SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

NOVEMBER 1, 2003 PAGES 273-288 VOL. 164, NO. 18

taking einstein for a spin

fire retardants snuffed out?

galaxy map charts the dark

new weapon fights hepatitis

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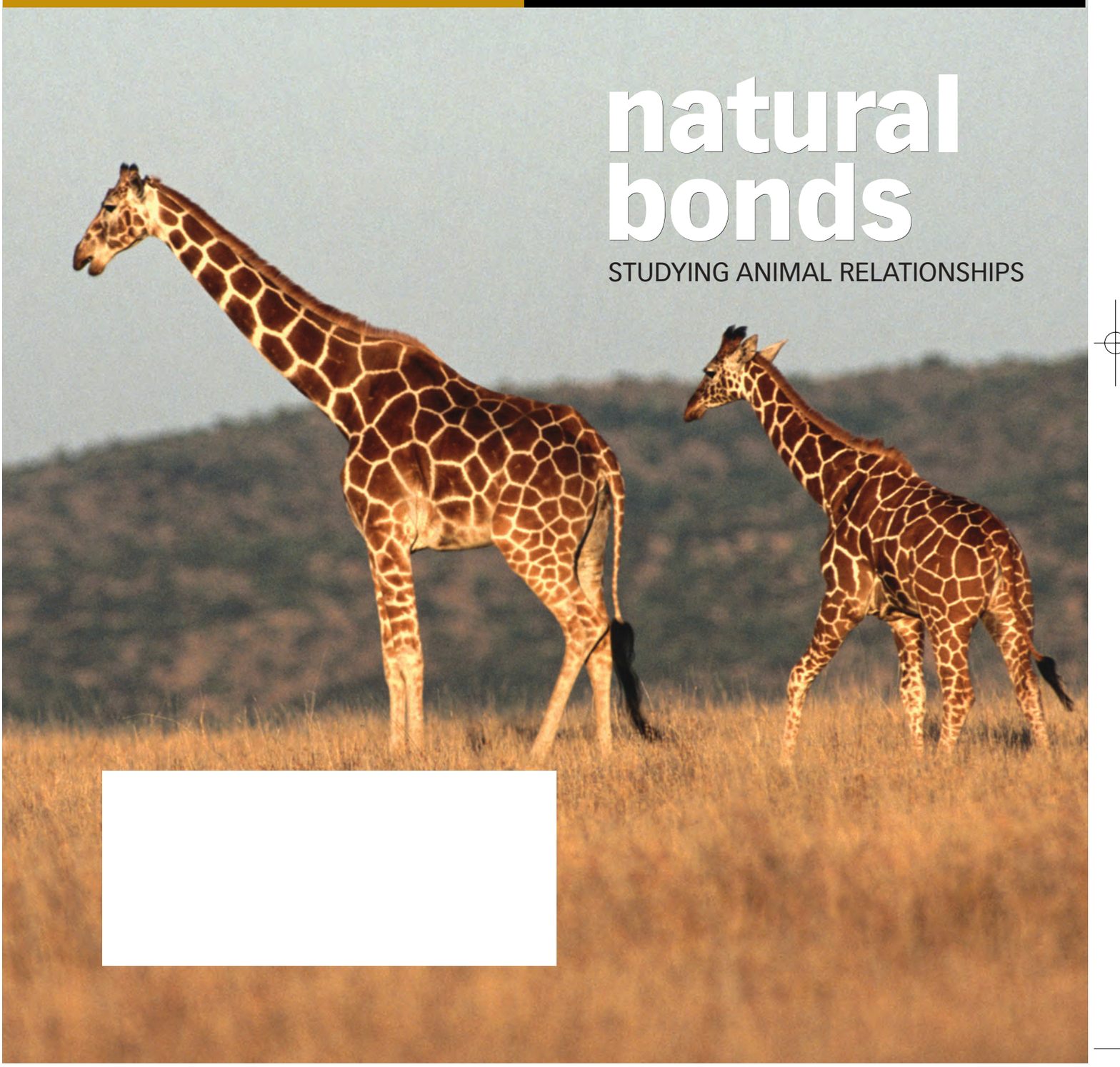

natural bonds

STUDYING ANIMAL RELATIONSHIPS

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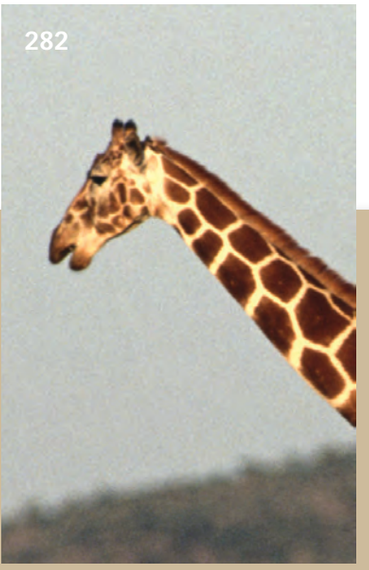

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Cover Reticulated giraffes, as other giraffe subspecies, have a reputation for weak social bonds, except between mothers and youngsters. With behaviorists studying the roots of cooperation and friendship, even the connections among giraffes are getting another look. Page 282

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Flaming Out?

Days may be numbered for two fire retardants

This August, at a meeting of Environmental Protection Agency scientists who are studying emerging pollutants, one family of chemicals unexpectedly stole the show: brominated flame retardants. Recently slated for bans in Europe and California, two classes of these compounds—mixes of polybrominated diphenyl ethers (PBDEs)—have had a low profile within the agency. But rank-and-file chemists and toxicologists raised what became the meeting's central question: What would it take for EPA to consider nationwide bans?

As it turns out, the U.S. manufacturer of both flame retardants has taken things into its own hands.

On Oct. 24, EPA issued a terse statement: "Great Lakes Chemical Corp. has initiated discussions with EPA regarding a possible voluntary phase-out of penta- and octa-PBDEs along with a full evaluation of a viable alternative." This week, Great Lakes spokesperson Wendy Chance acknowledged that her Indianapolis-based company had prompted the discussions and would "work aggressively with [EPA] on the issue."

PBDEs are molecules that can hold up to 10 bromine atoms in 209 different configurations, or congeners. Commercial mixtures of PBDEs used as flame retardants are typically dominated by congeners with a given number of bromines. The penta mix, with mostly 5-bromine PBDEs, is used to make foams, paints, and wire coatings resistant to burning. The octa formulation, with mostly 8-bromine PBDEs, is used primarily to flameproof plastic casings on office equipment.

PBDEs leach from treated products and have become ubiquitous, including in the bodies of people (*SN: 10/13/01, p. 238*). More troubling, new animal data indicate that penta and octa mixes can poison reproductive, nervous, and hormonal systems (*SN: 10/25/03, p. 266*). Manufacturers of the flame retardants estimate that their products save at least 300 U.S. lives annually.

A third PBDE formulation, based on the fully brominated, or deca, congener known as BDE-209 isn't slated for a phaseout anywhere. It "represents the major product in all markets, accounting for around 80 percent of the total PBDE production worldwide," note EPA scientists Linda S. Birnbaum and Daniele F. Staskal in a review paper in an upcoming *Environmental Health Perspectives*. What's more, they note, PBDEs in the commercial mixes, including the deca form, can shed bromines and thus convert into other PBDEs.

Chemist Heather Stapleton of the University of Maryland Center for Environmental Science in Solomons and her colleagues found that BDE-209 debrominates rapidly in fish. For 2 months, the researchers fed carp food laced with BDE-209. Over the succeeding 40 days, seven PBDEs began appearing in the animals' tissues, all with between 5 and 8 bromines.

Åke Bergman of Stockholm University notes that he and others have demonstrated that solar ultraviolet light can debrominate BDE-209 into smaller PBDEs. If these molecules warrant a phaseout and the deca form can transform into them, then BDE-209 also deserves a phaseout, he says. —J. RALOFF

Cosmic Survey

Galaxy map reveals dark business as usual

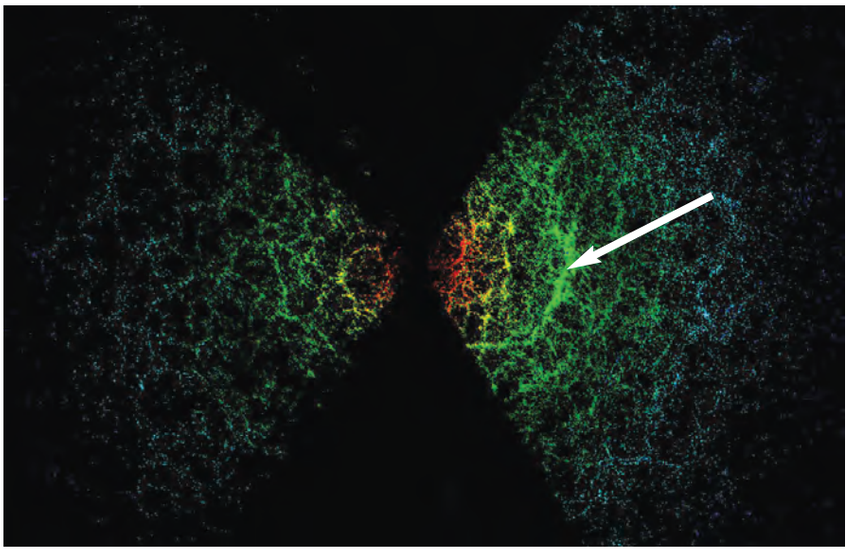
The most precise map of galaxies has confirmed that much of the cosmos is in the dark. The map, which covers 6 percent of the sky and includes 200,000 galaxies recorded by the Sloan Digital Sky Survey, supports previous evidence that most of the universe's matter is invisible. Without the gravity provided by this unseen material, dubbed dark matter, galaxies wouldn't have clustered as tightly as the Sloan map indicates they do.

By combining the galaxy map with the newest images of the cosmic microwave background, the relic radiation left over from the Big Bang, astronomers say they have also confirmed the existence of something even stranger. That stuff, known as dark energy, opposes gravity's usual tug, pushing objects apart and causing the universe to expand at an ever-faster rate (*SN: 10/11/03, p. 227*).

Temperature variations within the cosmic microwave background, as recorded by the Wilkinson Microwave Anisotropy Probe (*SN: 2/15/03, p. 99*), represent tiny lumps in the otherwise smooth soup of the infant universe. These lumps were the seeds from which galaxies arose. By comparing the size of these lumps with that of the vast clusters of galaxies in the Sloan map, astronomers have pinned down several key measures of the universe to an unprecedented accuracy.

Max Tegmark of the University of Pennsylvania in Philadelphia and a large team of collaborators find that the universe consists of 5 percent ordinary matter, 25 percent dark matter, and 70 percent dark energy. The new analysis puts the age of the universe at 14.1 billion years, give or take a billion years. The researchers announced the results Oct. 28 in two articles posted on the Internet (*http://xxx.lanl.gov/abs/astro-ph/0310725, http://xxx.lanl.gov/abs/astro-ph/0310723*).

"I've always felt very uneasy about dark energy and dark matter, despite all the papers I've written about them," says



M. JURIĆ, GOTT, TEGMARK, ET AL./SLOAN DIGITAL SKY SURVEY

BIG BUNCH Map of nearly 70,000 galaxies that lie near the plane of Earth's equator shows the biggest structure in the universe, a wall of galaxies (arrow) 1.37 billion light-years long. The wall lies about 1 billion light-years from Earth.

Tegmark. "Now, I feel I have to accept them."

Comments David N. Spergel of Princeton University: "I think that this is an important test of the emerging standard model," in which dark matter and dark energy are both required to explain the evolution of the cosmos.

The map's most eye-catching feature is the Sloan Great Wall of galaxies, a clustering of galaxies that stretches 1.37 billion light-years across the sky and is the largest cosmic structure ever found. Astronomers worried that such a humongous structure, 80 percent bigger than the famous Great Wall of galaxies first discerned in a sky survey 2 decades ago, might violate the accepted model of galaxy evolution. But modeling by Tegmark, J. Richard Gott of Princeton, and their coworkers reveals that such structures arise in about 15 percent of the computer simulations.

"It's a rare feature, but not embarrassingly so," says Gott, whose team recently posted its study's results on the Internet at *http://xxx.lanl.gov/abs/astro-ph/0310571*. —R. COWEN

Antiviral Advance

Drug disables enzyme from hepatitis C virus

It's odd to think that anyone would look upon a person infected with the AIDS virus with even a tinge of envy, but some of the estimated 170 million people worldwide infected with hepatitis C virus (HCV) may do just that. Whereas AIDS researchers have developed powerful drugs, including protease inhibitors, that target specific HIV proteins, physicians typically treat HCV with less effective, general antiviral medications, such as interferon and ribavirin.

At least three drug companies have now identified compounds that inactivate a key HCV protease in cell cultures and animals. As reported in an upcoming *Nature*, one of the protease inhibitors has even slowed HCV replication in people, without any obvious side effects. That human trial was only a few days long, however, and questions remain about whether the particular protease inhibitor tested is safe for long-term use.

The potential new HCV drugs all bind to the viral protease known as nonstructural protein 3 (NS3). In order for HCV to reproduce, NS3 must split large viral proteins into smaller, functional fragments, says Paul C. Anderson of the drug company Boehringer Ingelheim in Laval, Quebec. The same protease may also interfere with the body's ability to respond to interferon, a compound that normally stimulates the immune system. As a result, NS3 may enable the virus to hide out in the body for years, while slowly causing liver damage.

Researchers at Boehringer Ingelheim recently designed an oral drug that inhibits NS3. The compound, known as BILN 2061, sailed through initial tests in cells and animals. When given twice a day for 2 days to volunteers infected with HCV but still healthy, the compound dramatically reduced the presence of the virus in the volunteers' bloodstreams, Anderson and his colleagues will report in *Nature*. At scientific meetings, the company has reported similar results in infected people with liver damage.

Despite this success, Boehringer Ingelheim hasn't yet committed to larger trials of BILN 2061. Anderson acknowledges that the drug has caused some heart damage in monkeys when given to them at high doses over long periods. Even so, he stresses, "we have not dropped this compound." The company is now consulting with outside experts about how to proceed with further testing of BILN 2061.

At a liver-disease meeting in Boston this week, scientists from two other drug companies described initial cell and animal tests of their own NS3 inhibitors. One of the firms, Vertex Pharmaceuticals in Cambridge, Mass., plans to begin testing its drug candidate in people early next year, according to a spokesperson.

"I think targeted therapy will work," says HCV researcher T. Jake Liang of the National Institute of Diabetes and Digestive and Kidney Diseases in Bethesda, Md. "I'm certainly optimistic we will have something in 5 years." —J. TRAVIS

First Impressions

Early view biases spider's mate choice

A first date, even if it fizzles, can make a big difference to a wolf spider.

If an almost-grown-up female's last impression of a suitor is his sexy leg-waving display, she won't mate with him just then, but she'll grow up with a preference for males like him, says Eileen Hebets, of the University of California, Berkeley. Also, that female spider as an adult will prove less likely to eat males with her original pursuer's looks than with other male spiders, Hebets reports in an upcoming *Proceedings of the National Academy of Sciences*.

What shapes mating preferences matters because these forces end up shaping a species' traits and evolutionary changes. The previewing of courtship "is potentially a new way females develop preferences that we haven't thought about before," says Hebets.

Earlier investigations with other animals into how social experiences shape subsequent mating preferences have turned up various influences affecting the very young and adult, but not adolescent, animals. For example, lambs, if raised by adult goats, will grow up to prefer their fostering species for mating. On the other side of adolescence, adult females of a variety of vertebrate species tend to copy each other's mating choice.

STRATTON/PNAS

COLOR ME SEXY **A male wolf spider's front legs carry alluring black and brown patterns.**

The new experiment took the unusual tack of testing for social influences on mate choice in invertebrates, says Bennett Galef of McMaster University in Hamilton, Ontario. "It's a very straightforward experiment with a surprising result," he says.

For her experiment, Hebets caught young *Schizocosa uetzi* spiders in Mississippi and brought them to her lab, then at Cornell University. Males sport splashes of black and brown on a forward segment of their front legs. Hebets shopped around for nail polish that matched the shades ("Midnight Metal" and "Bronze Ice") and painted the segments either all black or all brown.

When Hebets placed a painted male with a young female, the male readily performed his courtship display. "He lifts first one leg, then the other—really slowly," Hebets says. At the same time, he sends vibrations

through the enclosure floor.

The young females, who didn't yet have sex organs, showed no interest in mating, but they evidently were impressed by the males who sought them. When the females reached adulthood, they were twice as likely to mate with males with the leg color of the original suitor than with males with legs of the alternate color. The suitor look-alikes were also half as likely to be eaten by their female partners.

The laboratory finding that female spiders are sexually impressionable when young, "opens up a lot of questions about social learning," says Gail E. Stratton of the University of Mississippi in Oxford, who discovered the species. —S. MILIUS

Out of Hiding

Lost asteroid reappears, bringing surprises

A team of astronomers has spotted Hermes, an asteroid that disappeared into the night after a close flyby of Earth in 1937. Ever since, some researchers have wondered—and worried—about the asteroid's path. Last month, scientists finally found Hermes, and they now know what to expect from it.

"Within the astronomical community, people were almost obsessed with finding this thing," says Tim Spahr of the Smithsonian Astrophysical Observatory in Cambridge, Mass.

Early in the morning of Oct. 15, Brian Skiff of Lowell Observatory in Flagstaff, Ariz., spotted a possible near-Earth asteroid. He alerted Spahr, who posted the finding on the Internet. Observers in California saw the asteroid within 30 minutes and sent additional positional data to Spahr.

Reviewing recent images of the sky, he could follow the asteroid and make rough calculations of its orbit around the sun. The trajectory he came up with convinced him the asteroid was Hermes. Within hours of the original sighting, Spahr announced Hermes' reappearance in an Internet circular of the International Astronomical Union (IAU).

"We've kind of expected that it could be found sooner or later," comments Alan Harris of the Space Science Institute in Boulder, Colo. "We've been waiting, and finally they've got it."

The precise calculation of Hermes' path through space was made by Steven Chesley and Paul Chodas of NASA's Jet Propulsion Laboratory in Pasadena, Calif. Usually, astronomers there use programs to predict whether or not an asteroid might slam into Earth. In this case, Chesley and Chodas ran such a program backwards to determine Hermes' path for the past 66 years.

They calculated that the asteroid made 31 unobserved circuits around the sun during this time. Six times, Hermes must have come within 9 million kilometers of Earth, or 24 times the Earth-moon distance. In 1942, Hermes came within 640,000 km, a mere 1.6 times the distance to the moon.

This year, Hermes will be at its closest—a comfortable 7 million km away—on Nov. 4. By extrapolating the orbit into the future, the astronomers verified there's no chance of Hermes hitting Earth within the next 100 years, which is as long into the future as astronomers typically predict for asteroids.

Hermes is "fairly large and capable of making close approaches to Earth," says Spahr. "It's nice to know where it is now."

Beyond knowing Hermes' orbit, researchers were interested in the asteroid itself. Using the Arecibo Radar Telescope in Puerto Rico, Jean-Luc Margot of the University of California, Los Angeles was able to tell that Hermes consists of two gravitationally tied pieces, each about 300 to 450 meters across and orbiting the other.

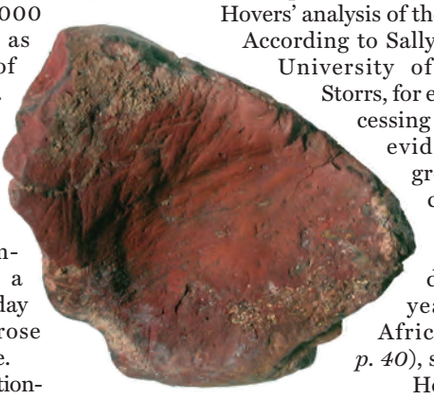
"What was particularly surprising was that it was a binary with equal components," says Margot, who presented the finding in an Oct. 20 IAU circular. Most binary objects have a primary body with a smaller satellite, he says. The unusual arrangement could help astronomers better understand how asteroids break into two and how one component influences the motion of the other. —K. RAMSAYER

Stone Age Code Red

Scarlet symbols emerge in Israeli cave

The Qafzeh Cave in Israel contains skeletal remains of modern *Homo sapiens* that are more than 90,000 years old, as well as more-recent signs of human occupation. Investigators now say that red ocher found in Qafzeh Cave's oldest sections supports the controversial theory that symbolic thinking, a hallmark of modern-day human thought, arose deep in the Stone Age.

Archaeologists traditionally have held that the assigning of separate meanings to certain items or colors emerged no more than 50,000 years ago, with the appearance of Upper Paleolithic cultures.



HUE CLUE An ancient lump of red ocher excavated at Qafzeh Cave contains evidence of scraping by stone implements.

G. LARON, INST. OF ARCHAEOL./HEBREW UNIV.

In the Middle East and Eurasia, however, "many symbolic behaviors that are considered modern existed for a time [before the Upper Paleolithic] and then disappeared, to be reinvented time and again," contends Erella Hovers of the Hebrew University of Jerusalem, who directed the Qafzeh project.

Her argument hinges on the discovery of 71 pieces of red ocher, a form of iron oxide typically used as a pigment, as well as ocher-stained stone tools, near several of Qafzeh's oldest *H. sapiens* graves. The same sediment holds the remains of large hearths and, intriguingly, scattered shells of inedible mollusks

Preliminary chemical analyses indicate that the ocher had been heated.

In the August-October *Current Anthropology*, Hovers and her coworkers propose that, more than 90,000 years ago, lumps of ocher from nearby sources were brought to the cave, carefully heated in hearths to yield specific hues of red, and used with the shells in possibly symbolic activities related to burying the dead.

Evidence of similar ocher use near human graves doesn't appear again at Qafzeh Cave until 12,700 years ago, the scientists say.

The precise meanings of the ocher-based practices remain unknown, Hovers notes. Many nonindustrial societies today regard the color red as symbolic of fertility or vitality.

Prehistoric artwork and other symbolic expressions commonly occurred in large populations that stayed for extended periods at resource-rich locations, Hovers says. In the small, nomadic groups typical of Stone Age Middle East, a capacity for symbolic behavior would have surfaced only for special activities at designated sites, such as the interment of the dead at Qafzeh Cave, she argues.

Several commentaries appear with the new report and offer mixed reactions to Hovers' analysis of the Qafzeh artifacts.

According to Sally McBrearty of the University of Connecticut in Storrs, for example, ocher processing at Qafzeh adds to evidence of "the very great antiquity of the color red as a symbolic category." Engraved ocher dates to 77,000 years ago in South Africa (*SN: 1/19/02, p. 40*), she notes.

However, Richard G. Klein of Stanford University argues that ocher use represented merely a step toward

advanced symbolic culture, which he says *H. sapiens* established around 50,000 years ago. —B. BOWER

Blame the Sea?

Ocean may be melting ice shelf from below

Significant portions of a large Antarctic ice shelf just south of one that suddenly broke apart in February 2002 are rapidly thinning and may suffer a similar, catastrophic demise in less than a century, scientists say.

Satellite observations collected between 1992 and 2001 suggest that the upper surface of the Larsen C ice shelf dropped as much as 27 centimeters per year during the period. About a quarter of that shrinkage, or 7 cm, may have resulted from snow packing down into denser material called firn, says Andrew Shepherd, a glaciologist at the University of Cambridge in England. Uncertainties about such factors as the height of ocean tides and the temperature and the salinity of water beneath the ice shelf would account for no more than a small fraction of the remaining loss in height above water, says Shepherd.

Therefore, he notes, as much as 20 cm per year of the upper surface's drop stems from melting. About nine-tenths of any mass of floating ice lies below the water's surface, suggesting that Larsen C is thinning overall by as much as 2 meters each year. Shepherd and his colleagues report their analysis in the Oct. 31 *Science*.

The likely cause of the thinning, says Shepherd, is relatively warm water beneath the ice shelf. Although water at a depth of 300 m just offshore of the ice shelf's edge is about –1.5°C, that's about 0.65°C above the melting point for ice at that depth. Many factors, including salinity and pressure, affect ice's melting temperature.

Even a small temperature increase in the water below an ice shelf can make a big difference in the overlying ice's melting rate, says Eric J. Rignot, a glaciologist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. His research suggests that each 0.1°C rise in water temperature can, in a year's time, melt away about 1 m of shelf ice.

In February 2002, 3,250 square kilometers of the Larsen B ice shelf splintered into thousands of icebergs (*SN: 3/30/02, p. 197*). Shepherd says his team's data suggest that during the previous decade, Larsen B, which was about 200 m thick when it collapsed, was thinning at an average rate of about twice that of Larsen C.

Larsen C is stable and isn't shedding more icebergs than normal, says Shepherd. However, at the ice shelf's current rate of thinning, Larsen C could reach a 200-m thickness, and therefore be susceptible to disintegration, in 70 years or so. If the waters in the region continue to warm, the ice shelf's demise could occur even sooner. —S. PERKINS

Water Repellency Goes Nano

Carpet of carbon nanotubes cleans itself

The amazing water-shedding ability of the lotus leaf has long inspired materials scientists. The leaf's wax-coated microstructures cause rain droplets to bounce off the surface, carrying away with them dust particles and other contaminants. In trying to reproduce this so-called lotus effect in the lab, chemical engineers have fabricated a similar self-cleaning material out of forests of carbon nanotubes.

Led by Karen Gleason of the Massachusetts Institute of Technology (MIT), the researchers first created arrays of tiny islands of nickel on a surface of silicon. From these islands, the researchers grew vertically aligned carbon nanotubes. "Sort of like a bed of pins" is how coinvestigator Kenneth Lau describes the result.

The minuscule pillars, each measuring 50 nanometers in diameter and standing 2 micrometers, form a rough surface. Because there are air pockets between the nanotubes, when a drop of water lands on the surface, "it's essentially held up by air," says Lau.

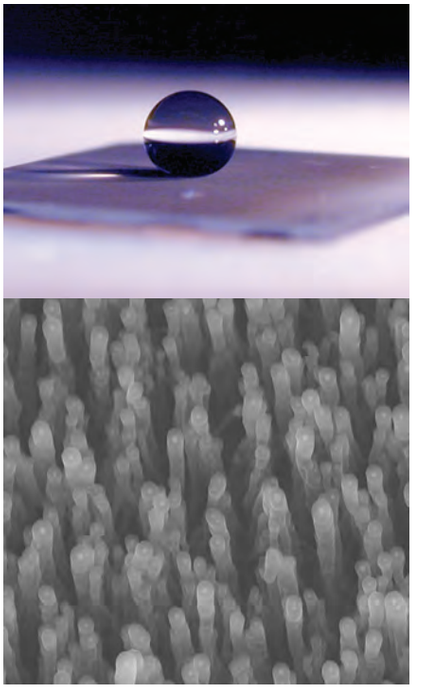
Using a technique called chemical-vapor deposition, the researchers coated the top of each carbon nanotube with poly(tetrafluoroethylene), otherwise known as Teflon. Not only did this arrangement stabilize the nanotube forest, but it also boosted the surface's water-repelling properties. When water droplets squeezed from a syringe hit the Teflon-coated nanotube carpet, the droplets bounced from and rolled off the surface.

Because the spacing between nanotubes was less than a micron, the material could repel tiny droplets of water just a few micrometers in diameter. The researchers describe the new material in a forthcoming issue of *Nano Letters*.

Materials such as these are called superhydrophobic because of their ability to repel water so completely. On more standard hydrophobic surfaces, such as the hood of a car, water droplets form flatter-bottomed spheres that might not roll off.

Researchers throughout the world have been striving to invent superhydrophobic materials for products such as antifouling paint, self-cleaning garments, or coatings on airplanes to prevent ice buildup. In pursuit of that goal, investigators have tried a variety of polymer fibers and spheres (*SN: 3/1/03, p. 132*). So far, however, the resulting materials have been too fragile to be practical.

To join the competition, the MIT group turned to one of nanotechnology's poster materials, carbon nanotubes. "Coating the nanotubes with [Teflon] is very neat and novel," says A. Levent Demirel, a chemist at Koç University in Istanbul, Turkey. Without the Teflon, the water droplets would eventually seep through the material.



NANOSTYLE WATERPROOFING Top: A water droplet forms a sphere on a superhydrophobic surface. Bottom: A microscopic view of that surface reveals a forest of carbon nanotubes.

NANO LETTERS

David Quéré, a chemist at the Collège de France in Paris, says the nanotube route to superhydrophobic materials is attractive, but he isn't yet convinced it will lead to commercial products. Even though the Teflon coating stabilizes the nanotubes, he says, "if you press your thumb on them, you immediately destroy the structures." —A. GOHO

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A SPIN THROUGH SPACE-TIME

A long-planned test of Einstein's theory is poised for takeoff

BY PETER WEISS

A satellite designed to test one of the more twisted predictions of Albert Einstein's general theory of relativity is finally at its launch site after 40 years of preparation. The probe will look for evidence of a gravitational effect known as frame dragging. Just as a dipper drags honey along as it twirls in a honey jar, any spinning body in space, including Earth, ought to drag some space-time along with it. That was Einstein's prediction, anyway. The effect has never been convincingly observed.

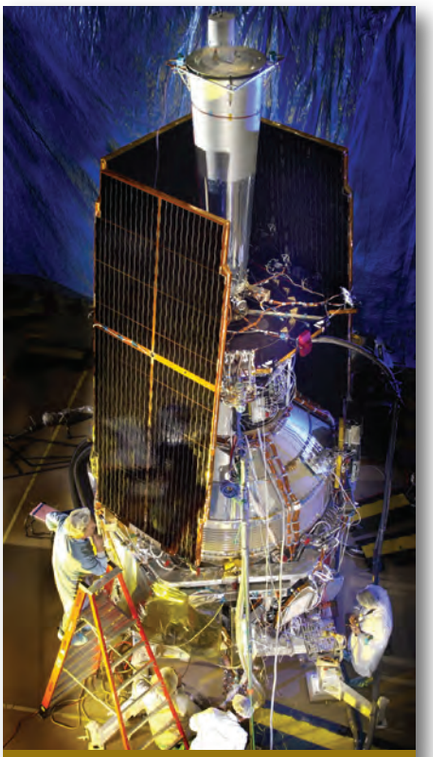
That's partly because Earth's tweaking of space should barely register on even the most sensitive instruments. Yet the effects of frame dragging may prove enormous in deep space where spinning, ultradense concentrations of mass known as supermassive black holes may torque space-time vigorously enough to create the enormously powerful jets of matter and energy known as quasars (*SN: 4/5/03, p. 214*).

Many relativity experts are enthusiastic about the prospects for Gravity Probe B (GP-B), as the spacecraft is known. Gathering hard evidence that "space is not the fixed fabric we think of" would be a "stunning achievement," says Clifford M. Will of Washington University in St. Louis, a gravitational physicist who served on a NASA-convened review panel that endorsed the mission's science goals last spring. He adds, "It's the kind of result that will be written in physics textbooks for years to come."

No one can say what the probe will find. Its measurements might confirm Einstein's prediction, or it might find discrepancies. Such anomalies could provide crucial clues for a model of the universe that might ultimately succeed relativity.

Other researchers, who are less sanguine about the mission, say that its scientific value has declined drastically during its long period of development. Those critics argue that the mission's estimated $700 million cost would have been better spent elsewhere.

Says physicist Kenneth Nordtvedt of Northwest Analysis in Bozeman, Mont., "The survival of GP-B through several decades . . . reveals to me how dysfunctional NASA has been in planning their strategy in this field of fundamental science."



FLYING THERMOS — Stacked inside Gravity Probe B's insulated tank of liquid helium, seen between the solar panels in this photo, are four gyroscopes and a telescope that can peer through the top hatch.

GP-B PROJECT

LET'S TWIST AGAIN In his 1916 general theory of relativity, Einstein proposed that massive bodies cause space-time to curve. What's more, he showed that gravity, which appears as an attraction between massive objects, is actually a manifestation of that curvature of space-time (*SN: 12/21&28/02, p. 394*).

Two years after Einstein unveiled his general theory of relativity, Austrian physicists Joseph Lense and Hans Thirring deduced from it that space-time would become twisted in the vicinity of a rotating body (*SN: 11/15/97, p. 308*).

Then, in the late 1950s, Stanford University physicist Leonard I. Schiff and George W. Pugh of the Defense Department independently proposed detecting Earth's frame dragging by sending an extremely stable gyroscope into an orbit that crosses the planet's poles. If Earth were indeed twisting space-time, the gyroscope's axis of rotation would tilt.

A gyroscope is a spinning object, usually a wheel, mounted in a frame that can swivel freely. The wheel's spin produces inertia that keeps the wheel's spin axis pointed in a fixed direction, so gyroscopes have long served as stable references for compasses and navigation systems.

The spacecraft, now in a prelaunch facility at Vandenberg Air Force Base near Lompoc, Calif., remains true to the original concept. In essence, the 3.5-ton, 7-meter-high satellite is a quartet of gyroscopes surrounded by much ancillary equipment. Some of that equipment keeps the gyroscopes ultracold—a requirement for high precision. Other features, such as a telescope and finely tuned thrusters, enable the spacecraft to stay exactly oriented on a distant star.

The satellite's fixed orientation is intended as a reference against which to compare the gyroscopes' orientations. Frame dragging is expected to make each gyroscope's spin axis drift just 42 milliarc-seconds per year in the direction of Earth's rotation. That's hardly more than ten millionths of a degree.

To create gyroscopes sensitive enough to register such minute rotations, the GP-B team has crafted niobium-coated, solid quartz spheres the size of ping-pong balls (*SN: 3/3/90, p. 143*). Nowhere do these silvery orbs deviate by more than 40 atoms from perfect sphericity. In each gyroscope, one of these balls will spin at 10,000 revolutions per minute while floating weightless within a chamber.

Besides the subtle drift, or precession, due to frame dragging,

the mission will also be looking for another, more readily detectable effect predicted by the general theory of relativity. Known as geodetic precession, this effect is expected to shift the gyroscopes' spin axes by more than 150 times as much as frame dragging does.

However, in this case, the gyroscopes' axes should swing in the direction of the satellite's polar orbit around Earth, perpendicular to the direction of the frame-dragging effect. Einstein's theory predicts that such gyroscopes will undergo geodetic precession merely because space-time is curved in the planet's vicinity. This effect would show up even if Earth were not spinning.

IT'S ALL RELATIVE Although geodetic precession seems huge compared with frame dragging, both effects are minuscule. GP-B is expected to measure frame dragging to an accuracy of 0.1 percent and geodetic precession to 0.0006 percent, or 6 parts per million.

At least for frame dragging, GP-B's expected accuracy is not really a coup, says Nordtvedt. By bouncing laser pulses off reflectors on the lunar surface so as to precisely monitor the Earth-moon separation, he and other researchers claim to have already confirmed to an accuracy of 0.1 percent that Earth's frame dragging matches the predictions of general relativity.

Using the distance measurements, Nordtvedt's team calculated the strength of the so-called gravitomagnetic field. Gravitomagnetism is a relativistic addition to the ordinary Newtonian version of gravity, which doesn't take the motions of bodies into account. It's the gravitomagnetic field that causes frame dragging, Nordtvedt says.

As welcome as measurements of the gravitomagnetic field are, they're only "indirect evidence" of frame dragging, contends Stanford University physicist C. W. Francis Everitt, who has led the GP-B project for decades.

"GP-B will provide a direct measurement," noted the review panel that last April endorsed the mission. "No other laboratory or space experiment, current or near term, has the capability to measure this effect to comparable precision."

Indeed, much of the long development of GP-B has gone to creating the gyroscopes and other technological wonders essential to making such fine measurements. Whatever the scientific merits of GP-B, "everyone universally acknowledges that this is . . . a beautiful instrument technologically," says NASA's Michael H. Salamon, who oversees the project for the agency's Office of Space Science in Washington, D.C.

Most likely, the mission will provide an anticlimactic result—a confirmation of the frame dragging that most physicists already accept. After all, general relativity has so far withstood all tests that scientists have thrown at it. Moreover, no current theory predicts a value for frame dragging that differs from general relativity's prediction enough for this mission to discern.

More thrilling would be a result that deviates from the predictions. But convincing gravity specialists of the result's validity would be difficult, unless the GP-B team could rule out all sources of instrument error, says gravitation theorist M. Coleman Miller of the University of Maryland at College Park, who is not associated with the mission.

GP-B actually stands a better chance of finding a flaw in Einstein's prediction of geodetic precession. From that result, mission scientists expect to compute a parameter known as gamma, which specifies how strongly mass distorts space-time. So far, none of scientists' many measurements of gamma, using telescope observations and space probes, has deviated from Einstein's predictions. However, GP-B's accuracy is expected to surpass them all.

"Some people view this part of GP-B as the more important test," Will says. That's because some theories related to string theory (*SN: 3/23/02, p. 187*)—a model in which infinitesimal, stringlike entities are the basic components of the universe rather than the pointlike particles favored today—predict a different value of gamma than general relativity does.

GP-B PROJECT

ROUNDNESS CHAMP — Nothing on Earth rivals the perfect roundness of the orb that each gyroscope on Gravity Probe B houses inside a quartz compartment, shown here in two pieces.

GRAND FINALE For GP-B to have reached the launch site is nothing short of a miracle to many people. No mission in the history of NASA has gone through such a long gestation period—or, perhaps, such a rocky one.

For most of its first 30 years, the project was a relatively minor technology-development effort on which NASA spent roughly $20 million. Then, in the early 1990s, the agency elevated the project to mission status and started pumping some $50 million per year into the effort.

During its long life, the project has surmounted one technical or political hurdle after another (*SN: 6/10/95, p. 367*). NASA has canceled and then reinstated the mission seven times. For his part, Everitt has campaigned tirelessly for the project in Congress and elsewhere.

In the past few years, the project has been particularly troubled. Originally scheduled to take off in December 1999, the mission missed that opportunity because a gyroscope malfunctioned, among other problems. Since then, GP-B has missed four rescheduled launch dates, in part because of technical problems. Those delays added $166 million to the mission cost, creating rancor among astronomers and other gravitation researchers whose projects were cut or postponed to keep GP-B alive.

One failure had a silver lining, recalls Everitt. The spacecraft flunked a crucial test in December 2002, leading to a threat last spring by NASA to cancel the project yet again. In that trial and a follow-up test that the spacecraft passed, Everitt and his colleagues found that their measurement accuracy would be "about a factor of 10 better than we originally thought," he says.

He attributes the windfall to "the extreme care of the people building the apparatus." Without that accuracy boost, the mission's forthcoming geodetic-precession measurement would have already been eclipsed by a recently published result.

In the Sept. 25 *Nature*, Bruno Bertotti of the University of Pavia in Italy and his colleagues report a new measure of gamma made by sending radio signals to the Saturn-bound spacecraft Cassini at a time when the sun was between it and Earth (*SN: 10/11/03, p. 238*). The new finding agrees with Einstein's predicted value for gamma to an accuracy of 23 parts per million. GP-B is expected to measure gamma 2.5 to 6 times as precisely.

Under close scrutiny from NASA officials, the GP-B team has completed all major technical and procedural requirements to meet its current launch date of Dec. 6. There's no spare probe, so for Everitt and others who have worked on the project for much of their careers, a crash of the launch vehicle would be devastating. Everitt puts it this way: "Suppose you were driving down the freeway and a 10-wheeler truck hit you. Would you be upset?"

Assuming the launch goes well, the pace of the mission will be intense. As soon as the spacecraft is aloft, a clock will begin ticking. After decades of buildup, the mission will have only 16 to 18 months to check the equipment's functions, take data for 13 months, and then carry out postexperiment validations of the instrumentation. After these months, the liquid helium that chills the instruments and serves as exhaust gas for the thrusters will be spent. Then, whatever the future of Einstein's space-time models, GP-B's long-awaited test of them will quietly come to an end. ■

BEAST BUDDIES

Do animals have friends?

BY SUSAN MILIUS

Meredith Bashaw says she started looking for social attachments among giraffes because they weren't supposed to have any. She needed a group to contrast with the more sociable animals she was examining as a beginning graduate student several years ago. Big field studies of wild giraffes in the 1970s hadn't found signs that the adults cared much one way or the other about which giraffe was munching on a neighboring tree. "Giraffes just seemed to move about the plains of Africa like random molecules in your coffee cup," says Bashaw.

For the past year and a half, though, Bashaw has been putting that notion to a harder test. Each morning, she has driven around the 90 acres of the San Diego Zoo's Wild Animal Park, keeping track of six of those long-necked molecules. She's searched for a pattern in her data on who hangs around with whom.

That issue of preferred associates comes close to the human notion of friendship, and it can prove just as important in understanding animal goings-on as it does in people watching. Baboons, bats, and dozens of other animals have been studied from this perspective. Biologists may start, like Bashaw, by asking whether individuals prefer to hang out with particular buddies. But other questions soon pop up. Does the sex or kinship of a companion matter? Are there benefits to the association? The answers to these questions may have implications for the evolution of human camaraderie.

HIGH SOCIETY ANIMALS? — Early field studies found no evidence that adult giraffes bothered much about particular companions, but a new study of Baringo giraffes like these challenges that notion.

ZOOLOGICAL SOCIETY OF SAN DIEGO

GIRAFFE SPOTTING Bashaw began her quest to reexamine giraffes at Zoo Atlanta when she heard that the park was going to ship away its male giraffe. Two females had lived for 9 years in the same enclosure with the male without pregnancies. So, Bashaw predicted that the male's disappearance wouldn't elicit much reaction in the two remaining animals.

"Unfortunately, we got a huge reaction," Bashaw says. Both females dramatically increased the time that they spent repetitively licking the fence of their enclosure and pacing. Zookeepers take tics such as these as a sign that something's wrong. Ten days after the male's disappearance, one female had tapered off in pacing, but the other persisted in licking until the keepers introduced challenging containers for the animals' food supply, which seemed to divert the giraffes from the fence.

The giraffes' distress following the removal of the male startled Bashaw into wondering whether the animals were truly indifferent to their associates.

She couldn't make a fair job of looking for preferences in Atlanta, where there were so few giraffes. But then she moved to San Diego to continue her graduate work, where the Wild Animal Park has 12 Baringo giraffes, making up one of the largest herds in North America. Also called Rothschild's giraffes, Baringos carry a distinctive spot pattern of polygons blurring into leafier shapes.

Bashaw became a connoisseur of spots as she learned to recognize individual adult female giraffes. The zoo photographs baby giraffes' necks and chests, noting spots with unusual shapes that will distinguish the animals throughout their lives. At first, Bashaw had to take the zoo's giraffe baby album into the field with her to tell the animals apart. "Shani has a heart-shaped spot on her neck, and Chinde has an asterisk," she says.

Each morning, Bashaw set out in a truck to follow the giraffes, noting each female's nearest neighbor and any encounters between the animals. Earlier field studies had reported occasional sightings of moms palling with moms when they had youngsters of a common age. But only one mother had a youngster in San Diego.

Mostly, each giraffe there browsed in one spot all morning. "A couple of times a week, something would startle an animal into running away, and Bashaw would roar off after it while simultaneously strategizing to keep the chase on the park roads, continuing to jot data on her record sheets, and watching for rhinos and other moving obstacles. Fortunately, she says, "the speed limit is 5 mph, so you're roaring rather slowly."

The giraffes arrayed themselves in patterns that varied considerably from one day to the next, says Bashaw. During 18 months, however, she found that a giraffe would end up with a particular animal as her nearest neighbor some 15 percent of the time. That's hardly intimate by standards of human friendship, but Bashaw points out that, in contrast, the same giraffe fed near some other individuals only 5 percent of the time.

Kinship makes a difference in the San Diego giraffe associations, she says. The adult group she watched had two mother-daughter pairs, and each member of a pair associated with her relative more often than with the other giraffes.

That pattern makes sense to ecologist Julian Fennessy of the University of Sydney in Australia. He's working with the Namibian Elephant and Giraffe Trust, based in Outjo, on the first detailed study of the Angolan subspecies of giraffe. They feed on the tough shrubbery that borders dried-up riverbeds in the Namib Desert.

Fennessy says he, too, now questions the older view of giraffes as having only loose, casual bonds. "Maybe it was like that in Kenya," where the old studies were done, he says. But in one of the desert-giraffe populations he monitors, he finds that certain females show up around other females perhaps a third to half the time he sees them. In another population he watches, which for some reason has predominantly males, he finds particular giraffes together more of the time. Fennessy says he's coming around to the view that the Namibian giraffes move around as "a group of close-knit friends, so to speak, plus some other giraffes that come along for a while and then move on."

That fits well with Bashaw's view: "Giraffe social structure is more complex than we thought."

BIG COMPANY — Among white rhinos, associations change with age. Young males venturing off on the perilous search for their own territories often buddy up with another youngster.

JUST FRIENDS "Friendship is the F-word; a word that primatologists have been reluctant to use in print, though we may use it freely when we chat with our colleagues about the animal we study," Joan B. Silk of the University of California, Los Angeles said in the February 2002 *Behaviour*, a collection of articles on animal associations. In her essay, Silk acknowledged the risks of calling a poorly understood, nonhuman behavior by a name that plucks at the human heart. Yet she called on primatologists to collect details about possible friendshiplike behaviors in other species.

Whether the search fizzles or triumphs, the results will prove interesting, says Silk. If behaviors reminiscent of human friendship fail to matter much in the lives of other animals, the puzzle would be how something so important to our societies arose only in the human lineage. Alternatively, if close analogs to components of human friendship turn up in other species, that pattern may reveal hints to how people's camaraderie evolved.

Primatologists started recording friendshiplike phenomena decades ago, although there's disagreement on what the observations mean. Barbara Smuts first splashed the F-word boldly across scientific literature in her 1985 book *Sex and Friendship in Baboons* (Aldine Publishing).

Among savanna baboons, bonds between particular males and females form a central feature of society, said Smuts, now at University of Michigan in Ann Arbor. Females actually spend little of their lives sexually receptive. For most of their adulthood, they're either pregnant or lactating. Yet Smuts found particular males and females grooming each other, sleeping snuggled together, and serving as living jungle gyms for the female's infant. If some bully baboon threatened the female, her male buddy rushed to her support. The male had often been a sex partner of the female at some point, but he wasn't necessarily the father of the current youngster. All in all, Smuts compared the relationship to friendship.

Silk isn't so sure. Among the baboons, she says, the female typically does more grooming than the male does, and he often loses interest if the youngster dies. Thus, the relationship isn't equal and depends in large part on the presence of a third party, an infant. That, says Silk, gets away from what she sees as the essence of friendship.

Current primate research is moving beyond who's grooming whom and is looking at what drives the relationship. For example, David Watts of Yale University and John Mitani of the University of Michigan in Ann Arbor have been observing chimpanzees in Uganda's Kibale Park since the mid-1990s. The researchers have found close relationships among particular male chimpanzees. Male friendships don't turn up often in nonhuman primates, but among chimps, certain males in a group often groom each other, hunt together, share meat, and come to each other's aid when fights break out. Kinship data so far show no evidence that the males have a preference for maternal kin, the team reported in the February 2002 *Animal Behaviour*.

Doing a friendly favor for a relative makes sense because the kindness benefits shared genes, but befriending nonkin is harder to explain. Theorists have proposed that nonkin social pairings evolve when animals trade favors, such as grooming a troopmate who reliably grooms back or who jumps in swinging during a fight.

Watts reviewed the Kibale Park male chimps' web of interactions in the February 2002 *Behaviour*. He concluded, in agreement with theoretical predictions, that these male pals groom and share meat in exchange for support in fights.

Among blue monkeys in Kakamega Forest in Kenya, females cluster with other females and a male or two. Within these bands, though, certain pairs of females spend extra time grooming or hanging around each other, Marina Cords of Columbia University reported in the February 2002 *Behaviour*.

Cords wonders whether she could use these monkeys to test a new proposal for forces driving friendships. According to this idea, suggested in 2003 by Peter Henzi of the Bolton Institute in England and his colleagues, certain animals may groom with extra enthusiasm those associates that fight in the front lines when monkey troops clash. In other words, groomers exchange their efforts for a compatriot's military service. The idea caught Cords' attention, she says, because territorial rivalries play a big part in the life of these blue monkeys. Almost every other day, she saw loud bouts of chasing and bluffing, with occasional grappling. Afterwards, the females of each troop "get together and groom like crazy," Cords says. "It reminds me of a sports team."

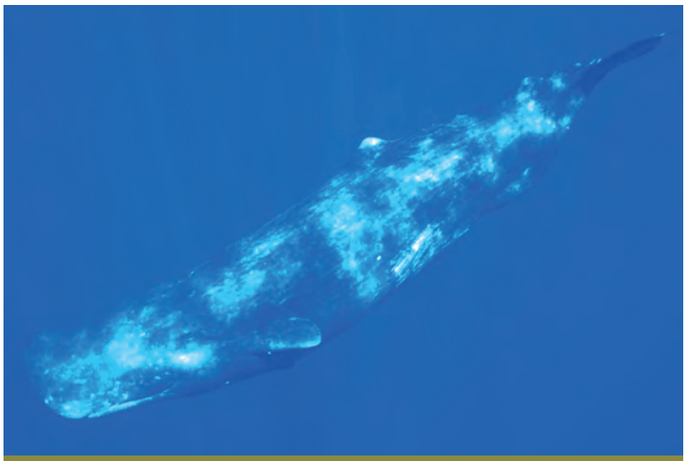
ODD COUPLES Other researchers have looked for signs of friendship in animals more distant from humans. Hal Whitehead of Dalhousie University in Halifax, Nova Scotia, has worked out methods for analyzing records of disparate sightings of hard-to-observe animals and checking for patterns of association. This type of analysis suggests that female sperm whales don't have particular friends but rather maintain a tight, lifelong group in which it's one for all and all for one.

These clusters of about 10 whales comprise females, often related on their mother's side, as well as their young, explains Whitehead, a biological statistician. From time to time, one group encounters another, and they swim along together for several days.

Whitehead and his colleague Jenny Cristal analyzed four such whale caravans in the eastern Pacific tropics. The whales of one group don't mingle with those of another, the researchers found.

Within its own group, no whale appeared extra likely to position itself near another specific individual. Such homogeneity within the group "is generally not expected," Whitehead says. "Either we haven't looked at it carefully enough yet, or there may be something special about the deep ocean."

If that open vastness does have anything to do with the sperm whales' egalitarianism, Whitehead speculates that it's because the animals don't compete for their food, which tends to occur in huge patches. "In the deep ocean, there's not stuff you can keep to yourself," he says, so inequities are less likely to arise between individuals and partnerships offer little advantage.



ONE FOR ALL — So far, evidence hasn't turned up indicating that sperm whales have friendshiplike preferences for one another. Females do swim in lifelong groups, but bonds within a group seem homogeneous.

In contrast, male bottlenose dolphins have become a classic example of marine mammals that do join up with one or two particular buddies. Richard C. Connor of the University of Massachusetts–Dartmouth and his colleagues watched dolphins in Australia's Shark Bay during the late 1980s and discovered pairs and trios lasting years. The male pals cooperate in herding a female, sometimes swimming or leaping in water-ballet symmetry on either side of her.

Among the nonprimate land animals, vampire bats practice a dramatic form of social bonding. The bats can't go for more than a few nights without a blood meal. If a bat has failed to feed and is rapidly heading toward starvation, another bat in the roost will often regurgitate some of its collected blood. Bats do this even for nonkin. Gerald Wilkinson of the University of Maryland in College Park has found that vampire bats that have been rescued by such feeding are more likely than are other roost mates to return the favor to their rescuers.

White rhinos apparently get a different benefit from buddying up. When the rhino equivalent of teenage males in South Africa's Hluhluwe-Umfolozi Park leave home, they take up with traveling partners along the way, according to Adrian M. Shrader of the University of Witwatersrand. The newbie often chooses a young male more familiar than he is with the immediate locale, Shrader and Norman Owen-Smith reported in the August 2002 *Behavioral Ecology and Sociobiology*. The affiliations can last days or years.

Harder to understand though, according to Silk, are the bonds so close and widespread in *Homo sapiens*. She says, "None of our models of reciprocity [among nonhuman animals] can accommodate the psychology of human friendship." ■

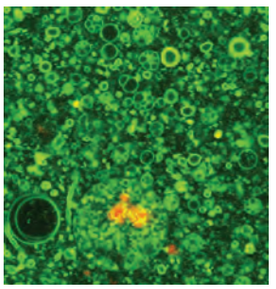
OF NOTE

EVOLUTION

Clays catalyze life?

Billions of years ago, the very first cells emerged and gave rise to life on Earth. How these ancient cells formed has been a mystery. Now, a team of evolutionary biologists suggests how clay—perhaps near hydrothermal springs on the ocean floor—may have spurred the formation of these early cells.

Previous studies have shown that clays can catalyze the assembly of RNA molecules, the instructions that cells use to make proteins. Perhaps the same might be true for cellular lipid membranes, reasoned Jack Szostak and his colleagues at Massachusetts General Hospital in Boston.



CLAYMATION In a simulated protocell, lipid vesicles (green) encapsulate RNA (red) bound to clay.

To test their theory, the researchers added small particles of montmorillonite—a clay widespread in the environment—to a solution of small lipid spheres called micelles. Almost immediately, the micelles began to assemble into larger, fluid-filled sacs, or vesicles. Because the clay is acidic, says Szostak, it destabilizes the micelles, prompting them to aggregate into the larger vesicles.

To see whether these microscopic sacs would encapsulate RNA in a cell-like fashion, the researchers attached RNA molecules labeled with a fluorescent tag to clay particles and mixed these in a solution of micelles. Vesicles harboring the glowing RNA were clearly visible through a microscope. "The effect was really dramatic," says Szostak, who described his work in the Oct. 24 *Science*. —A.G.

BIOMEDICINE

Cancer drug might fight Alzheimer's

A drug for leukemia and colon cancer might also inhibit the formation of the waxy plaques found in the brains of people with Alzheimer's disease, a study of animals shows. The drug, imatinib mesylate, which is marketed as Gleevec, is an enzyme suppressor.

In the Oct. 1 *Proceedings of the National Academy of Sciences*, researchers report that experiments on cultured rat brain cells show that the drug reduces the formation of the peptide called amyloid-beta, which typically forms into the plaques. The drug works by hampering the activity of gamma secretase, an enzyme that cleaves a precursor compound to form amyloid-beta peptide.

When dripped into guinea pigs' spinal fluid via a small pump implanted under each animal's skin, imatinib mesylate suppressed the formation of amyloid-beta-peptide plaques in the guinea pigs' brains, says William J. Netzer of Rockefeller University in New York. The spinal drip was necessary because imatinib mesylate doesn't pass through the blood-brain barrier. Doctors might someday deliver the drug this way as a treatment for Alzheimer's disease, Netzer says. Or scientists could develop a version that permeates the blood-brain barrier.

In the animal studies, imatinib mesylate slowed plaque formation without inhibiting gamma secretase's cleavage of a protein known as Notch. Notch plays a key role in brain and immune system development, but only when cut by an enzyme. Other gamma secretase inhibitors have thwarted Notch cleavage, diminishing their prospects as anti-Alzheimer's drugs. —N.S.

PHYSICS

New type of material that heat can't bloat

Most substances expand when warmed. That can be bad, especially in devices such as precision telescopes, whose components must maintain their shapes across a wide temperature range. Now, scientists have discovered a metallic compound that nixes thermal expansion by what appears to be an unprecedented mechanism.

Mercouri G. Kanatzidis and his colleagues at Michigan State University in East Lansing created the compound by heating a mixture of equal parts of ytterbium, gallium, and germanium to 850°C and then cooling the melt to room temperature. The resulting silvery metal neither enlarges nor shrinks over the broad range of about −200°C to room temperature, the scientists report in the Oct. 16 *Nature*.

That stability may result from internal electron rearrangements, the researchers propose. With heating, the material's crystal lattice swells normally. However, some thermally excited ytterbium ions expel an electron and therefore shrink just enough to compensate for the lattice expansion.

Because many other elements should be capable of ytterbium's shrinking trick, the new approach could amount to a versatile strategy for making zero-expansion materials, says Kanatzidis. —P.W.

ENVIRONMENT

California acts on plastic additive

Late last week, California added diethylhexyl phthalate (DEHP)—a compound used to make plastics flexible—to the list of known reproductive toxicants regulated under the state statute called Proposition 65. Polyvinyl chloride (PVC) typically contains up to 40 percent DEHP. The chemical, which leaches out of PVC products such as blood-storage bags and intravenous tubing, can disrupt the normal development of male reproductive organs in animals (*SN: 9/2/00, p. 152*).

Manufacturers now have 1 year to label affected products to be sold in California as containing a reproductive poison. Neither the federal government nor any other state has acted against DEHP.

Concerns over DEHP's migration from products and its toxicity prompted a team of engineers led by Jeongsoo Choi of Seoul (Korea) National University to develop a new class of plasticizers based on nontoxic compounds known as epsilon-caprolactone molecules, now used in such things as surgical sutures. He described the new additives' performance 2 weeks ago at a conference on environmental hormones in New Orleans.

Choi's team initially tried using an epsilon-caprolactone polymer that has a linear, chainlike molecular form. However, once added to PVC, the long molecules tangled, creating a product that was only 60 percent as plastic as the DEHP version. So, the Seoul team reengineered the epsilon-caprolactones into a treelike, "hyperbranched" polymer. Some 20 times as massive as the linear form, the newly patented compound doesn't tangle, leaving PVC as flexible as if it were made with DEHP, Choi reported. More important, he told *Science News*, unlike DEHP, the new alternative "doesn't migrate out—at all."

His team is working with a Korean company to test the new PVC formulation in blood bags and food wrap. —J.R.

PALEONTOLOGY

Tracks suggest chase, capture, and after-meal respite

The still life portrayed in a 315-million-year-old set of fossil footprints discovered in southwestern Indiana is a poignant vignette of life, death, and satiation.

The 1.3-meter-long, S-shaped trackway preserves the footprints left by two different creatures. The left and right feet of the animal that made the smaller set of impressions were spaced about 2.3 centimeters apart, says Joe Monks of Purdue University in West Lafayette, Ind. The tracks left by the larger animal have a left-right spacing of about 5.5 cm and straddle those made by the smaller creature all along the trail of prints. Both sets of impressions are scuffed, which, along with the two tight curves, suggests the animals were moving rapidly, says Monks.

At the end of the trackway, the smaller set of footprints disappears, indicating that the larger animal caught and ate the smaller one. Just centimeters away, the ancient siltstone preserves a so-called resting trace, the impression of a creature's belly and its splayed hind limbs. The distance between the rear feet on that resting trace is the same 5.5-cm spacing of the presumed predator's tracks. A postmeal pause is characteristic of reptiles, which often bask in sunlight to raise their body temperatures and thereby accelerate digestion.

Monks says that all the footprints in the Indiana trackway may have been made by *Notalacerta missouriensis*, an early reptile whose fossils have been identified from other rocks in that formation. The circuitous route and apparent speed of the chase also hint that early reptiles were active predators and possibly cannibals. —S.P.

PALEOBIOLOGY

Role of gastroliths in digestion questioned

The discovery of large, polished stones inside the body cavities of some fossils of large plant-eating dinosaurs led many paleontologists to believe that the gastroliths—Greek for "stomach stones"—aided the creatures' digestion by grinding up tough vegetation. New analyses of the gastroliths in ostriches are casting doubt on that theory.

Many modern-day birds, which merely gulp their food because they have no teeth and can't chew, swallow stones that help grind grain, seeds, and vegetation in the creatures' gizzards. In ostriches, the muscle contractions in this gastric mill occur two to three times per minute, says Oliver Wings of Germany's University of Bonn.

In experiments in which Wings fed ostriches 2-centimeter cubes of various types of rock, he found that sandstone blocks quickly crumbled in the birds' gizzards and that limestone lumps dissolved after just a couple of days. Tougher minerals such as rose quartz and granite eroded more slowly. Interestingly, says Wings, none of the stones retrieved from the ostrich gizzards developed a highly polished surface such as that of the stones found within dinosaur fossils.

Typically, gizzard stones account for just over 1 percent of an ostrich's body weight. If that ratio held for a 50,000-kilogram *Seismosaurus*, the beast would have carried more than half a ton of rocks in its immense belly, says Wings. However, the *Seismosaurus* fossil found with the most gastroliths held only 15 kg of stones, the largest no bigger than a grapefruit.

Wings contends that it's unlikely such a small stash, dispersed through a vat-size stomach, could have significantly helped grind vegetation. Instead, he suggests, the stones may have been ingested accidentally. Or, he notes, dinosaurs may have habitually swallowed rocks for their mineral content, and the gastroliths that survived to be fossilized were those that were resistant to erosion and stomach acid. —S.P.

PALEONTOLOGY

Healed scars tag *T. rex* as predator

Although *Tyrannosaurus rex* has a reputation as a fierce predator, the evidence to back up that notoriety has been both rare and debatable. Now, a fossil *Triceratops* skull with healed bone scars may compel paleontologists to give *T. rex* its due.

Previously, all of the gnaw marks on bones that have positively identified *T. rex* as the chewer have shown no sign of healing, says John W. Happ of Shenandoah University in Winchester, Va. It's impossible to tell whether those traces are signs of predation or scavenging. A healed wound would indicate that the intended victim got away from a predator, Happ notes.

The partial skull of a large adult *Triceratops* unearthed in Montana in 1997 has several wounds that probably were inflicted by a *T. rex*, says Happ. All of the wounds show signs of infection and healing, an indication that the *Triceratops* lived for several years after the attack. The outer third of the creature's left brow horn is missing, and cone-shaped indentations on what's left match the tooth tips of a typical large tyrannosaur. Also, Happ says, the 65-millimeter gaps between three deep, parallel scrapes on the left side of the skull match the tooth spacing of *T. rex*, the only meat eater in the ecosystem. —S.P.

PALEOECOLOGY

Ancient atmosphere was productive

How could ancient landscapes have provided all the vegetation needed to nourish massive herds of hungry, multiton dinosaurs? New laboratory experiments suggest that in the era just before the dinosaurs went extinct, extra carbon dioxide in the atmosphere may have done the trick, boosting plant productivity to at least three times that of today's ecosystems.

During portions of the Cretaceous period, which ended about 65 million years ago, some regions of western North America supported dense populations of large, plant-eating dinosaurs. In that era, the atmospheric concentration of carbon dioxide ranged as high as 2,000 parts per million (ppm)—more than five times today's values. Oxygen made up as much as 30 percent of the air, in contrast to today's 21 percent. Atmospheric pressure then was about 25 percent higher than it is today.

By growing seedlings of *Ginkgo biloba* in a hyperbaric chamber, Sara M. Decherd of North Carolina State University in Raleigh and her colleagues investigated the effects such an atmosphere might have had on plants. *G. biloba* is a still-thriving species whose leaves can be found in the Cretaceous fossil record.

In experiments that lasted 24 hours, plants in atmospheres that contained carbon dioxide concentrations of 2,000 ppm grew five times as fast as those exposed to modern concentrations of the gas. In similar but separate tests, elevated concentrations of oxygen slightly slowed plant growth. When concentrations of both carbon dioxide and oxygen were raised to their Cretaceous levels, at the expense of atmospheric nitrogen, plants grew about four times as fast as they did in current-atmosphere conditions. In monthlong tests, growth slowed after an initial spurt but seedlings still produced three times as much new foliage as did those grown under current conditions, says Decherd. —S.P.

Books

A selection of new and notable books of scientific interest

BEST TREES FOR YOUR GARDEN

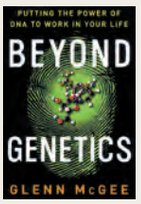
ALLEN PATERSON

While most people focus on low-growing shrubs, ground covers, and flowers, Paterson invites everyone to look up and appreciate the value of thoughtfully placed trees within a landscape. Focusing on how trees affect the growth of plants around them, Paterson begins with an introduction to how trees function. This section includes basic information, such as the effect of large leaves versus small ones on surrounding plants. The bulk of the book is a guide to selecting trees for a landscape. A lengthy encyclopedia features different varieties. Details include height, spread, speed of growth, leaf shape, and flower characteristics. Paterson targets this guide to amateur gardeners and professional landscapers and includes data appropriate for both audiences. ***Firefly, 2003, 208 p., color photos, flexibind, $24.95.***

BEYOND GENETICS: Putting the Power of DNA to Work in Your Life

GLENN MCGEE

The editor of *The American Journal of Bioethics* surveys the potential effects of genomics on our lives within the next 20 years or so. For instance, McGee predicts that by 2010, pharmaceuticals will be customized to groups of people according to their genetic information. Home DNA analysis will tell people to which of these groups they belong. Similar, quick genetic analyses will allow people to determine their strengths—in sports or the arts, for example. McGee's aim isn't to head off a socially dangerous technology. He argues that we aren't going back in time. Genomics is upon us, he writes, and we must find the most constructive ways to use it. He offers thoughts on issues such as the buying and selling of individual genes and how individuals will use and protect the knowledge they gain about their genetic makeups. ***Morrow, 2003, 231 p., hardcover, $24.95.***



GAINING GROUND: A History of Landmaking in Boston

NANCY S. SEASHOLES

Remarkably, nearly one-sixth of Boston is built on filled-in rivers and swamps. Seasholes speculates that these 5,250-plus acres of fill are more than may be found in any other North American city. The process of building seawalls and filling tidal flats began in the 1630s in an effort to straighten out the shoreline of what became known as the Town Dock. The burgeoning China trade and an influx of Irish immigrants in the mid-19th century spurred the process. In this copiously illustrated volume, Seasholes reveals the history of land making in Boston. She traces this process geographically from each area's first permanent settlements to the present day, defining where, when, why, by whom, and with what Boston land was created. Humanmade areas include Beacon Hill, Dorchester, South Boston, Back Bay, and Charlestown. Maps show the original shoreline in relation to today's streets and track the progress of land making over time. One chapter is devoted to the technology of landmaking. ***MIT Pr, 2003, 532 p, b&w photos/illus., hardcover, $49.95.***

KING OF FISH: The Thousand-Year Run of Salmon

DAVID R. MONTGOMERY

Today, the salmon is an icon of the Pacific Northwest. Not so long ago, however, people would have just as readily associated the fish with the bounty of rivers and streams in New England and Great Britain. The decline of the fish in the Atlantic would seem to have been a wake-up call. But Montgomery points out that despite scientific knowledge of the salmon's life cycle and 50-years-or-older laws to protect the fish in the Pacific Northwest, its population there continues to decline. Montgomery traces human impact on the salmon over the course of the past 1,000 years, showing how we have damaged the fish's environment time and again. He points to dams, pollution, and overfishing as the main culprits. On a note of optimism, in the final chapter, Montgomery provides suggestions for how the king of fish can be preserved. ***Westview, 2003, 290 p., hardcover, $26.00.***

SMALL THINGS CONSIDERED: Why There Is No Perfect Design

HENRY PETROSKI

Few people sing the praises of engineers. Even fewer do it as well as Petroski, whose previous tributes include *To Engineer Is Human* and *The Evolution of Useful Things*. In this celebratory tome, he turns away from the monumental projects of skyscrapers and bridges and goes for the commonplace: chairs, lightbulbs, cup holders, toothbrushes, potato peelers, and the ubiquitous duct tape, to name a few. While some authors might find such material uninspiring, Petroski's insight into the creative process by which common objects are invented and improved is anything but ho-hum. He describes with wit and engrossing detail how inventors strive to make the perfect object, no matter how simple or utilitarian it may be. He shows, for instance, how it took the inventors of various paper cups years and many discarded models—from cups that opened like paper bags to those that came with pleats—to create the products that we now use and discard without a second thought. Petroski also points out that these items became commercial successes only after the public learned that shared water glasses could carry germs. Equally intriguing are the author's detours into the unintended consequences of product changes intended as improvements. For instance, most ergonomic toothbrushes render standard toothbrush holders useless. ***Knopf, 2003, 288 p., b&w photos/illus., hardcover, $25.00.***

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

LETTERS

Hard lesson

I read with interest "Coronary calcium may predict death risk" (*SN: 9/13/03, p. 174*). Can you tell me what contributes to these deposits in arteries?

JULIE WINSLETT, DAHLONEGA, GA.

It's not ingestion of calcium, at least in people with normal kidney function, says Paolo Raggi of Tulane University in New Orleans. Rather, the condition stems from damage to vessel walls wrought by high blood pressure, high cholesterol, smoking, and other factors. —N. SEPPA

Subsonic booms

There is a striking similarity in the wave patterns of the ash plume on the cover of the Sept. 13 issue (for "Danger in the Air: Volcanoes have a long reach," *SN: 9/13/03, p. 168*) and those in the gas of the Perseus Cluster ("A Low Note in Cosmos: Sounding out a new role for black holes," *SN: 9/13/03, p. 163*). Could it be that volcanoes produce sound waves we can't hear but can see in the plume?

PAUL HEINS, GAINESVILLE, FLA.

Volcanoes do indeed produce abundant pressure waves that have frequencies below the threshold of human hearing. In fact, because these pulses can travel thousands of kilometers, they can reveal distant, major eruptions. —S. PERKINS

Who's to know?

It's very appealing to think that a noninvasive test could pick up the earliest signs of cancers or cardiovascular disease ("To Your Health? Controversy surrounds whole-body scans—a costly screen for silent threats," *SN: 9/20/03, p. 184*). Despite passionate testimonials of how whole-body CT scanning "saved my life," we don't know what the tumors found really would have done. We don't know that these patients' lives were improved, much less saved. In medicine today, intelligence doesn't always prevail when it comes to clinicians ordering laboratory tests. How can we expect patients to do any better?

ALFREDO A. SADUN AND REBECCA E. SADUN,
KECK-USC SCHOOL OF MEDICINE, LOS ANGELES, CALIF.

Correction *In "Centenarian Advantage: Some old folks make cholesterol in big way,"* (SN: 10/18/03, p. 243), *the full name for the gene* CETP *should have been given as cholesteryl ester transfer protein.*