanotubes Baughman uses, known as the single-walled carbon nanotubes. — J. GORMAN

Lease on Life

Old mice live longer when given young ovaries

Here's one more reason to be obsessed with reproduction. A new study with aging mice suggests that the reproductive system plays a role in determining how long animals live.

James Carey and his colleagues at the University of California, Davis transplanted ovaries from 2-month-old mice into mice whose ovaries had been removed a few weeks after birth. The procedure extended some of the animals' lives. It proved equivalent to enabling a 50-year-old woman to live to age 92 instead of 80, her current life expectancy, Carey explains.

"The gonads are communicating with the body to stay young for reproduction," he says.

In the June *Aging Cell*, Carey and his coworkers describe their experiments with five groups of female mice. One group retained its original ovaries. In four groups, the researchers removed the animals' ovaries when the mice were only 3 weeks old and thumbnail size. Of those mice, one group remained without ovaries. The researchers transplanted 2-month-old ovaries into the other groups when the animals reached 5, 8, or 11 months of age.

Carey compared the remaining life expectancies of each group when the mice were 11 months old, an age at which they're normally no longer capable of reproduction. The mouse group that had their original ovaries had about a month more to live than the group that had their ovaries removed and not replaced.

A mouse's age when it received its ovary transplant influenced its life expectancy. The mice that received new ovaries at 11 months of age benefited most, living 60 percent longer than those that had their ovaries removed but not replaced and 40 percent longer than those still with their original ovaries.

The mice that had received ovaries at 8 months had 24 percent longer to live than the mice with no ovaries did, and the group that received ovaries at 5 months lived

A. DALTON ET AL.

about 7 percent longer.

"Clearly, there's some kind of cross talk between the reproductive organs and the soma [body] of the animal," says Leonard Guarente of the Massachusetts Institute of Technology, who investigates the genetic factors of longevity.

The ovary-transplant process kills many mouse egg cells. So, it's not clear whether the differences seen in the experiment result directly from the transplanted ovaries or indirectly from the reduction in eggs. In previous research, the nematode *Caenorhabditis elegans* lived 60 percent longer than normal if its germ cells—eggs or sperm—were destroyed, Cynthia Kenyon of the University of California, San Francisco reported in the Jan. 18, 2002 *Science*.

Kenyon cautions that the germ-cell connection to longevity she found in nematodes may not apply to mice. "When we understand both systems better," she says, "we can find out whether it's a coincidence or whether there's some evolutionarily conserved mechanism operating in the two animals."

In time, Carey speculates, the research could lead to life-prolonging interventions that exploit whatever signal helps keep the mice youthful.

"Reproduction is the cardinal function in life," Carey says. "It denies logic to believe that it isn't central to aging." —S. MCDONAGH

Not So Green?

Using hydrogen as fuel may hurt environment

Fossil fuels are often reviled because they produce planet-warming carbon dioxide. However, replacing them with hydrogen gas—considered to be a clean-burning source of energy—may generate a different set of environmental problems, including large and long-lasting ozone holes, according to a new analysis.

The potential problems with hydrogen don't stem from the oxidation of the gas itself, which produces only water vapor. Instead, drawbacks may arise from the almost inevitable leaks of hydrogen gas from facilities that produce it, containers that store it, and fuel cells that use it to generate electricity, says John M. Eiler, a geochemist at the California Institute of Technology in Pasadena, who has analyzed seepage rates from current hydrogen facilities.

Around 15 percent of the hydrogen gas produced to meet future fuel needs could leak into the atmosphere, Eiler and his colleagues estimate in the June 13 *Science*. That loss could boost the atmospheric concentration of hydrogen at Earth's surface from its natural level of 0.5 parts per million to around 2.3 ppm, they say.

According to the researchers' scenario, some of the gas leaked at ground level eventually will make its way into upper layers of the atmosphere and react with oxygen to create water. An infusion of hydrogen gas would moisturize the upper atmosphere, which is typically dry because it's so cold. The result would be cooler and cloudier upper layers, the researchers say.

That change wouldn't be good for the upper atmosphere's ozone layer because many of the chemical reactions that destroy ozone take place on ice crystals, says Eiler. If all technologies that derive their energy from fossil fuels were instead powered by hydrogen fuel cells, the ozone hole over Antarctica could get 4 percent larger, lose up to 7 percent more ozone than it currently does, and last about 1 week longer each spring. Effects on the Northern Hemisphere's ozone hole, which currently isn't as extensive as the one over Antarctica, might be stronger, the researchers hold.

A rise in atmospheric concentrations of hydrogen gas could have several other effects, says Eiler. An increase in high-altitude clouds might boost the proportion of incoming radiation reflected back into space. Also, soil microbes that use hydrogen gas as a nutrient might become more prolific, with unknown ecological results.

The atmospheric consequences described by Eiler's team "certainly are plausible," says Paul C. Novelli, an atmospheric scientist with the National Oceanic and Atmospheric Administration in Boulder, Colo. Whether those outcomes materialize may well depend on the hydrogen-munching soil microorganisms that are a major consumer of atmospheric hydrogen, Novelli notes.

Eiler agrees. He and his colleagues' recent research suggests that as much as 90 percent of the hydrogen gas emitted from today's sources, which include vehicles and forest fires, ends up locked in soil. —S. PERKINS

Fixed Focus

Adjustable lenses from liquid droplets

Grinding glass is one way to make a lens. Using plastic goop, a little salt, and electricity is now another way. That's what researchers at Lucent Technologies' Bell Labs in Murray Hill, N.J., have done to create lenses the size of sesame seeds.

The lenses are even adjustable. The salt added to the goop, a liquid-polymer precursor, makes it electrically conductive, so the lenses' shapes can be adjusted by applying voltages. Once the droplet assumes the desired form, a few minutes under an ultraviolet lamp polymerizes the liquid into a hard lens.

These lenses may cut the price of the assemblies of laser chips and light-manip-

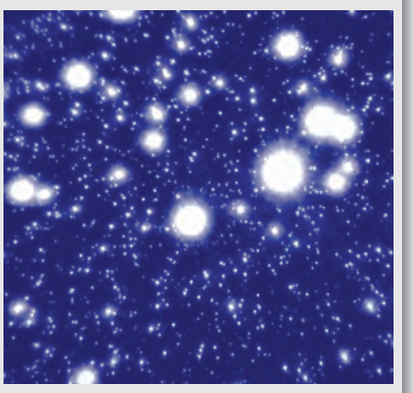
Sharpening a Heavenly Image

Clear view of globular cluster's crowded core

Using innovative optics to take the twinkle out of starlight, a telescope in Hawaii has recorded the sharpest-ever infrared images of the globular cluster M-13, a crowded grouping of Milky Way stars. The resolution is comparable to discerning the separation between car headlights on the Golden Gate Bridge while standing 3,850 kilometers away in Hawaii. Researchers presented the images last week at a meeting of the Canadian Astronomical Society in Waterloo, Ontario.

Like other so-called adaptive-optics systems, the device installed on the Gemini North Telescope atop Hawaii's Mauna Kea reduces blurriness by using a flexible mirror whose computer-controlled shape changes 1,000 times per second to compensate for Earth's turbulent atmosphere. Compared with other systems, the Gemini device corrects for turbulence higher in the atmosphere, where most of it occurs, and thus sharpens images over a slightly wider region of sky, notes project scientist Glen Herriot of the National Research Council of Canada in Victoria, British Columbia.

Gemini imaged the center of M-13 at several infrared wavelengths, which will enable astronomers to determine the type, mass, and age of individual stars, says Tim Davidge of the National Research Council. —R. COWEN



GEMINI OBSERVATORY

CORE IMAGE Center of the globular cluster M-13, some 23,000 light-years away. This image was taken at one of the three near-infrared wavelengths recorded by the Gemini North Telescope.

ulating components in fiberoptic telecommunications systems, says chemist Shu Yang, a member of the Lucent team. Currently, installing such assemblies requires a technician to use an expensive micromanipulator to make time-consuming alignments of tiny, hard lenses. The droplet strategy may offer an easy-to-tweak alternative, Yang says.

To shape a lens before hardening it, the Lucent researchers start with a glass slide coated with a conductive film. After etching that film to form an electrode, they deposit a slick coating similar to Teflon and finally add a droplet of polymer precursor. The liquid beads up into a lens shape on the naturally repellent coating.

In the absence of a voltage, the droplet has as little contact with the coating as possible. This produces a rounded lens with a small focal length, so the drop can focus light only to a point near itself.

However, as a voltage is applied, electric charges accumulate beneath the droplet, creating an electric field that draws the droplet toward the coating. That downward tug flattens the droplet, increasing its focal length by up to 30 percent as the voltage is raised.

By applying a more complex pattern of voltages, which is possible because the electrode has several independent sectors, the researchers can also exert a sideways force on the liquid lens. Such a capability could prove useful for aligning the lens with other miniaturized components, the team reports in the June 5 *Advanced Materials*.

Making the new type of lens is "a clever and imaginative step," comments John A. Rogers of the University of Illinois at Urbana-Champaign, who is on leave from Lucent. "The ability to tune these types of photocurable lenses and then lock them into place . . . could reduce significantly the cost of many kinds of optoelectronic components." —P. WEISS

Domestic Disease

Exotic pets bring pathogens home

The current outbreak of monkeypox in the Midwest is the first report of this smallpox-related virus in people in the Western Hemisphere, according to infectious-disease investigators. It's also the first time the disease has been associated with prairie dogs. However, the animals, caught wild in Texas and South Dakota and sold as pets, have been known to transmit other serious infections, the scientists say.

DOG DAYS Prairie dogs, which dig large communal burrows in western North America, can transmit diseases such as monkeypox. Its symptoms in people include pus-filled blisters (inset).

U.S. FISH AND WILDLIFE SERVICE; (INSET) MARSHFIELD CLINIC

Since early May, monkeypox has sickened several dozen people, mainly in Wisconsin and Indiana, says Stephen Ostroff of the Centers for Disease Control and Prevention in Atlanta.

In central and western Africa, monkeypox appears naturally in some rodents and sometimes spreads to monkeys or people through bites or close contact with infected rodents. Monkeypox rarely moves from person to person.

There had been no human deaths in the U.S. outbreak as of press time, although in Africa the virus typically kills about 4 percent of people it infects. Initial symptoms in people include fevers, sweats, and headaches. Pus-filled blisters later form, burst, and heal into scars similar to those caused by chickenpox or smallpox.

Since only people carry or spread smallpox, the apparent link between symptoms in the first U.S. patient—a 4-year-old girl—and a prairie dog bite helped doctors at the Marshfield (Wis.) Clinic avoid mistakenly diagnosing the infection as the more deadly disease, says pathologist Kurt D. Reed of that clinic.

African studies show that smallpox vaccination reduces the risk of monkeypox infection by about 85 percent, but immunity wears off over time. At least one person infected in the current monkeypox outbreak received a smallpox vaccination several decades ago.

Because pet dealers catch prairie dogs in the wild, the animals can bring unusual diseases—including tularemia and plague—into the home. In the U.S. monkeypox outbreak, however, prairie dogs already in captivity probably caught the virus from a rodent that had been imported from Africa, says veterinarian Richard Hull of the Illinois agriculture department.

A company near Chicago that buys and sells exotic pets simultaneously held a sick Gambian giant pouched rat and some prairie dogs, Hull says. Prairie dogs that the company then sold to a pet dealer in Milwaukee later infected people. Some of the animals died or developed rashes, lost fur, and discharged fluid from their eyes and noses. Investigators are working to determine how the infection could have jumped between the two rodent species. In one case, a rabbit seems to have acquired an infection from a prairie dog at the veterinarian's office and then infected its owner.

"Intermixing of species from the Old World and the New World . . . is just a setup for problems," says Reed. Health and wildlife officials express concern that if infected animals escape into the wild, monkeypox might join the roster of diseases established in North America. To prevent that, officials in several states have prohibited the release of pet prairie dogs into the wild.

In 1999, West Nile virus became the most recent infection known to gain a foothold among wild animals in North America. Earlier this year in China, investigators traced the virus causing severe acute respiratory syndrome to the civet, a wild mammal. —B. HARDER

OCEANS ASWIRL

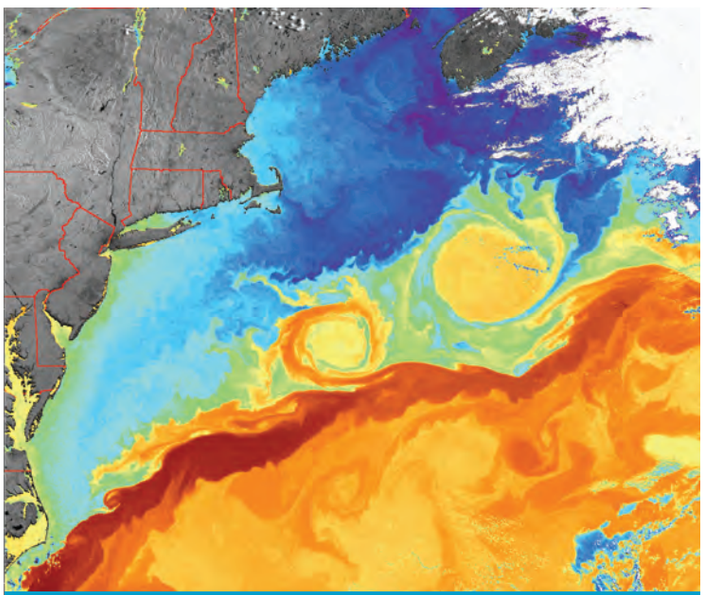
Massive eddies influence Earth's climate, marine ecosystems, even big business

BY SID PERKINS

The hallmarks of rotation are written all over the ocean. Huge currents flowing past islands and peninsulas generate enormous swirls in their wake, occasionally casting off giant whirlpools. Currents meandering across the open ocean can also shed massive, long-lasting eddies. Just as the atmosphere's large- and small-scale motions mix the air, the ocean's hierarchy of eddies blends cold waters with warm, the nutrient-rich with the nutrient-poor, and the salt-laden with fresher waters.

In the process, these massive swirls—many of them hundreds of kilometers across—transport some of the ocean's heat from tropical climes to higher latitudes and create biological oases vast enough to be visible from space. What's more, eddies can influence weather across a wide region, and their currents can have effects ranging from disrupting operations at deep-sea oil platforms to influencing the outcomes of long-distance yacht races.

Too large for earthbound scientists to recognize directly, researchers wielding ever more powerful computer models, informed by data collected from ships, are beginning to account for the effects of eddies on Earth's oceans and climate.



JOHNS HOPKINS UNIVERSITY/OCEAN REMOTE SENSING GROUP

TALE OF TWO EDDIES — This June 11, 1997, satellite image shows the Gulf Stream in dark reddish-brown and two warm-core eddies, north of the Gulf Stream, in tan. Cold waters are depicted in shades of blue. The white region at upper right and the blue area at lower right are clouds.

CHURN IT UP When the marine microorganisms that form the base of the ocean's food chain die, they often sink to the seafloor, carrying nitrates, organic carbon, iron, and other nutrients with them. Therefore, large portions of the ocean's surface—especially those that lie over deep waters—can lack basic chemical ingredients required for life to flourish.

In some areas, particularly along the western edges of continents, strong currents usher nutrient-rich waters to the surface. In the open seas, however, it's typically ocean eddies that scoop those vital substances back from the abyss.

Cyclonic eddies—those that rotate in the same direction as a cyclone, which is counterclockwise in the Northern Hemisphere and in the opposite direction in the Southern Hemisphere—usually bring relatively cold, nutrient-filled waters to the ocean's upper, sunlit layers, where phytoplankton can proliferate. These so-called cold-core eddies fuel a population explosion among zooplankton, shrimp, fish, squid, and other aquatic species higher up the food chain, says Douglas C. Biggs, an oceanographer at Texas A&M University in College Station. "A cold-core eddy can be a real biological hotspot," Biggs notes.

The centers of anticyclonic, warm-core ocean eddies typically are zones of downwelling and therefore are nutrient-deficient. However, fluid friction along the edges of these whorls can create counter-rotating eddies that bring cool, nutrient-rich waters to the surface. Also, the swirling action of warm-core eddies can entrain and concentrate cooler waters—and their biological inhabitants—from surrounding ocean regions.

These phenomena are well known among the crews of fishing trawlers, who often seek out eddies to maximize their catch. Some of the ocean's top nonhuman predators do the same thing, says Bruce Mate, an oceanographer at Oregon State University's Hatfield Marine Science Center in Newport.

He and his colleagues tagged and tracked several right whales in the shallow waters off Nova Scotia during the early 1990s. At one point during a feeding season, one of the whales left the group, swam offshore to a warm-core eddy 360 kilometers southeast of Cape Cod, and fed along its edge for 6 days. The eddy was pulling relatively cool waters south from the Gulf of Maine, and the right whale gorged on the abundant copepods that were being funneled into a narrow zone at the eddy's edge, says Mate.

Now, Mate is part of a team that since last July has been tracking 18 radio-tagged sperm whales—a small part of the estimated 1,000 or so sperm whales that live in the northern portions of the Gulf of Mexico. One of the team's hypotheses is that these whales often forage within eddies or along their edges. A third of the tags, which cost about $5,000 each, are still active. When the last tag falls silent later this summer, says Mate, the researchers will analyze the whales' movements with

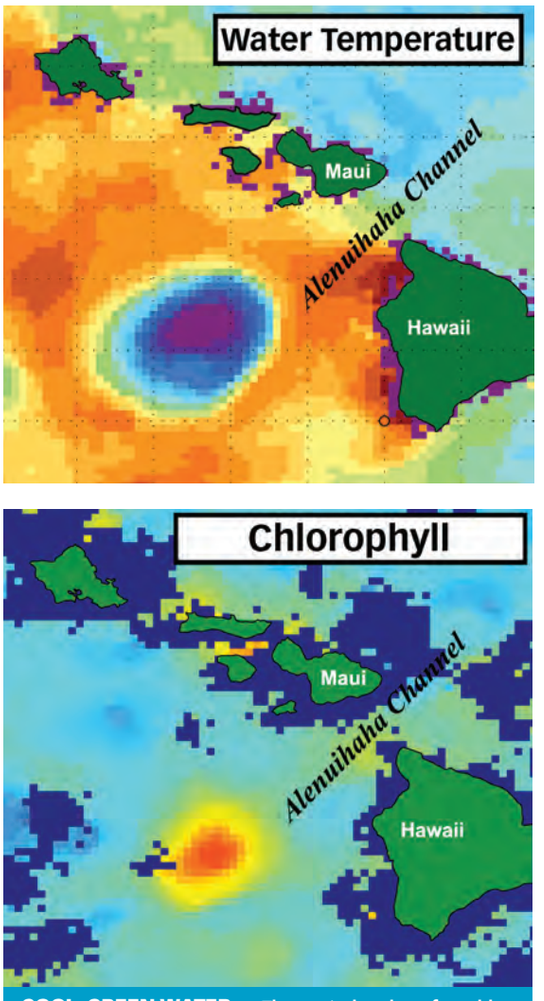
respect to the position and movement of eddies, among other ocean phenomena.

Most large eddies in the Gulf of Mexico are shed from the Loop Current, which gets its name from the path it takes across southeastern portions of the Gulf. After this current passes through the Yucatán Strait between Mexico and Cuba, it heads north toward Louisiana and then loops back to the east and passes south of Florida. At irregular intervals of 3 to 17 months, great eddies with warm-water cores spin off the Loop Current and drift westward across the Gulf. These eddies, which range up to 400 km across and have a clockwise rotation, are some of the largest in the world, says Robert R. Leben, an oceanographer at the University of Colorado in Boulder. The rotating currents generated within the eddies can flow at up to 4 knots, or 2 meters per second.

Slow as that sounds, it's more than strong enough to hamper operations at deep-sea oil-drilling platforms that dot the northern portions of the Gulf, says Leben. Some procedures, such as laying pipeline on the seafloor or positioning a ship that's drilling for oil, can be performed in steady currents of up to 2 knots. However, Leben notes, faster currents or chaotic flows can damage equipment or lead to accidents. Because the eddies progress across the Gulf at speeds of only 2 to 5 kilometers per day, a single eddy that stretches hundreds of kilometers may shut down operations at a particular location for weeks at a time.

Leben operates a Web site that monitors the positions of Gulf eddies. Because thermal expansion of the water makes a warm area mound higher than the cool waters surrounding it, satellites that use radar and other methods to measure sea level with an accuracy of a few centimeters can spot the warm-core eddies as broad bumps in the ocean. Such overhead observations also enable scientists to estimate the speeds of the currents associated with the eddy. Higher mounds tend to generate stronger currents.

Information on eddies has come in handy for sports enthusiasts. A team competing in a recent cross-Gulf yacht race consulted Leben about how to use the data on his Web site to predict the currents that boats would encounter. It might have helped, says Leben, because the savvy crew won the competition.



COOL, GREEN WATER — The central region of a cold-core eddy (top image, purple), located southwest of Maui in September 1999, hosted high concentrations of chlorophyll-bearing phytoplankton (bottom image, orange).

NASA/NOAA/UNIV. OF HAWAII

WHEN TO SPIN Although scientists don't know what phenomena trigger the Loop Current to shed eddies, computer models are identifying possible players.

Hyun-Chul Lee and Lie-Yauw Oey, oceanographers at Princeton University, have developed a computer simulation of the Loop Current and those currents that flow along the northern coast of South America. The model looks at the effects of the currents' temperature and salinity, the wind patterns across the region, and the presence of eddies already in the Gulf.

Under average conditions, with no eddies or winds present, the simulated Loop Current sheds an eddy about once every 9 months, says Lee. Seasonal changes in water temperature and salinity don't seem to affect this rate. However, month-to-month variations in wind patterns cause the time between eddy shedding to fluctuate between 4 and 12 months. Lee and Oey reported results of their simulations at the fall meeting of the American Geophysical Union (AGU) in San Francisco last December.

The researchers' model also showed that when winds aren't taken into consideration, eddies already swirling in the Gulf tend to extend the duration between eddy sheddings by several months, so intervals then range from 9 to 15 months.

The results correspond qualitatively with those of a computer model developed by Jorge Zavala-Hidalgo, an oceanographer at Florida State University in Tallahassee. His simulations show that large cyclonic eddies occasionally form in the northern portions of the Gulf and block the northward intrusion of the Loop Current. This, in turn, prevents the current from shedding a warm-core eddy, says Zavala-Hidalgo. In such circumstances, according to the model, the current instead spins off a series of small, cold-core eddies that move along the western coast of Florida. Zavala-Hidalgo also presented his findings at last fall's AGU meeting.

Both Zavala-Hidalgo's and Lee and Oey's models seem to closely mimic ocean observations. The longest known period between eddy sheddings by the Loop Current, the 19 months from February 1998 to August 1999, occurred when a large eddy remained in the northern Gulf for several months.

The chemistry of the Gulf's water, not just its motions, is affected by these eddy dynamics. For example, the interaction between eddies intermittently shed by the Loop Current and the seasonal variation of fresh water dumped into the Gulf of Mexico by the Mississippi and other rivers affects the overall salinity of water in the Gulf, says Zavala-Hidalgo. In the summer, winds predominantly blow toward the east. If an eddy then forms just off the Mississippi delta, it can entrain low-salinity water and transport it intact along the Florida's western coast as far south as the Florida Keys.

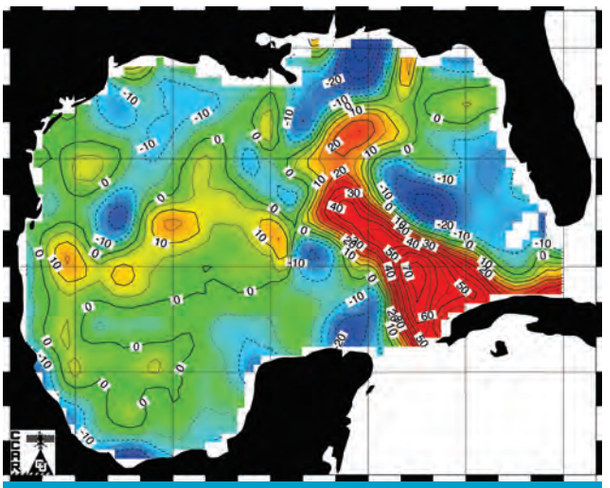
WEATHER OR NOT Because the temperature of the water trapped in an eddy often differs substantially from that of the surrounding water, the big swirl can often significantly influence local weather. When a coastal eddy stalls off Los Angeles, for example, it can reduce temperatures and increase rainfall in the metropolitan area. Elsewhere, moisture evaporating from warm-core eddies that are shed into the North Atlantic by the Gulf Stream can produce a thick ocean fog if the moisture drifts back over cold water and condenses.

The heat-carrying capacity of eddies can transport thermal energy from southern oceans to Antarctica. Today, the surface

waters surrounding that ice-covered continent are almost completely isolated from other oceans by a circumpolar current that races forever eastward along a latitude unblocked by any landmasses.

Each year, warm-core eddies shed from this so-called Antarctic Divergence Zone transfer southward the equivalent of about 0.3 petawatt of power, which is approximately half the amount of power delivered annually to northern Europe by the Gulf Stream, says John Marshall, a planetary scientist at the Massachusetts Institute of Technology. Even though this power is spread out along the entire 22,000-km distance traveled by the circumpolar current, it's still enough to moderate Antarctica's frigid climate somewhat, perhaps raising the temperature by as much as 1°C in coastal regions, Marshall notes.

Like their counter-rotating cohorts in the Northern Hemisphere, the cold-core cyclonic eddies surrounding Antarctica can concentrate biological activity. In one example, satellite images of the ocean near the Antarctic coast south of Australia in early December 2001 showed chunks of sea ice being swept into eddylike swirls about 150 km across, says Stephen R. Rintoul, an oceanographer at the Commonwealth Scientific and Industrial Research Organization in Hobart, Australia. By late December, the ice had disappeared, but on-site measurements by Rintoul and his ship-faring colleagues showed that the amount of chlorophyll in the surface waters of the eddies had jumped to as much as 15 times what it had been 2 months earlier. Satellite and shipboard observations indicated that the phytoplankton continued to proliferate until late January 2002 but then died out by early March. Rintoul and his colleagues report their analyses in the May 1 *Geophysical Research Letters*.



COLORADO CENTER FOR ASTRODYNAMICS RESEARCH

IN THE LOOP — This May 20, 2003, image of the Gulf of Mexico depicts variations in sea level, with the relatively taller and warmer Loop Current shown in red and several cold-core eddies in dark blue. Numbers in white boxes indicate centimeters above or below average sea level.

The ships didn't take enough data to determine whether the eddy-related biological bounty resulted from upwelling of nutrients or influx of nutrients from coastal waters, Rintoul says. Supporting the second scenario, satellite images suggest that small quantities of phytoplankton—and dissolved iron—were swept out to sea from shallows and transported northward by eddies. The blooms might have been later fueled by increasing sunlight as the summer days lengthened.

Future cruises through eddies in the region may determine the factors that stimulate the plankton blooms. This is just the sort of real-world data gathering that researchers need to refine their computer models of eddies and the swirling waters' multiple effects on phenomena ranging from local plankton populations to the planet's climate. ■

IF IT LOOKS LIKE A SPHERE...

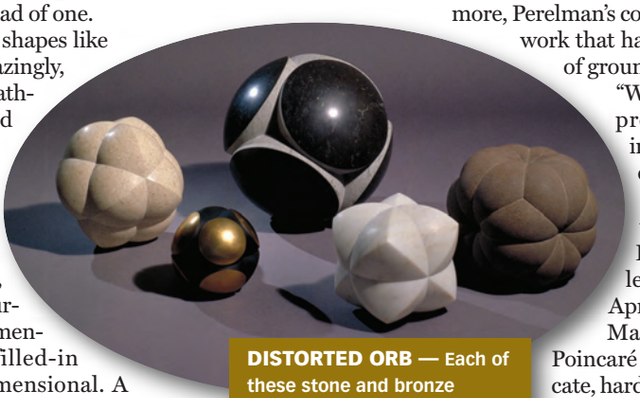
Exploring the newly proposed solution to a famous problem about three-dimensional shapes

BY ERICA KLARREICH

Look around at the world, and the objects in it—buildings, trees, people, birds, insects—appear to come in an endless variety of shapes. At first, cataloging these diverse shapes may seem impossible. But on closer inspection, relationships emerge. The bumpy surface of a starfish, for example, is simply a stretched and distorted version of a sphere. The same goes for the surface of a table or a telephone pole. In contrast, a coffee cup is not a sphere but instead a distorted version of a doughnut, and a pretzel can be considered a doughnut with three holes instead of one.

What about more complicated shapes like a fishnet or a bicycle wheel? Amazingly, more than a hundred years ago, mathematicians proved that every closed surface in space is simply some version of a sphere, a doughnut surface—which they call a torus—or a torus with extra holes.

Even though spheres and tori sit in three-dimensional space, mathematicians focus on their surfaces and so view them as two-dimensional, unlike solid balls and filled-in doughnuts, which are three-dimensional. A small patch of a sphere or torus surface looks almost like a piece of a flat plane and has area rather than volume.



DISTORTED ORB — Each of these stone and bronze objects, created by artist Allen Linder, can be viewed topologically as a distorted version of a sphere.

LINDER

Mathematicians also study an analogous collection of what they call closed three-dimensional shapes. Unlike ordinary three-dimensional objects, these shapes live in four-dimensional—or higher—space and curve in on themselves as the sphere and torus do in three-dimensional space. Although such shapes are difficult to visualize, some cosmologists speculate that our own universe may be of that form, rather than the infinitely extending space that most people envision.

For a century, mathematicians have wondered whether there's a classification of three-dimensional shapes like the simple breakdown of two-dimensional shapes into spheres and tori. Now, a Russian mathematician may finally have proved that the answer is yes (*SN: 4/26/03, p. 259*). Details are starting to emerge of his work, which gives a way to distort a three-dimensional object, little by little, to make its shape more uniform.

A few years ago, the Clay Mathematics Institute in Cambridge, Mass., offered a $1 million bounty to anyone who could settle the Poincaré conjecture, a 99-year-old question about three-dimensional shapes that's one of the most famous problems in mathematics. After working for years in near seclusion and supporting himself largely on personal savings, Grigory Perelman of the Steklov Institute of Mathematics in St. Petersburg, Russia, announced that he has proved the conjecture, which gives a way to identify whether a complicated shape is a distorted version of a sphere. He also claims to have proved the much broader Thurston geometrization conjecture, which considers all closed three-dimensional shapes.

Over the years, dozens of mathematicians have mistakenly claimed to have proved the Poincaré conjecture. For this reason, mathematicians—including Perelman himself—are not rushing to judgment. Perelman has declined to talk to the press until colleagues verify his proof.

It will take months, some mathematicians say, to dissect the details of Perelman's densely written papers. But Perelman's track record makes many optimistic that his work will stand up to scrutiny. "He's singularly brilliant," says Jeff Cheeger of the Courant Institute of Mathematical Sciences at New York University. What's more, Perelman's colleagues note, the portions of his work that have already been verified are full of groundbreaking ideas.

"Whether or not he has a complete proof, he has clearly made very important contributions to mathematics," says John Milnor, a mathematician at the State University of New York at Stony Brook who attended a series of lectures Perelman gave there in April and May.

Many past attempts to prove the Poincaré conjecture have involved intricate, hard-to-check arguments. "This one feels like a much more natural, very promising approach," Milnor says. "It seems like the right way to handle the problem."

RECOGNIZING THE HYPERSPHERE Even though a sphere and a torus are two-dimensional to mathematicians, there's no way to fit them into a flat plane without squashing them. Similarly, some three-dimensional shapes can't fit comfortably into ordinary three-dimensional space.

For instance, just as the sphere is the two-dimensional boundary of the three-dimensional ball, mathematicians have defined the hypersphere as the three-dimensional boundary of the four-dimensional ball—a space that's hard to visualize but that can nevertheless be analyzed mathematically. Researchers have also discovered a three-dimensional analog of the torus, as well as an infinitely large family of more exotic three-dimensional spaces.

Around 1900, French mathematician Henri Poincaré wondered whether there's an easy way to tell when a given closed three-dimensional space is a distorted version of the hypersphere. Poincaré made a daring conjecture. To recognize a hypersphere, he guessed, all that's needed is information about one-dimensional curves in the space. If every closed loop of thread in the space can be drawn in to a single point, then the space is a hypersphere in disguise, he hypothesized. On a torus, by contrast, a loop that goes

around the hole can't be pulled tight to a single point.

Poincaré's conjecture is one of the simplest possible questions to ask about three-dimensional spaces, yet it has stumped mathematicians from Poincaré's time to the present. Surprisingly, higher-dimensional spheres turn out to be more amenable to analysis. Decades ago, mathematicians proved the corresponding conjectures for spheres of four dimensions and higher.

GEOMETRIC BUILDING BLOCKS In the late 1970s, mathematician William Thurston, now at the University of California, Davis, envisioned a way to tame the menagerie of three-dimensional spaces—an idea that gave mathematicians a roadmap for proving the Poincaré conjecture. The key, Thurston suspected, was in an analogy between the geometry of three-dimensional spaces and that of two-dimensional surfaces.

Every closed surface can be distorted into a particular shape with an especially uniform geometry. For starfish, tables, and telephone poles, that most uniform shape is simply the sphere, which looks the same at every point.

Among tori, the doughnut surface is more homogeneous than the coffee cup, but it is not perfectly uniform. Points on the outer ring are positively curved, like a sphere, while points on the inner ring are negatively curved, like a saddle's central point. However, mathematicians have found a way to conceptualize a completely uniform torus, in which each small patch of the torus has the same geometric structure as a flat piece of paper.

All other two-dimensional surfaces—the tori with multiple holes—can be given what's called hyperbolic geometry, which makes the surfaces negatively curved at all points.

Among closed surfaces, spherical, flat, and hyperbolic geometry are mutually exclusive. Breaking down these surfaces into geometric types thus gives a way to distinguish two-dimensional spheres, for example, from other surfaces. A similar breakdown for three-dimensional spaces, Thurston realized, would give mathematicians a useful tool for distinguishing hyperspheres from other shapes, the goal of the Poincaré conjecture.

WILD SPHERE — In the 1920s, Princeton mathematician J.W. Alexander imagined a wildly distorted sphere, which sprouts two arms that reach out to each other yet never touch. These arms, in turn, each sprout a pair of fingers, and the fingers each sprout a pair of even smaller extensions, and so on. Despite this complexity, the object is still topologically a sphere. Artist and mathematician Helaman Ferguson captured some of the intricacy of Alexander's "horned sphere" in this bronze sculpture.

Mathematicians have known for decades that three-dimensional spaces can't be categorized as neatly as two-dimensional surfaces can. Some spaces, for instance, consist of a hyperbolic chunk and a flat chunk sewn together. Other spaces have geometric structures that don't match any of spherical, flat, or hyperbolic geometry.

In pioneering work, Thurston proposed that there is nevertheless a precise way to classify the geometry of three-dimensional spaces. Each closed space, he conjectured, can be given a special geometric structure built from components selected from eight geometric types. Three of the eight are spherical, flat, and hyperbolic geometry; the other five are slightly more complicated but still uniform geometries. Thurston, who proved large portions of his conjecture, was awarded a Fields Medal—mathematics' version of a Nobel prize—in large part for this body of work.

"What Thurston proposed was a revolutionary idea that went well beyond the Poincaré conjecture," Cheeger says.

ERASING THE BAR If Thurston's conjecture can be proved, the Poincaré conjecture will follow automatically. The logic goes more or less like this: In a closed three-dimensional space, if all loops of thread can be pulled tight to a point, mathematicians know that the only one of the eight geometries that can fit the space is spherical geometry. That means that no matter how convoluted the space appears, it must simply be a distorted version of the hypersphere.

After Thurston's work, mathematicians who wanted to prove the Poincaré conjecture could focus on demonstrating that Thurston's vision of three-dimensional spaces is correct. By the early 1990s, Richard Hamilton of Columbia University had proposed a technique that he hoped would do just that—show that each three-dimensional space can be smoothed out into Thurston's special pieces. He defined a method, called the Ricci flow, for changing the shape gradually at each point to make the space more uniform. His equation resembles the physics equation that describes how heat spreads through a material.

"If you take a body where parts are hot and parts are cold and you let it stand, heat tends to flow by itself until the temperature is even," Milnor says. "In Hamilton's process, you have a manifold that is very curved in some places, maybe flat or negatively curved in other places, and you just let the curvature flow and try to even itself out."

For instance, the Ricci flow would make an egg-shaped surface gradually flatten out on the ends and bulge even more in the middle, getting closer and closer to a perfect sphere.

Hamilton was aware, however, that the flow would not always produce a uniform geometry. At any point in the space, the flow is determined mainly by the local geometry, not by the overall shape of the space. So, sometimes the geometry of one part of the space might change much faster than that of another part, producing a highly uneven geometry overall.

For example, picture a dumbbell—two weights connected by a thin bar—each portion of which is flowing with a mind of its own. The bar wants to even out its geometry with the weights to turn the whole thing into a nicely rounded sphere. Each weight, on the other hand, wants to make itself as spherical as possible. In the three-dimensional version of the dumbbell, depending on the initial geometry, the weights may predominate, growing rounder and rounder while the bar stretches into a long, thin neck.

Hamilton's idea for dealing with this difficulty was simply to snip out the neck at some appropriate point, continue the Ricci flow on the pieces, and glue the neck back in at the end. The resulting shape would have the right kinds of building blocks for Thurston's conjecture. But for more complicated shapes than the dumbbell, he couldn't show that these necks were the only extreme geometric forms the flow would produce. Other extremities, such as awkward protrusions he called cigars, might result.

What's more, perhaps every time the flow evened out one portion of the space, that portion's extreme shape would have moved somewhere else, like bulges in a rug that is being fit into a room too small for it. Extreme geometric features might cycle around and around, without the whole space ever growing uniform.

These questions dogged Hamilton and his followers for more than a decade. Then last November, Perelman sent several mathematicians an e-mail, saying only that he had posted a paper on the Internet that might be of interest to them. In the paper, he writes that his work "removes the major stumbling block in Hamilton's approach to geometrization." Although the posted paper makes no reference to the Poincaré conjecture, experts in the field immediately realized what he was driving at.

FERGUSON

MUSIC OF THE SPHERES In the early 1990s, working in the United States, Perelman had emerged as a major player in Riemannian geometry, which studies subjects such as curvature. "In that domain he was considered a phenomenon at that time, incredibly brilliant," recalls Cheeger.

Then abruptly, Perelman all but vanished from the mathematical scene. In 1995, he turned down job offers from several top universities and returned to Russia. When U.S. mathematicians asked Perelman's colleagues at the Steklov Institute what he was working on, they generally replied that they had no clue.

Some mathematicians speculated that Perelman had quit mathematics. Every now and then, however, one or another mathematician would receive an e-mail from Perelman with probing, insightful questions. "All of a sudden, there would be concrete evidence that he was following certain developments," Cheeger says.

Once Perelman's first paper on the Ricci flow appeared on the Internet in November 2002, rumors started flying that he had proven the Poincaré conjecture and Thurston's geometrization conjecture. On March 10, Perelman posted a second paper that developed the ideas in his first paper and explicitly claimed a proof of the two conjectures. He has promised a third paper with a few remaining details.

This spring, Perelman visited the United States to present lectures on his work in Cambridge, Mass., and Stony Brook. So far, he has answered all the questions raised about his work, several mathematicians told *Science News*.

To understand the behavior of the Ricci flow, Perelman devised a way to capture a specific characteristic of any three-dimensional space. Roughly, he described what the pitch of a space would be if someone could ring the space like a bell. Perelman then proved that as the space slowly morphs under the Ricci flow, its pitch gets higher and higher.

KNOTTED GEOMETRY — Helaman Ferguson created this marble sculpture to celebrate William Thurston's powerful idea that there is a precise way to classify the geometry of three-dimensional spaces, no matter how tangled or distorted.

FERGUSON

Perelman's result immediately shows that the geometry of a space can't cycle around under the Ricci flow—if it did, its pitch would be unchanged after each cycle. Perelman claims that the result about pitch, together with other ideas that he develops in his papers, also does away with the possibility of cigars and other potential obstacles to carrying out Hamilton's program.

"Perelman's results are as spectacular as the Poincaré conjecture," says Dennis Sullivan, a mathematician at Stony Brook. "In just a few pages of work, he puts a hand grenade in the brick wall Hamilton had run into and blows a hole through it. Whether that has enabled him to crawl through to the meadow on the other side remains to be seen."

Many mathematicians have accepted the correctness of Perelman's result about the pitch of a space, but they have not finished studying the portions of Perelman's papers that explore the ramifications of the result. Once Perelman's papers have been published, if no one exposes a hole in his work within 2 years, he will be eligible for the Clay Institute's prize.

For many mathematicians, however, the appeal of the Poincaré conjecture lies beyond the million-dollar prize and accompanying fame. "It's important for the same reason Beethoven's Ninth Symphony is important," Sullivan says. "It's great." ■

OF NOTE

ASTONOMY

Galactic RAVE

Viewing galaxies so distant that the light now reaching Earth reveals what they looked like billions of years ago isn't the only way to learn about how galaxies form. Astronomers can examine a much closer specimen—our own Milky Way.

In contrast to previous Milky Way projects, which measured the motions of some 2.5 million stars as they march across the sky, a survey that began in April will track the movement of stars toward or away from Earth. By measuring this component of motion, which is currently known for only 20,000 stars, astronomers plan to reconstruct more details about how the Milky Way formed.

The survey, known as RAVE (Radial Velocity Experiment), uses a 1.2-meter telescope in Coonabarabran, Australia. By 2005, scientists expect RAVE to have measured the radial motion of 100,000 stars. With these data, astronomers will identify dozens, perhaps hundreds, of star groupings that appear to be streaming coherently, says RAVE leader Matthias Steinmetz of the Astrophysical Institute in Potsdam, Germany.

Since these streams represent the remnants of small satellite galaxies that were snared by the Milky Way billions of years ago, they'll indicate how the galaxy's components assembled. —R.C.

BEHAVIOR

Toddlers ride rail to tool use

At 16 months of age, many children adapt the way they use a handrail as they walk across a perilously narrow bridge to reach their parents on the other side. These on-the-fly changes that keep them from falling represent an early example of tool use, a hallmark of human intelligence, conclude two psychologists in the May *Developmental Psychology*.

Sarah E. Berger of Adelphi University in Garden City, N.Y., and Karen E. Adolph of New York University studied 24 boys and 24 girls. Most had been walking for about 4 months. Each 16-month-old had a series of chances to walk from one platform to another across a 29-inch-long wooden board that was either narrow (5 or 7 inches across) or wide (from 14 to 28 inches across). On half the trials, a handrail was placed on one side of the bridge. An experimenter followed alongside children to ensure their safety.

Toddlers always tried to walk across wide bridges, rarely touching the handrail when it was available. Most reached their destination on their own.

In contrast, toddlers often stayed off narrow bridges that lacked a handrail but usually attempted to cross those that had one.

OF NOTE

A majority of such crossings were successful, especially if kids first touched and explored the handrail and then grabbed it on the way across while slowing their pace and taking smaller steps. Kids also did better on narrow bridges if they switched their method of holding the handrail during a crossing, such as going from a one-handed grip facing frontward to a two-handed grip facing sideways. These adaptations show that the toddlers were using the handrail as a tool to help them achieve a goal that they could not otherwise attain, say the researchers. —B.B.

EARTH SCIENCE

Satellites unravel a spot of mystery

Satellites in the right places at the right time may have solved the puzzle of a strange phenomenon high in Earth's atmosphere.

The so-called proton auroral spots, which glow brightest at ultraviolet wavelengths, occur at altitudes of about 120 kilometers, says Tai Phan, a space physicist at the University of California, Berkeley. The spots occur when protons in the solar wind—the torrent of charged particles streaming from the sun—slam into Earth's atmosphere. Scientists have suggested that when the planet's protective magnetic field is disrupted, these high-energy protons break through and can reach the atmosphere. The satellite data gathered last year bolster that scenario.

On March 18, 2002, a 5.5-hour gust of solar wind struck Earth, says Phan. During that time, NASA's IMAGE spacecraft was about 33,000 km above the North Pole and spied a proton auroral spot over Greenland. Simultaneously, the four spacecraft of the European Space Agency's Cluster mission, which orbit Earth in close formation and monitor the solar wind's effects, passed through a stream of high-energy protons over the same region. Other Cluster instruments indicated that a portion of Earth's magnetic field had temporarily fractured and that protons were accelerating through the gap.

Phan and his colleagues report their findings in the May 15 *Geophysical Research Letters*.

Last year's lucky harvest of satellite data now enables scientists to infer changes in Earth's magnetic field from IMAGE observations alone. They also may shed light on how charged particles are accelerated by strong magnetic fields, such as those on the sun that cause solar flares, Phan notes. —S.P.

TECHNOLOGY

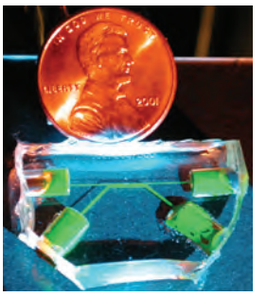
Tiny device brings out the best in sperm

Sperm cells prepare a lifetime for just one goal: the race to an unfertilized egg. Now there's a microscale apparatus that pits the little wigglers against each other in a preliminary heat. By separating top swimmers from the rest, the itsy-bitsy racecourse may ultimately improve the odds for infertile couples.

In many cases of infertility, the semen contains an insufficient percentage of normal, mobile sperm. Centrifuging and other existing means of separating the healthier sperm cells from the legions of listless ones typically net a low percentage of good swimmers and may even damage them.

The new sperm sorter boosts the percentage of mobile sperm from an average of 44 percent in a semen sample to 98 percent in fluid removed from the device, report Gary D. Smith and Shuichi Takayama of the University of Michigan in Ann Arbor and their colleagues.

As noted in *Nature*'s online news service and described in an upcoming *Reproductive BioMedicine Online*, two narrow conduits in the device merge into a broader channel a few human hairs wide. That geometry exploits a well-known quirk of miniature fluid flows. When tiny, undisturbed streams of liquids merge, the contents of those streams tend not to mingle. "That's the beauty of this system," Smith says.



SWIM MEET The merger of two fluid channels (green lines) efficiently harvests hearty sperm cells from a population of cells riddled with stragglers.

In the sorter's main channel, semen running within one conduit meets a spermfree solution from the other conduit. Only active sperm cross the border between the two flows, becoming concentrated in the formerly spermfree solution.

While sorted sperm from a man haven't yet been tested on a woman's egg, mouse eggs have been fertilized by sorted mouse sperm, Smith says. —P.W.

B. CHO/UNIV. OF MICHIGAN/SCIENCE

OF NOTE

PHYSICS

A new twist on ropes

The mooring and towing of oil rigs and huge ships rely on the strength and durability of thick ropes and the splices that join those ropes. Yet the mathematical models used to evaluate ropes have long left the splices out of the equations.

Now, Christopher M. Leech of Tension Technology International in Eastbourne, England, has mathematically evaluated three major classes of rope splices. The new analysis, slated for an upcoming *Proceedings of the Royal Society of London A*, can yield precise predictions about how different types of splices behave, Leech says.

One of the junctions studied is a common braided form called the admiralty splice. Among numerous findings, Leech concludes that friction between strands in an admiralty splice prevents sawlike interstrand motions and holds the splice together. Countering those benefits of the braided geometry, however, the everyday stretching and contracting of the splice rotates strands relative to each other in a scissoring action, creating a splice-damaging type of friction.

To evaluate such factors as friction in old and new splice designs, Leech has added his model of splice behavior into software that previously could predict only the behavior of unspliced rope. —P.W.

ASTRONOMY

Lucky shot

To protect itself from debris, the Hubble Space Telescope literally had to turn its back on last November's Leonid meteor storm. As luck would have it, that put the luminous Helix nebula directly in the telescope's line of sight. On May 9, NASA and the European Space Agency released the portrait that Hubble took of the nebula.

At a distance of 650 light-years, Helix is one of the closest known planetary nebulae. These glowing bodies got their moniker a century ago when astronomers, using the smaller telescopes of the time, described their appearance as planetary disks. In reality, the objects are sculpted by a rush of gases expelled by dying, sunlike stars.

Because the Helix nebula looms large, it took several exposures for the Hubble's recently installed Advanced Camera for Surveys to record most of it. The resulting mosaic highlights in unprecedented detail thousands of spokes along the nebula's inner rim. The spokes emanate from the nebula's central, dying star and formed when a hot wind from the star crashed into colder shells of dust and gas that the star had expelled earlier.

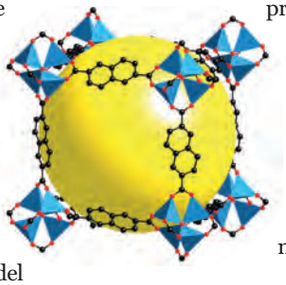
Astronomers have concluded that the Helix nebula resembles a bubble only because of the viewing angle from Earth. Earth-orbiting and ground-based telescopes happen to be looking directly down on a trillion-kilometer-long cylinder. —R.C.

MATERIALS SCIENCE

Convenient hydrogen storage?

Hydrogen attracts attention as a clean-burning fuel that could eliminate the United States' dependence on fossil fuel. Finding a way of storing the gas safely and compactly in cars has been proving difficult, however.

A team of researchers says it's developed hydrogen-storage materials that, with modifications, might do the trick. In previous work, the scientists reported that varieties of their porous materials can hold large amounts of methane (*SN: 6/23/01, p. 398*). They've now shown that the materials, which are composed of microscopic frameworks of metal such as zinc and organic parts such as naphthalene, attract and sequester hydrogen.



HYDROGEN HOLDER A new type of material for storing hydrogen contains metal components (blue triangles) and organic links (black rings). Yellow ball represents empty space.

The Department of Energy has specified that a good storage material should hold at least 6 percent of its weight as hydrogen. So far, however, no practical storage material has met this goal. Part of the problem is that storing the gas requires significantly compressing hydrogen at low temperatures and dangerously high pressures. In some cases, the contained hydrogen chemically bonds to the storage materials and doesn't come out easily.

In comparison, the porous materials that Omar Yaghi of the University of Michigan in Ann Arbor and his colleagues describe in the May 16 *Science* can store and easily release 2 percent of their weight in hydrogen at room temperature and only 10 times atmospheric pressure. That's the pressure found in a cigarette lighter, says Yaghi. What's more, the work revealed a potential path to the Department of Energy's 6 percent goal: increasing the size of the organic components in the storage framework. —J.G.

GLOWING GASES This portrait of the Helix nebula combines images taken by the Hubble Space Telescope with a wider image taken by a ground-based telescope. Glowing hydrogen and nitrogen gasses are shown in red; oxygen, in blue.

M. MEIXNER AND T. RECTOR/NASA, NOAO, ESA

OCEANOGRAPHY

More fish survive if plankton bloom early

Data collected by Earth-orbiting satellites and oceangoing trawlers suggest that juvenile haddock off Nova Scotia are more abundant in years when plankton populations peak earlier than normal.

Scientists have been surveying the abundance of fish off the eastern coast of Nova Scotia since 1970, says Trevor Platt of the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. One index used to characterize fish survival is the number of fish less than 2 years old in a catch divided by the weight of older fish taken. That index was particularly high in 1981 and 1999, indicating an abundant juvenile population.

Satellite observations of the region show that in those 2 years, populations of phytoplankton peaked at least 2 weeks earlier than average. For the years when such satellite data were available—1979 through 1981 and 1997 through 2001—the timing of the spring phytoplankton bloom accounted for 89 percent of the variation in the fish-survival index.

Platt and his colleagues speculate that when phytoplankton bloom earlier than normal, larval haddock have access to more food and may be shielded from predators more effectively in the cloudy water. The researchers report their analyses in the May 22 *Nature*. —S.P.

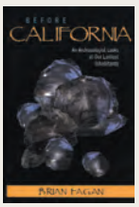
Books

A selection of new and notable books of scientific interest

BEFORE CALIFORNIA: An Archaeologist Looks at Our Earliest Inhabitants

BRIAN FAGAN

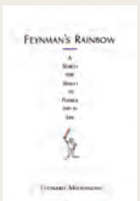
One of the world's best-known popularizers of archaeology takes readers on a tour of the Golden State from ancient times to the Spanish influx of the 16th century. The first part of the book is a broad overview of the 13,000 years from 11,200 B.C. to A.D. 1542. Fagan then examines the first settlement of the Paleo-Indians, the earliest colonization of the Pacific coast, increasing social complexity, gender differentiation, and conflict and trade among diverse early inhabitants of this area. The book's third section focuses on the period from 2500 B.C. to 2000 B.C., when hunting assumed importance and people began to exploit the seacoasts. Those changes led to social organization and trade. Finally, Fagan recounts the 3,500 years leading up to the mid-16th century. Pre-Californians of that period included salmon fishers of the north coast, clam diggers living among shell mounds in San Francisco Bay, and migratory Indians of the desert regions. ***Rowman & Littlefield, 2003, 400 p., b&w photos/illus., hardcover, $24.95.***



FEYNMAN'S RAINBOW: A Search for Beauty in Physics and in Life

LEONARD MLODINOW

As a Ph.D. fellow at Caltech in the early 1980s, Mlodinow occupied an office among those of some of the world's leading physicists, including Murray Gell-Mann, John Schwarz, and Richard Feynman. Mlodinow says he found that he didn't really belong. Moreover, no new ideas were coming to him to advance his thesis. He began to doubt himself and his future. One day, he worked up the nerve to knock on the door of his inspiration—Feynman—who welcomed him and subsequently entered into a dialogue with him over the next couple of years. In those discussions, Mlodinow queried Feynman about his thoughts on how a scientist thinks, the nature of creativity, and how people know whether they have what it takes to compete and become an accomplished thinker and researcher. Those who know of Feynman can imagine the answers, which are profound and offbeat. Mlodinow taped his conversations and shares transcripts of them here, along with what the dying Feynman imparted about life to a young, lost scientist. ***Warner, 2003, 171 p., hardcover, $21.00.***



THE ILLUSTRATED ENCYCLOPEDIA OF TREES

DAVID MORE AND JOHN WHITE

For the past decade, Moore has meticulously painted every tree he could find in the British Isles and Europe. Those 2,000-plus illustrations combine here with a brief overview of each tree's history as well as facts about its height, hardiness, garden value, and the merits of its wood. Because many of the varieties now found in Britain and Ireland were collected from other areas of Europe and North America, this tome is a relatively complete collection of information on trees found outside the tropics. In all, more than 1,000 species and varieties of trees are profiled and illustrated—not only in full bloom, but also in winter silhouette. There is close-up artwork detailing leaves or needles, bark, blossoms, fruit, nuts, and cones. Trees are arranged by family. ***Timber Pr, 2002, 800 p., color illus., hardcover, $79.95.***

A MATHEMATICIAN PLAYS THE STOCK MARKET

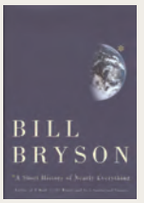
JOHN ALLEN PAULOS

Mathematicians should have an edge in the stock market. You'd think their expertise and scientific sense would yield predictions of market trends. Mathematician Paulos thought that, so a few years ago, he invested in WorldCom. He held on tight as his investment skyrocketed and then plummeted into oblivion while the Securities and Exchange Commission investigated the company for accounting fraud. In *A Mathematician Plays the Stock Market*, Paulos provides an amusing entry into the mathematical concepts of investing and gauging stocks' performance. In a chatty style offering stories and vignettes, he examines how investors can quantify risk, what options are, and what the efficient market hypothesis is really all about. He also considers the substantial effect of investor behavior and herd psychology on market volatility. After poking mathematical holes in superinvestor Warren Buffett's fundamental notions and other sacred cows of Wall Street, the author offers his own advice: Stick to index funds. ***Basic, 2003, 215 p., hardcover, $25.00.***

A SHORT HISTORY OF NEARLY EVERYTHING

BILL BRYSON

Readers are probably most familiar with Bryson's exciting travel books. On the return from one of his exotic journeys, it occurred to him that he was relatively uninformed on matters involving matter, geology, physics, and astronomy. He then set out to answer some of the fundamental questions about our planet and its place in the universe. Through interviews with some of the world's leading scientists today and biographical research into historical figures, Bryson compiled a clear, concise tour of the sciences that is intriguing and fun. He asks and answers questions that a child might ask and most adults don't know how to answer. Why, for instance, is the ocean salty but the Great Lakes not? How much does Earth weigh? How old is the universe? By profiling scientists in all their eccentricities, the author provides an unusual perspective on the people who have come up with the answers. ***Broadway, 2003, 544 p., hardcover, $27.50.***



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LETTERS

The true test

"Preeclampsia Progress: Blood test for predicting pregnancy problems" (*SN: 5/10/03, p. 293*) says, correctly, that our research group performed ultrasound of the main blood vessel of the women's arms as a measure of vessel-cell function throughout the body. However, we identified women at risk of preeclampsia by performing ultrasound tests to assess blood-flow restriction of arteries in the uterus during the second trimester of pregnancy.

MAKRINA D. SAVVIDOU,
KINGS COLLEGE LONDON, ENGLAND

In the house

The article on the half-life of bismuth-209 ("Not even bismuth-209 lasts forever," *SN: 5/3/03, p. 286*) says that the alpha decay of bismuth-209 was not listed in any reference table. As much as I hate to disagree, the "Chart of the Nuclides," 12th edition revised to April 1977, by Knolls Atomic Power Laboratory for Naval Reactors, USDOE, that I have hanging on my wall lists the half-life of bismuth-209 as greater than or equal to 2×10^{18} years with an alpha-particle-decay mode of 3.07 million electronvolts.

JAMES A. BRADBURY, GROTON, CONN.

Which wave?

"Sensing a Vibe: Seismic-alert system could give Los Angeles a few seconds' warning" (*SN: 5/3/03, p. 276*) says that the S waves travel at about one-half the speed of the P waves. Then, in "Seismic waves resolve continental debate" on page 285 of the same issue, it would appear that the P waves travel at one-half the speed of the S waves. Am I not interpreting the data correctly, or are the labeling and definitions different for the two articles?

NICHOLAS L. REUTER,
RAYMOND WALTERS COLLEGE, BLUE ASH, OHIO

The difference in speed mentioned in the second article is the slight difference between two types of S, or shear, waves. Horizontally polarized S waves travel somewhat faster than vertically polarized ones. Both types of S waves travel about one-half the speed of P waves. —S. PERKINS

Correction *In "Bad Dancers: Childhood chills give bees six left feet"* (SN: 5/24/03, p. 324)*, the photo of a honeybee was incorrectly credited. The photographer is Fiola Bock of the University of Würzburg Bee Group.*