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SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

dynamic coatings
stonehenge village found
a hubble eye goes blind
prion disease derailed

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big chill?

THE MODERN-DAY THREAT OF NUCLEAR WINTER

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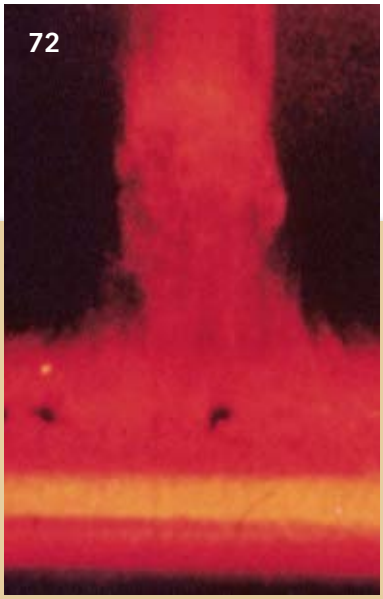

Features

This Week

Of Note

Departments

Cover Today's combination of nuclear proliferation, political instability, and urban demographics poses a renewed threat of nuclear winter. The sunlight-blocking effect of smoke and soot from even a limited nuclear war could trigger a climate catastrophe. The atomic explosion shown here occurred at the Nevada Test Site northwest of Las Vegas before dawn on Feb. 6, 1951. (Corbis) Page 72

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Suburb of Stonehenge

Ritual village found near famed rock site

A. STANFORD/AERIAL-CAM FOR NATIONAL GEOGRAPHIC

VILLAGE REBIRTH Excavations in England reveal clay floors of prehistoric houses at a site that may have been occupied by the builders of Stonehenge. One work area, floor at upper right, cuts across the remains of a road that ran to a nearby river.

Excavations in southern England of a village dating to 4,600 years ago are transforming archaeologists' notions about the function of nearby Stonehenge, the legendary set of massive stones that people positioned on Salisbury Plain around the same time.

Researchers led by Michael Parker Pearson of the University of Sheffield in England suspect that the same community built both the village and Stonehenge as parts of a religious complex devoted to the dead. "We think we're looking at a village that was occupied by the builders of Stonehenge," Parker Pearson says.

After massive feasts in town, villagers transported bodies about 2 miles up the River Avon to Stonehenge, where some were interred after cremation, according to Parker Pearson. The huge stones memorialized the villagers' deceased relatives, he asserts.

Parker Pearson and Julian Thomas of the University of Manchester in England described the new findings Jan. 30 during a teleconference held by one of their funding organizations, the National Geographic Society in Washington, D.C.

Many investigators have viewed Stonehenge as an isolated site used for religious or astronomical purposes.

Parker Pearson's team focused on a location called Durrington Walls. There, other researchers had detected magnetic traces of dozens of hearths typical of dwellings. Durrington Walls is a large henge, an enclosure surrounded by an earthen bank and ditch. That henge was last investigated in 1967.

The new project began in 2003 and will run through 2010. Last September, Parker Pearson and his coworkers uncovered remains of eight houses at the site. Each house measured about 16 square feet and had a central fireplace set in a clay floor. Postholes and slots in the floors once anchored wooden furniture. Debris, including huge numbers of animal bones and cooking implements strewn across the floors, represents the remains of ancient feasts, Parker Pearson says.

Radiocarbon dates for the houses overlap with previous age estimates for cremated remains discovered at Stonehenge.

The Durrington Walls houses bordered a stone road, 90 feet wide and 560 feet long, found in 2005 and further excavated last year. The road runs from the remains of a huge ceremonial circle of timbers to the river. Two miles upstream, a comparable road stretches from the river to Stonehenge.

Thomas excavated two Durrington Walls structures on a terrace and surrounded by wooden fences and ditches within the henge. He suggests that these structures and at least three others nearby served either as shrines or as houses for community leaders.

The pair of roads at Stonehenge and Durrington Walls illuminates the complementary relationship between the sites, Parker Pearson holds. For instance, Stonehenge's thoroughfare, discovered in the 18th century, aligns with the midsummer-solstice sunrise, while the Durrington Walls road lines up with the midsummer-solstice sunset. Similarly, a set of three giant stones at Stonehenge frames the midwinter-solstice sunset, while the Durrington Walls timber circle aligns with the midwinter-solstice sunrise.

Parker Pearson says that villagers appear to have used Durrington Walls as a place for periodic celebrations of life—held before they moved their dead up the river to the afterlife via cremation at Stonehenge, a symbol of permanence.

Archaeologist Caroline Malone of the University of Cambridge in England calls the new findings "extremely exciting." She notes that to confirm their theory, the researchers need to find more evidence of graves and funeral activities in the Durrington Walls vicinity. —B. BOWER

Disaster's Consequences

Hurricane's legacy includes arsenic

Within the construction debris strewn across the Gulf Coast by Hurricane Katrina is a disturbing amount of arsenic, according to a new study. The tainted rubble, as it is currently managed, might contaminate groundwater, the researchers say.

Before 2004, chromated copper arsenate (CCA) was the preservative most commonly used to prevent pest infestation of construction wood. Because of arsenic's toxicity, the Environmental Protection Agency has since banned use of the chemical for residential projects (*SN: 1/31/04, p. 74*). However, many old utility poles, decks, and fences contain CCA-treated wood.

During March 2006, Helena M. Solo-Gabriele, an environmental engineer at the University of Miami in Coral Gables, Fla., and her colleagues surveyed debris in New Orleans. They used a handheld X-ray–fluorescence spectroscopy unit to determine the concentration of arsenic within 225 pieces of lumber from seven sites.

Of that sample, 52 pieces contained arsenic, with a mean concentration of 1.24 grams per kilogram of wood.

Hurricane Katrina generated approximately 72 million cubic meters of debris,

according to the Louisiana and Mississippi departments of environmental quality. Other researchers estimate that 50 percent of this debris is construction and demolition waste, of which 33 percent is wood.

Having found that CCA-treated wood accounted for 23 percent of the wood waste that they examined, Solo-Gabriele's team estimated that 1,740 metric tons of arsenic hides within hurricane debris scattered across Louisiana and Mississippi. They report their findings online and in an upcoming *Environmental Science & Technology*.

"There's a tendency not to think about how much [CCA-treated wood] is really out there," says Solo-Gabriele. If this wood ends up in unlined landfills, which don't retain the water that percolates through the waste, arsenic might leach out and contaminate groundwater, she says.

John H. Pardue, an environmental engineer at Louisiana State University in Baton Rouge, notes that Louisiana normally bars lumber treated with arsenic from entering unlined landfills. But the emergency rules in place since Katrina lifted that ban. Solo-Gabriele's report "confirms that large amounts of arsenic are making their way into debris landfills," says Pardue.

"I believe the storm-debris landfills will be the environmental legacy of these storms," he says. "While many environmental issues were handled well after the storm, the way debris has been handled has been abysmal."

After a disaster, the control of arsenic-treated wood is "way down the list" of priorities, says environmental scientist John D. Schert of the University of Florida in Gainesville. Disposal of this wood "is a really difficult, complicated waste-management problem," he says. —A. CUNNINGHAM

Kaput

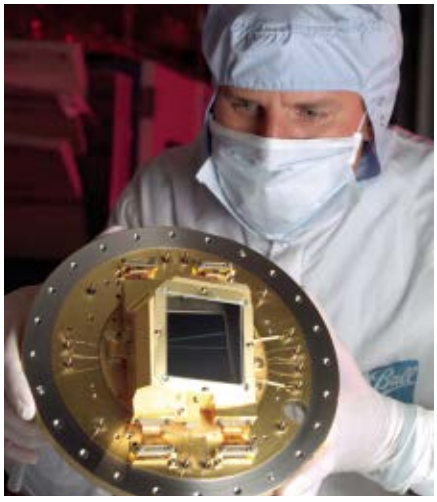
Hubble's main camera stops working

The sharpest, most sensitive camera on the aging Hubble Space Telescope has stopped working, and its most impressive capability can't be revived, NASA announced this week.

The problem began on Jan. 27, when the orbiting observatory abruptly went into "safe mode," turning off its nonessential detectors, including several in the telescope's showcase instrument, the Advanced Camera for Surveys (ACS). An investigation revealed a short in circuitry powering the camera.

The glitch doomed the ACS' two exquisitely sensitive visible-light detectors, which since last June had been powered by a backup electronics system after a power-supply malfunction (*SN: 7/8/06, p. 19*). That original problem didn't affect the camera's most limited detector, which studies only ultraviolet emissions from bright objects such as hot stars. Although the new problem shut down that detector, engineers hope that by switching back to the primary power supply toward the end of February, they'll reactivate the instrument.

Hubble's three other instruments—a less sensitive visible-light camera, a near-infrared camera, and the telescope's fine-guidance sensors, which can be used to track the motion of stars—are expected to resume operation by early February, according to Preston Burch, Hubble's associate director and program manager at NASA's Goddard Space Flight Center in Greenbelt, Md. He detailed the observatory's status during a telephone briefing on Jan. 29.



BLIND EYE **A component of Hubble's Advanced Camera for Surveys is shown here before installation in 2002.**

Observation using the ACS has accounted for two-thirds of studies with the observatory, notes Burch. Installed by astronauts in March 2002, the camera has taken the deepest portrait ever of the universe and revealed planet-spawning disks of gas and dust around nearby stars.

"The seemingly permanent loss of the ACS is a blow to the astronomical community," says astronomer Lynne Hillenbrand of the California Institute of Technology in Pasadena, Calif. "It should be recognized, however, that [Hubble] is an aging facility very close to its nominal mission lifetime, which expires in 2010, and we might expect continued hardware failures."

Some planned ACS observations could be carried out instead by longer exposures with the wide-field camera, Burch notes. The agency says that it has plenty of studies to keep Hubble's three remaining instruments busy until shuttle astronauts arrive for a long-delayed servicing mission, now scheduled for September 2008 (*SN: 11/4/06, p. 294*).

Then, the crew will install a sensitive ultraviolet spectrograph and a new infrared camera and attempt to repair a spectrograph that has stopped working. Repairs to the ACS would be too risky and labor intensive, says Burch. —R. COWEN

Early Fix

Prion disease remedied in mice

Mad cow disease and other brain disorders stemming from prion proteins have long resisted cure. Now, in a test in mice, a prion disease caught early has been reversed.

Prions—misfolded versions of a natural protein called PrP—trigger normal PrP to misfold in the same way. Over time, prion infection kills so many neurons that the brain becomes riddled with holes.

In the new study, neurologist Giovanna R. Mallucci of the Institute of Neurology in London and her colleagues tested whether shutting off the prions' supply of PrP could alter the course of disease. They worked with genetically engineered mice that make PrP only for the first 9 weeks of life and normal mice that make PrP indefinitely.

The researchers infected both groups, shortly after birth, with prions that cause scrapie in sheep.

At 8 weeks of age, mice in both groups showed cognitive deficits. For example, mice normally spend more time exploring unfamiliar sets of objects than known ones. But the infected mice spent the same time examining strange or familiar arrangements of blocks, indicating that the animals had forgotten familiar arrangements. The mice also lost some of their natural inclination to gather food pellets.

Over the next several weeks, the normal mice continued to decline. However, the transgenic mice, which stopped making PrP, showed improvements, says Mallucci. By 12 weeks of age, they had regained memory and motivation.

Brain changes paralleled the behavioral changes. At 8 weeks old, the mice had lost function at many brain synapses, the junctions where messages are transmitted between neurons. But transgenic mice recovered synapse function soon after their PrP production stopped, Mallucci and her colleagues report in the Feb. 1 *Neuron*. While PrP's natural role is poorly understood (*SN: 2/4/06, p. 68*), mice lacking it don't seem to suffer consequences, she adds.

This and previous work indicate that the body can clear prions once the PrP

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supply is eliminated, says Howard J. Federoff, a physician and neuroscientist at the University of Rochester School of Medicine and Dentistry in New York. "This heralds an opportunity for therapeutic development that many in the past might have thought worthless," he says.

The new study showed that brain impairments occurred in the mice before the appearance of large accumulations of prions and extensive cell death.

"They are seeing [behavioral] alterations before there is massive damage in the brain," says neuroscientist Claudio A. Soto of the University of Texas Medical Branch in Galveston. "This is very important because [that's when] these changes are still reversible."

Eventually, scientists might develop drugs to neutralize PrP, devise a gene therapy to silence the gene encoding PrP, or interfere with RNA to stop the protein's production, Mallucci says.

However, identifying patients in early stages of prion diseases might be difficult, says Soto. It's hard to distinguish the initial damage in prion diseases from deficiencies caused by more-common conditions, such as Alzheimer's disease, he says.

Mallucci hypothesizes that a still-unknown toxic substance is released when prions convert PrP. —N. SEPPA

Bite This

Borrowed toad toxins save snake's neck

An Asian snake stocks its defensive arsenal by collecting toxins from poisonous toads, scientists report.

The tiger keelback snake stores toxins in glands behind its head, says Deborah A. Hutchinson of Old Dominion University in Norfolk, Va. An attacker biting the snake's neck bursts the glands and gets a burning mouthful and sometimes a blinding squirt into the eyes.

Earlier studies had suggested that the snake doesn't make the gland's toxic contents but harvests those compounds from toads that it has eaten. In a paper published online for an upcoming *Proceedings of the National Academy of Sciences*, Hutchinson and her colleagues report a variety of experiments that confirm that scenario.

"The case is unique in that this is a vertebrate sequestering a vertebrate-prey toxin," comments Edmund D. Brodie III of the University of Virginia in Charlottesville. In contrast, he says, although the common garter snakes that he studies eat poisonous newts and the poison lingers in their bodies, they don't sequester it in special glands.

The glands of the poison-collecting Asian snake, *Rhabdophis tigrinus*, don't play a role in the snake's attacks on its prey. In its bite, the tiger keelback delivers slow-acting salivary toxins, which disable a clotting factor in the blood of its victims. People have bled to death from the snakes' bites, but the snakes seldom deliver a lethal dose. "They really have to chew on something," says Hutchinson.

A. SAVITZKY

ROUGH NECKS Tiger keelback snakes, found in Asia, carry defensive toxins in swollen glands on the back of their necks. When the snake eats the toad *Bufo japonicus* (inset), it arms itself with the toad's toxin.

The snake's defensive behavior displays the glands when an attacker looms, Hutchinson says. However in the 1990s, biologist Akira Mori of Kyoto University in Japan found little displaying among tiger keelbacks on the Japanese island Kinkazan. The snakes there tend to flee their predators. Since the island has no poisonous toads, Mori proposed that the snakes need to eat toads to have the defensive toxins, called bufadienolides.

To test that idea, Hutchinson, Mori, and their colleagues analyzed gland fluids in snakes from various places in Japan. The researchers found high toxin concentrations in snakes from zones that contained poisonous toads but no toxins in fluids from snakes from toadfree Kinkazan.

The researchers also tracked gland contents from snakes hatched in the lab. The team found that mother snakes from high-toad zones passed along enough toxins to protect their offspring for at least 2 months. However, when the mother snakes came from the toadfree island, the youngsters hatched without toxins in their glands.

When researchers fed the latter juveniles a toxinfree diet of fish and harmless frogs, the young snakes' neck glands remained toxinfree. However, such hatchlings fed toxin-bearing toads developed toxic fluids, the researchers report.

"The thing that I found most interesting was the provisioning of offspring by mothers," comments Brodie.

Sequestering toxins is well known in invertebrates, poison arrow frogs, and a few birds that eat poison-bearing invertebrates, notes Becky Williams of the University of California, Berkeley, who has studied garter snakes. Many snakes eat toxin-bearing amphibians. Williams adds, "I would not be surprised to discover that other snakes like these sequester toxins." —S. MILIUS

Waves from the Big Bang

Upcoming detectors may view newborn universe

Ripples in space-time, new research shows, may soon give scientists a glimpse of the universe as it looked a tiny fraction of a second after its birth. That's the moment when the initial runaway expansion of the universe ended in a burst of tremendous turbulence, shaking the fabric of space-time so violently that it's reverberating faintly even today, according to some cosmological models.

Albert Einstein predicted the existence of these waves in his general theory of relativity, which unifies time and space into a four-dimensional space-time. Gravitational effects of the birth of the universe and other extreme events can send distortions in space-time rippling outward as what scientists call gravitational waves.

Observational evidence for gravitational waves is thus far only indirect, but most physicists agree that the waves exist. "Anyone who sees a gravitational wave is going to be just enormously excited about that," says Richard Easther of Yale University.

In recent decades, scientists have calculated the distinctive gravitational-wave patterns that would result from various phenomena, such as colliding black holes.

Now, two groups of scientists led by Easther and by Juan García-Bellido of the

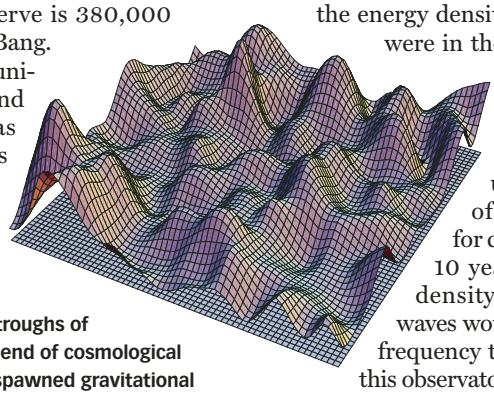
Independent University of Madrid have calculated the waves that would be generated by the violent end that some scientists have hypothesized for inflation—a theorized period of rapid expansion that lasted for roughly one-billion-trillion-trillionth (10^{-33}) of a second following the Big Bang.

The teams' calculations show that a generation of gravitational wave detectors now under development may be sensitive enough to detect these waves. If so, scientists would have a new way to confirm that inflation did occur and to measure its properties.

"This would be a direct window on that early time," says Jolien Creighton, a physicist at the Laser Interferometer Gravitational-Wave Observatory (LIGO), a pair of linked gravitational-wave detectors operating in Hanford, Wash., and Livingston, La.

Astronomers plumb the early universe by detecting light that left a distant object long ago. Currently, the furthest back that scientists can observe is 380,000 years after the Big Bang.

Before then, the universe was so hot and dense that it was opaque to all forms of electromagnetic radiation, including visible and infrared light, radio waves, and X rays. However, gravitational waves would easily pass through this early fog and provide insight into the first moments of the Big Bang.



UNRULY BEGINNING **These simulated peaks and troughs of energy density at the end of cosmological inflation would have spawned gravitational waves. At that time, the area represented by this graph was a trillionth of the cross-section of a proton, but with cosmic expansion, it would now be about 1 square meter.**

Easther's and García-Bellido's groups used different mathematical models for the end of inflation. Both teams found that if the energy density during inflation were in the lower half of the possible range, the waves produced would be detectable by an upgraded version of LIGO scheduled for completion in about 10 years. If the energy density were higher, the waves would have too high a frequency to be detectable by this observatory.

Easther's group reports its results in an upcoming issue of the *Journal of Cosmology and Astroparticle Physics*. García-Bellido's group's calculations will appear in *Physical Review Letters*.

With direct observation of the universe's first moments, scientists may learn how densely the universe was packed with energy during inflation and how inflation came to an end. —P. BARRY

Top Prospects for Tomorrow's Labs

National competition yields a dream team of young scientific talent

Twenty young women and 20 young men last week aced an early challenge in their scientific careers. They entered the high school science playoffs—the finals of the annual Intel Science Talent Search.

This year marks the first time in the competition's 66-year history that female finalists have achieved numerical parity with male ones. Young women accounted for nearly 52 percent of this year's 1,705 entrants, each of whom submitted a research project in science, math, or engineering.

Judges selected finalists on the basis of their promise as future researchers and on their projects' originality and scientific merit. In March, the finalists will assemble in Washington, D.C., to compete for top honors and more than half a million dollars in scholarship prizes.

"This competition inspires talented high school students to pursue serious research and submits their work to review that is as rigorous as any they will face as professional scientists," says Elizabeth Marincola, publisher of *Science News* and president of Science Service.

Science Service, which runs the competition, and the competition's sponsor, Intel Corp. of Santa Clara, Calif., announced the finalists on Jan. 31. They are:

Alabama: Marshall Bradley Everett, Shoals Christian School, Florence.

California: Alexandra Maria Courtis, Davis Senior H.S., Davis; Sean Matthew Wahl, Troy H.S., Fullerton; Carol Yoon Joo Suh, Palos Verdes Peninsula H.S., Rolling Hills Estates.

Colorado: Meredith Ann MacGregor, Fairview H.S., Boulder.

Connecticut: Sophie Cai, Ridgefield H.S., Ridgefield.

Illinois: Nora Xu, Illinois Mathematics and Science Academy, Aurora.

Kentucky: Yin Yin Wu, Atherton H.S., Louisville.

Maryland: Emma K. Call, Baltimore Polytechnic Institute, Baltimore; Brian Robert Lawrence and Richard Matthew McCutchen, Montgomery Blair H.S., Silver Spring.

Michigan: Sohan Venkat Mikkilineni, Detroit Country Day School, Beverly Hills; Temple Mu He and Siyuan Liu, Troy H.S., Troy.

New Hampshire: Gongmyung Lee, Phillips Exeter Academy, Exeter.

New Jersey: Daniel Adam Handlin, High Technology H.S., Lincroft; Megan Marie Blewett, Madison H.S., Madison; Neha Anil Deshpande, South Brunswick H.S., Monmouth Junction.

New York: Daniel Scott Katz, Hebrew Academy of the Five Towns and Rockaway, Cedarhurst; Rebecca Lynn Kaufman, Croton-Harmon H.S., Croton-on-Hudson; Rui Wang, Fairport H.S., Fairport; Abhinav Rohatgi, Garden City H.S., Garden City; Sarah Dana Bayefsky-Anand, The Abraham Joshua Heschel School, New York City; Kathryn Blair Friedman, The Chapin School, New York City; Kaitlin Duncan, Plainedge H.S., North Massapequa; Catherine Schlingheyde, Oyster Bay H.S., Oyster Bay; Hermain Suhail Khan, Staten Island Technical H.S., Staten Island; Oren Brecher, Suffern H.S., Suffern; Jimmy Hom, Syosset H.S., Syosset; Natalie Avella Cameron, Walter Tresper Clarke H.S., Westbury.

North Carolina: John Vincent Pardon, Durham Academy, Durham.

North Dakota: Gregory Drew Brockman, Red River H.S., Grand Forks.

Ohio: Erin Marie Schikowski, Hathaway Brown School, Shaker Heights.

Oklahoma: Mary Masterman, Westmoore H.S., Oklahoma City.

Oregon: Dmitry Vaintrob, South Eugene H.S., Eugene.

Rhode Island: Shu Wan, Classical H.S., Providence.

Texas: Yieu Chyan, Texas Academy of Mathematics and Science, Denton; Gabriel Joel Mendoza, Americas H.S., El Paso.

Virginia: Sarah Elizabeth Marzen, Thomas Jefferson H.S. for Science and Technology, Alexandria.

West Virginia: Kelydra Elizabeth Welcker, Parkersburg South H.S., Parkersburg. —B. HARDER

EASTHER, J.T. GIBLIN JR., AND E. LIM.

Explore the History of Buddhism

in this enlightening 24-lecture series

A religion without a god? How could that be? And how could it have captured and captivated so many millions of people in so many countries for so many centuries?

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Professor Eckel begins by saying that "Buddhists love to tell stories." He approaches Buddhism as the elaboration of a series of stories. The stories begin with the rich religious culture of India. Siddhartha Gautama was born into a princely family and a life of luxury in India in 566 B.C.E. At the age of 29, he determined to seek the truth about life and death. He left his wife and son and became a wandering ascetic.

After years of struggle, he came to the pivotal moment in his life. As he sat under a banyan tree, he "woke up" to the meaning of life ("Buddha" means "Awakened One"). This awakening was the realization that "all of life is suffering" and that freeing the mind from the cycle of birth and death leads to the inner peace of *nirvana*.

The stories then examine Buddhism after the Buddha's death. They trace the interpretation of his teaching, or *Dharma*, and the development of the early Buddhist community.

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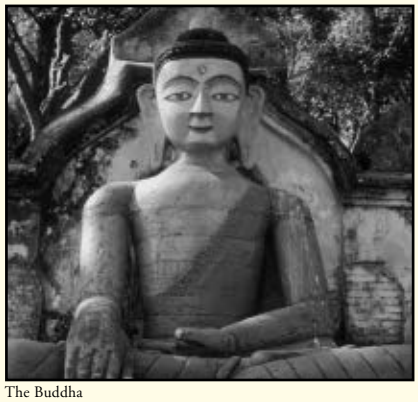

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The Buddha

About Your Professor

Dr. Malcolm David Eckel is Associate Professor of Religion at Boston University. He earned his Masters in Theology at Oxford and Ph.D. in the study of comparative religion at Harvard. In 1998, Professor Eckel received the Metcalf Award for Teaching Excellence, his university's highest award for teaching.

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SUDDEN CHILL

Even a limited nuclear exchange could trigger a climate catastrophe

BY SID PERKINS

In the mid-1980s, at the height of the Cold War, the United States and the Soviet Union each had thousands of nuclear warheads, along with a multitude of aircrews and missiles, sitting on red alert to carry those bombs to their targets at a moment's notice. The philosophy of mutual assured destruction—the notion that any use of nuclear weapons would trigger a full-fledged exchange that neither nation would survive—may have deterred any use of such bombs since World War II.

As devastating as a nuclear war between superpowers would have been, the after-effects probably would have been worse. In the 1980s, scientists estimated that a war in which each superpower used half its nuclear arsenal would have destroyed the upper atmosphere's ozone layer and, by filling the skies with dust and smoke, decreased temperatures at ground level in some regions as much as 40°C for up to a decade. Scientists and antinuclear advocates dubbed this chilling result nuclear winter. The lengthy famine sure to follow probably would have killed more people than the brief war would have.

Today, the Cold War is over, the Soviet Union is no more, and the United States and Russia are dismantling their nuclear stockpiles. Together, the two countries now maintain about 20,000 weapons, less than a third of the number that sat at the ready in 1986.

But there's no reason to celebrate just yet, new studies suggest.

"While there's a perception that a nuclear build down by the world's major powers in recent decades has somehow resolved the global nuclear threat, a more accurate portrayal is that we're at a perilous crossroads," says Brian Toon, an atmospheric scientist at the University of Colorado at Boulder and one of the researchers who first floated the idea of a nuclear winter.

Today's threat stems from a variety of factors, Toon and his colleagues say. Nations are joining the nuclear club with unnerving regularity, others are suspected of having ambitions to do so, and dozens more have enough uranium and plutonium on hand to build at least a few Hiroshima-size bombs. The leaders of some of these nations may have no qualms about using such weapons, even against a nonnuclear neighbor. Increasingly, people are living in large cities, which make tempting targets.

Finally, the results of today's climate simulations—which are much more sophisticated than those that were available in the 1980s—suggest that even a nuclear exchange of just a few dozen weapons could cool Earth substantially for a decade or more.

The current combination of nuclear proliferation, political instability, and urban demographics "forms perhaps the greatest danger to the stability of human society since the dawn of man," warns Toon.

Recognizing this danger, on Jan. 17, the Bulletin of the Atomic Scientists moved the minute hand on its "doomsday clock" 2 minutes closer to midnight. "It's been 60 years since nuclear weapons have been used in war, but the psychological barriers that have helped limit the potential for the use of nuclear weapons in this country and others seems to be breaking down," says Lawrence M. Krauss, a member of the group and a physicist at Case Western Reserve University in Cleveland.

TALE OF TWO CITIES — The amount of combustible material per square kilometer in Bangalore, India (top), is much higher than that in less-populated suburban Nashville (bottom). Thirteen times the area included in each of these 1-kilometer-wide images would be incinerated by a Hiroshima-size nuclear blast.

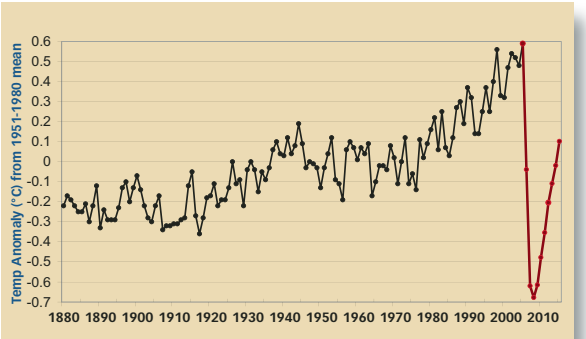
JOIN THE CLUB In 1950, there were two nuclear powers—the United States, whose Manhattan Project developed the bombs dropped on Hiroshima and Nagasaki at the end of World War II, and the Soviet Union, which conducted its first nuclear test in August 1949. By 1968, when the Treaty on Non-Proliferation of Nuclear Weapons was proposed, France, the United Kingdom, and China had joined the pack. Outside that treaty from its beginning, India, Pakistan, and North Korea have developed weapons and conducted tests. Also, Israel is widely suspected of possessing nuclear weapons.

A handful of nations once possessed nuclear weapons but abandoned them. Belarus, Ukraine, and Kazakhstan inherited warheads when the Soviet Union fell apart in 1991 but have since transferred those weapons to Russia. South Africa has admitted constructing, but later disassembling, six nuclear devices, possibly after one test, says Toon.

In total, he says, at least 19 nations are now known to have programs to develop nuclear weapons or to have previously pursued that goal. Many more nations, through their power-generating and research nuclear reactor programs, have the raw materials for constructing nuclear devices, he and his colleagues reported in December 2006 at a meeting of the American Geophysical Union in San Francisco. Those raw materials aren't scarce: At least 40 nations have enough uranium and plutonium on hand to construct substantial nuclear arsenals.

Disturbingly, some of the nations with abundant bomb material have or have recently had strained relations with their neighbors. At the end of 2003, for example, Brazil probably had enough plutonium on hand to make more than 200 Hiroshima-size bombs, while its former rival Argentina could have produced 1,100 such bombs. Although North Korea probably has enough nuclear material to fabricate only a handful of the devices, South Korea has enough plutonium to construct at least 4,400. Pakistan could make 100 or more nuclear bombs, and its neighbor India could put together well over 10 times as many, the researchers estimate.

Today, at least 13 nations operate facilities that enrich uranium, plutonium, or both, says Toon. Altogether, 45 nations are known to have previous nuclear weapons programs, current weapons stockpiles, or the potential to become nuclear states.



COOL SPELL — Average global temperature has risen for more than a century, but a hypothetical 100-bomb nuclear exchange between India and Pakistan would more than offset that change. The 1.25°C drop attributable to such a nuclear war is shown in red on this graph of average global temperature changes since 1880.

MOVING TARGETS In the late 1970s, researchers analyzed a variety of scenarios describing a nuclear war between the United States and the Soviet Union. In some simulations, analysts presumed that either side's primary targets would be military facilities rather than population centers. In such an attack, between 2 million and 20 million people would die—largely as a result of radioactive fallout, not the blasts. At the other extreme, a full-scale Soviet attack that included U.S. economic targets, such as cities and ports, would use thousands of weapons and kill up to 160 million people.

Neither of those scenarios accurately portrays a nuclear war between regional rivals. A new nuclear power probably wouldn't have enough weapons on hand to target its opponent's entire military infrastructure. Therefore, "a small country is likely to direct its weapons against population centers to maximize damage and achieve the greatest advantage," Toon notes. Leaders of a fledgling nuclear power probably wouldn't believe that they could survive an opponent's first strike. Moreover, a small nuclear power might be more inclined than a superpower to strike first.

Because of recent growth and shifts in the world's population, more people are living in urban areas with more than 10 million residents, says Richard P. Turco, an atmospheric scientist at the University of California, Los Angeles. Such megacities often have a densely populated urban core full of flammable materials: schools, offices, shopping malls, gas stations, vehicles with their complement of motor oils and fuels, and even the asphalt paving.

The brief but intense thermal pulse of a nuclear explosion immediately ignites any combustible material nearby. "It's like a bit of sunlight brought down to Earth," says Turco. A Hiroshima-size nuclear bomb packs the same explosive punch as about 13,500 metric tons of TNT and can cause urban fires that release more than 1,000 times the energy of the bomb itself. The bomb that destroyed Hiroshima scorched an area of about 13 square kilometers.

On average, about 11 metric tons of flammable material are associated with each resident of a megacity, Turco and his colleagues reported at the San Francisco meeting. The team used population data to estimate not only how many people would die but also how much smoke and soot would be produced as the result of any given nuclear exchange.

If a Hiroshima-size bomb were to explode in the sky above each of the 50 most densely populated areas of the United States, more than 4 million people would die, the researchers estimate. Exploding 50 bombs over both India and Pakistan could cause 12.4 million and 9.2 million deaths, respectively.

The firestorms triggered by such nuclear volleys would produce millions of tons of smoke and soot, Turco notes. Lumber in buildings would generate about 40 percent of the soot. The rest would result from the combustion of petroleum products such as motor fuels, plastics, and asphalt roofing. Because soot from those sources repels moisture, water vapor in the air wouldn't condense on the particles. Therefore, rain wouldn't efficiently cleanse the air, and the soot would remain aloft longer than soot from a natural fire would.

UP, UP, AND AWAY Tracking and monitoring the smoke plumes from natural wildfires provides researchers with a notion of how soot and other small particles from nuclear firestorms would spread throughout the atmosphere, as well as data about the storms' possible effects on climate.

In general, high-flying particles of ash and soot either absorb sunlight or scatter it. Some of that energy heats nearby particles, while some bounces back into space. That process cools Earth's surface while heating the atmosphere around the particles, says Mike Fromm, an atmospheric scientist at the Naval Research Laboratory in Washington, D.C. The smoke from small wildfires typically rises only a few kilometers and stays within the troposphere, the layer of the atmosphere where most weather occurs. Within the past decade, however, scientists have recognized that the plumes from major blazes can reach the stratosphere.

Take, for example, the Chisholm fire, a 7-day blaze that consumed almost 1,200 km² of timber in central Alberta in May 2001. The thick plume of smoke from that fire was the tallest ever observed, Fromm reported at the San Francisco meeting. Satellite observations of particles in the atmosphere in late June indicated that smoke had reached the stratosphere and spread over much of the Northern Hemisphere, reaching as far south as Hawaii and as far north as Svalbard, a Norwegian island in the Arctic Ocean. Similarly, smoke from a large fire surrounding Canberra, Australia, early in 2003 spread over much of the Southern Hemisphere.

Smoke and soot from huge blazes generally reach the stratosphere in a two-stage process, says Eric J. Jensen, an atmospheric scientist at NASA's Ames Research Center in Mountain View, Calif. First, the hot, buoyant air carries the particles to heights of around 10 km and spreads them into a layer hundreds of meters thick. Then, solar radiation heats the dark particles further, warming the surrounding air, which slowly rises higher and carries the particles with it.

Results of a recent computer analysis illustrate the phenomenon, says Jensen. He and his colleagues simulated a high-altitude smoke plume from a summer fire by modeling 10,000 metric tons of smoke particles dispersed in a 500-m-thick, 100-km square layer of atmosphere at a height of 9 km. After 1 hour of simulation time, solar radiation warmed the particles and the air, providing

NASA/GODDARD INSTITUTE FOR SPACE STUDIES AND ROBOCK ET AL.

an updraft of about 1 m per second. After 10 hours, most of the smoke reached an altitude of 11 km, putting it into the stratosphere.

CHILL IN THE AIR Although wildfires are a prodigious source of small particles in the atmosphere, the largest suppliers of what scientists call natural aerosols are major volcanic eruptions. The sun-blocking effect of the minuscule bits of volcanic ash and droplets of water and sulfuric acid can cool Earth's climate significantly for months or even a year or two. The aerosols are especially persistent if they reach the stratosphere, where they waft above most weather and therefore aren't efficiently cleansed from the atmosphere.

Once the volcanic plumes spread at high altitude, they typically prevent no more than 1 percent of the sun's light from reaching Earth's surface (*SN: 2/18/06, p. 110*). But high-flying smoke and soot in the aftermath of even a limited nuclear war—one with as few as 100 Hiroshima-size bombs—would be much denser than that and the materials would block the sun as effectively as the thick clouds of a stormy day do, says Luke Oman, an environmental scientist at Rutgers University in New Brunswick, N.J. He and his colleagues used computer models to simulate the effects of just such a war between India and Pakistan.

If those bombs exploded over the most-populated areas of the nations, more than 5 million metric tons of smoke and soot would soar into the sky. Most of those particles would stay aloft for more than 6 years, says Oman. On average, the temperature at Earth's surface would drop around 1.25°C for up to 3 years—about four times the short-term cooling effect resulting from the 1991 eruption of Mount Pinatubo in the Philippines. After 10 years, the global average temperature would still be 0.5°C below normal.

Those temperature decreases may seem no more than a slight chill, but they're substantial, says Alan Robock, also of Rutgers University. Temperatures in the first few years after a 100-bomb India-Pakistan war would be cooler than during a centuries-long cold spell called the Little Ice Age, which ended during the mid-1800s. Average global temperatures were at that time between 0.6°C and 0.7°C below what they are today, and glaciers advanced in mountainous regions worldwide.

While temperatures at Earth's surface would drop, those in the stratosphere would increase by 30°C or more for at least 3 years, says Michael J. Mills, an atmospheric scientist at the University of Colorado at Boulder. At those higher temperatures, the large quantities of nitrogen oxides formed during the nuclear explosions—when nitrogen in the air literally burns—would destroy high-altitude ozone at rates much higher than normal, he notes.

> "Only disarmament can prevent the possibility of a nuclear environmental catastrophe."
>
> — ALAN ROBOCK, RUTGERS UNIVERSITY

In the team's simulations, between 50 and 70 percent of the ozone high over polar regions disappeared. Losses were lower over the tropics, but ozone there still decreased by at least 10 percent. A 100-bomb nuclear exchange would create "a global ozone hole," says Mills. Because animals are adapted to the particular level of ozone protection that's normal for their latitudes, any significant ozone loss could be catastrophic, he suggests.

"Only disarmament can prevent the possibility of a nuclear environmental catastrophe," Robock grimly told the audience at the San Francisco meeting.

That a nuclear winter could be triggered by a regional war is particularly ironic, adds Stephen Schneider, a climate scientist at Stanford University. A few decades ago, people were afraid that an all-out nuclear war between superpowers would trigger a climate catastrophe. Today, the United States and Russia could simply end up as helpless bystanders—who would nevertheless be left out in the cold. ■

SAVVY SKINS

Researchers pour new functions into coatings

BY AIMEE CUNNINGHAM

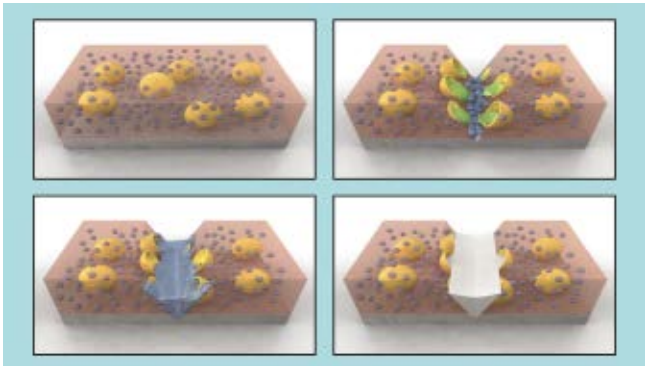
Among the innovations highlighted in the Dec. 10, 2006 New York Times magazine's "Year of Ideas" was a coating manufactured by Nissan. Called Scratch Guard Coat, this substitute for clear-coat car finishes—currently available on a sports utility vehicle in Japan—repairs surface scratches. Though deep scratches are beyond the resin coating's capabilities, it fills in slight scuffs in a day to a week.

Scratch Guard Coat notwithstanding, most coatings found on products today do their jobs in a much simpler way. They typically provide a passive barrier between the environment and some object prone to degradation, be it a car, a bridge, or a cheap metallic dish rack. By taking action to repair a product, the Nissan coating is a step toward a more dynamic coating world.

But in the realm of new coating possibilities, Nissan's entry only scratches the surface. Materials scientists and chemists are already developing coverings that pack in more functions and complexity. "This is certainly a major growth area," says Paul V. Braun, a materials scientist at the University of Illinois at Urbana-Champaign. "It's been picking up in the last few years."

The newest coatings incorporate multiple functions, offer chemical reactivity, or act in response to stimuli in the environment. Once out of the laboratory, they could provide germ-busting doorknobs, artery-opening stents with powerful anticlotting properties, or polymer skins that self-heal before corrosion can mar the covered product.

"People have developed ideas of how to apply new advances in material science to coatings," Braun says.



CRACKED OPEN — Schematic of a self-healing coating shows (top left to lower right) a scratch that bursts capsules containing catalyst (green liquid) and droplets of a liquid prepolymer (blue). In the gash, the two components react, healing the coating before the underlying metal can begin to corrode.

BRAUN

KILLER COATINGS Making surfaces germfree often takes no more than a good scrub with soap and water. But the doorknobs and walls of hospitals, for example, are continuously prone to contamination by some of the nastiest microbes around. In these cases, a coating that kills bacteria or viruses might reduce the spread of infections, particularly those from the antibiotic-resistant bugs that plague hospitals.

At the Massachusetts Institute of Technology (MIT), materials scientist Michael F. Rubner and chemical engineer Robert E. Cohen have combined their laboratories' efforts to create a multilayered antibacterial coating that kills microbes in two ways: on contact and by chemical release. The covering, which they say can be applied to fabrics and hard surfaces, is an example of "how nanotechnology is working its way into the coating world," says Rubner.

The researchers build the coating layer by layer (*SN: 8/9/03, p. 91*). The first 40 layers alternate between positively charged and negatively charged polymers. Twenty additional layers provide a surface of silica nanoparticles.

Attached to the nanoparticles are molecules called quaternary ammonium compounds. Previous studies had shown that these molecules provide antimicrobial activity by disrupting bacterial membranes on contact.

When exposed to water, the coating also releases silver, a long-recognized antibacterial agent, from the polymer-only layers. Silver ions initially bind to the polymers' chemical groups. If left as such, the ions would leach out quickly on contact with moisture, and "you'd lose them within a day," says Rubner.

His group therefore performs another chemical step that gathers the silver ions into nanoparticles. When exposed to moisture, the nanoparticles break down slowly, releasing the bacteria-killing silver ions. This extends the release period to weeks or possibly months, Rubner says.

In tests against *Staphylococcus epidermidis*, the silver was more deadly than the ammonium compounds, Rubner notes. But when the silver was depleted, ammonium compounds held fast to the silica nanoparticles and continued to kill bacteria on contact. The researchers report on the dual-action covering in the Nov. 21, 2006 *Langmuir*.

Another coating, developed by MIT chemist Alexander M. Klibanov and his colleagues, kills both the influenza virus and deadly bacteria on contact.

To create the coating, Klibanov's group chemically modified a commercially available polymer to make its chains highly water-repellent and positively charged. Dissolving the polymer in an organic solvent produced a paint that can be brushed or sprayed onto a surface, or an object can be dipped into the paint. As the paint dries, the solvent evaporates, leaving behind polymer chains that repel each other because of their charges. In that arrangement, fragments of some of the chains stick out from the surface.

The researchers had previously demonstrated that a paint made of the polymer chains kills bacteria by punching holes in their cell membranes. They reasoned that the system might also damage viruses enveloped by membranes. In their new work, Klibanov

and his colleagues painted the spiky coating on a glass slide and tested it against influenza A virus. The coating killed at least 99.99 percent of the virus that it contacted, the researchers report in the Nov. 21, 2006 *Proceedings of the National Academy of Sciences*.

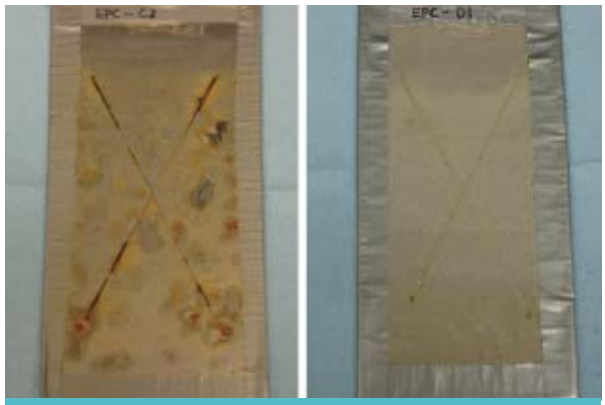
Impaled bacteria and viruses gradually build up on the coating, reducing its effectiveness, notes Klibanov. But "if you take a sponge and wash the surface with soapy water, the surfaces are rejuvenated and are as good as new," he says.

The group's initial studies show that bacteria don't develop resistance to the coatings, but the researchers haven't tested whether viruses can do so. Klibanov envisions the coatings applied throughout hospitals: on air-duct surfaces, walls, doorknobs, uniforms, and so on. He says that Boeing has expressed interest in coating surfaces on its planes that passengers touch.

KINDER COATINGS Advanced coatings could also find their way into the human body. This reflects a change in opinion on how to design biomaterials, notes Joerg Lahann, a chemical engineer at the University of Michigan in Ann Arbor. Previously, "you tried to make [biomaterials] as inert as possible," he says, but some researchers are now devising surfaces with properties "more similar to what the biological system looks like."

A way to achieve this is to attach biomolecules normally found in the body, such as enzymes, to an implant. To do this, Lahann and his colleagues create coatings that bind biomolecules.

The researchers begin by attaching a chemical group to a monomer, the individual unit of a polymer chain. They choose this anchoring group depending on what sort of molecule—sugar, alcohol, or protein, for example—they want to bind to the coating. After being converted into a gas, the monomers settle on a surface and link into a polymer. These polymers can coat materials from stainless steel to plastic and can effectively cover objects with complex geometries, Lahann says.



X MARKS THE RUST — The painted metal strip at left shows rust in an X-shaped scratch and elsewhere after sitting in salt water for 120 hours. In the strip at right, a prepolymer and catalyst in the coating have reacted to protect the metal.

In the final step, a researcher immerses the polymer-covered object in a solution of the chosen biomolecule, which then binds to the anchor group.

The team has recently increased the selectivity of the anchor groups, which enables the researchers to control the ratios of biomolecules that attach to the surface. They described this step toward making coatings with a modular design in the June 15, 2006 *Advanced Materials*.

Among the implants that Lahann and his colleagues have targeted are stents, the metal scaffolds used to prop open blocked arteries. Some coated stents release drugs to prevent cell growth in the vessel. Although drug-releasing stents have been popular since their approval by the Food and Drug Administration in 2003, they have since been linked to an increased risk of blood clots and heart attack.

For the new stent project, Lahann has teamed up with Mark E. Meyerhoff, a chemist at the University of Michigan. Meyerhoff's group developed a system that makes molecules naturally found in the blood generate nitric oxide, the same chemical that the cells lining blood vessels normally release to prevent clotting. A copper catalyst jump-starts the reaction.

To devise a clot-stopping stent coating, the researchers anchored the copper catalyst to certain areas of the coating. In their initial tests in vials of blood, Meyerhoff and Lahann found that the coating generates nitric oxide concentrations comparable to those that a layer of healthy vessel-lining cells makes.

"This is nature's solution to the clotting, and we try to mimic that," says Lahann. The team has begun testing coated stents in pigs.

CARING COATINGS Bridges and ships could also use a coating upgrade. Braun says that the U.S. Navy treats the majority of its ships for corrosion every 3 to 5 years. Extending this protection would reduce the cost significantly, he says.

Dmitry G. Shchukin of the Max Planck Institute in Potsdam, Germany, and his coworkers have devised a gel coating that halts corrosion soon after it starts. Within the gel are 70-nanometer-diameter particles of silica, each covered with polymer layers containing reservoirs of benzotriazole, a chemical that inhibits corrosion.

Corrosion begins whenever a scratch to the covering exposes the underlying metal to oxygen and water. However, this changes the acidity of the damaged spot, triggering the release of benzotriazole. Within about 24 hours, the chemical inhibitor coats the damaged area and hinders the corrosion process, Shchukin says. The team described the coating in the July 1, 2006 *Advanced Materials*.

Braun's group, by contrast, has developed a thin-film polymer that heals scratches before corrosion has a chance to start. The coating is related to a self-healing composite material devised by Braun's colleague Scott R. White of the University of Illinois (*SN: 2/17/01, p. 101*).

The coating includes two self-healing components: an encapsulated catalyst and droplets of polymer ingredients. The researchers mix this liquid pre-polymer and the capsules containing the tin-based catalyst into the coating before it cures, says Braun.

A scratch to the coating—minor or deep—cracks open some of the capsules holding the catalyst, which then flows into the scratch. Some liquid prepolymer also seeps in. The catalyst reacts with the liquid and forms a solid that repairs the damage, preempting any corrosion.

At the 2006 Materials Research Society Fall Meeting in Boston last November, Braun's group presented the results of corrosion tests on steel strips coated with films containing both the catalyst and the prepolymer or one without the other. Scratches to the single-component films became rusty after immersion in salt water for 120 hours. But the dual-component film kept its metal rust-free under the same conditions.

FUTURE FILMS As coating research progresses, more items that might benefit from an extra skin become apparent. Lahann foresees prosthetic body parts with coatings that perform just as well as natural surfaces in the body. For example, integrating an artificial foot would require the prosthesis to mesh with many surfaces—bone, skin, muscle, and so on.

"I think multifunctional [coating] materials will really be critical in that respect," says Lahann.

Braun envisions a variety of complex coatings still to come: clear coverings that would enable a car windshield or a laptop screen to self-repair scratches; self-healing coatings for hip replacements and other implants; and even systems that could repeatedly heal damage to the same spot, perhaps by incorporating a network of plumbing that could replenish healing components.

"Every one of those that I mentioned I think is possible," says Braun. The trick, he says, "will just be coming up with the right combination of materials science and chemistry." ■

BRAUN

OF NOTE

BEHAVIOR

Child abuse heralds adult inflammation

New findings from a long-term investigation indicate that child abuse leads to a potentially dangerous disruption of the body's stress response in adulthood. Previously abused individuals display elevated blood concentrations of inflammatory substances that fight infections and repair damaged tissue, say psychologist Andrea Danese of King's College London and her colleagues.

Prior research has linked persistent inflammation to heart disease, diabetes, and chronic lung disease.

Danese's group analyzed data on 866 people born in Dunedin, New Zealand, between April 1972 and March 1973. Volunteers underwent medical and psychological tests at regular intervals from ages 3 to 32.

Home observations and reports from parents and children established that 83 participants had experienced abuse or serious traumas by age 11. These incidents included maternal rejection, physical abuse, sexual abuse, and two or more changes in a child's primary caregiver.

At age 32, previously abused individuals exhibited markedly higher concentrations of two inflammatory substances—C-reactive protein and fibrinogen—than their unabused peers did, the researchers report in the Jan. 23 *Proceedings of the National Academy of Sciences*. Abused volunteers' blood also carried elevated numbers of infection-fighting white blood cells.

Especially high concentrations of inflammatory substances appeared in participants who had suffered severe abuse as children, the investigators say. The findings held true when the scientists accounted for other inflammation-boosting factors, including low birth weight and use of alcohol and cigarettes. —B.B.

CHEMISTRY

Magnet makeover

A new family of magnets may be a first step toward organic versions of the familiar metal objects, researchers say.

Fabricating metal magnets requires high temperatures, notes Robin G. Hicks, a chemist at the University of Victoria in British Columbia. With organic substitutes, it may be possible to mix up magnets in a room-temperature solution and easily mold them into films or other shapes that could find new uses, he says.

Hicks and his colleagues describe in the Jan. 18 *Nature* three metal-organic magnets. To create them, the researchers mixed a nickel-containing chemical into solutions of organic compounds. They then stirred each mixture for several hours at room temperature, exposing the mixtures to air only during the last half of the process.

After this two-stage chemical reaction, the researchers filtered out dark, powdery solids combining the organic materials with nickel and oxygen.

STICK TO IT A researcher holds a conventional magnet that attracts the dark powder, a new metal-organic magnet, in the vial.

Team members held magnets to the sides of the flasks as a first test of success or failure. "It's easy to tell if you've made a magnet," says Hicks.

Further tests revealed that the organic substances remained magnetic at temperatures up to 200°C and suggested that they could be easily demagnetized, a valuable trait in some applications. The researchers are now determining the chemical structure of the molecules that they created.

This first group of organic magnets is not moldable, but the team expects that trait to be attainable. "Using organic chemistry to control the structure of the organic molecules in turn provides a handle for controlling the structure and the properties of the magnet you make," Hicks says. —A.C.

BIOMEDICINE

Trade-offs in fibroids treatments

A minimally invasive procedure to cure uterine fibroids was less expensive, but also less effective, than surgery in a new study.

Uterine fibroids are benign tumors that can cause pain and heavy bleeding.

Hysterectomy is the only sure cure for fibroids, but that procedure ends a woman's reproductive capacity. Alternatively, doctors can surgically remove only the fibroids. In a third, newer approach, called uterine-artery embolization, a doctor shrinks the fibroids by inserting barriers within small arteries that supply the fibroids with blood.

Researchers identified 157 women with fibroids embedded in the uterine wall and randomly assigned 106 to get embolization, 43 to get hysterectomies, and 8 to undergo surgical removal of fibroids.

The patients getting either type of surgery averaged 5 days of hospitalization, whereas embolization patients were in the hospital just a single day. Rates of complication were similar for the procedures.

But 10 of the women getting embolization required a further procedure—either surgery or another embolization—when fibroids recurred during the first year. One surgical patient, who underwent fibroid-only removal, subsequently needed a hysterectomy.

One year after any of the initial procedures, measurements of a woman's quality-of-life were about the same for the three groups, report Jonathan G. Moss of Gartnavel Hospital in Glasgow, Scotland, and his colleagues in the Jan. 25 *New England Journal of Medicine*. —N.S.

BIOMEDICINE

Old cure may offer new malaria option

An herbal-tea remedy for malaria contains a component that may form the basis of a novel drug against the disease, tests in mice show. The compound, called tazopsine, is derived from the bark of a tree (*Strychnopsis thouarsii*) found in Madagascar's eastern rain forest.

In lab dishes, tazopsine killed the two common malaria parasites *Plasmodium falciparum* and *Plasmodium yoelii*. Tests in mice newly infected with *P. yoelii* showed that tazopsine given orally protected 70 percent of the animals, the researchers report in the December 2006 *PLoS Medicine*.

But tazopsine proved toxic at high doses, limiting the amount that could be given. To get around that, the researchers broke down tazopsine into seven constituent parts. They found that one, dubbed NCP-tazopsine, killed the parasite as well as the whole compound did.

When the scientists gave a quadrupled dose of NCP-tazopsine to mice heavily infected with *P. yoelii*, the chemical caused no side effects and killed all the parasites before they could pass through the animals' livers and infect their bloodstreams.

R. JAIN AND K. KABIR/UNIV. VICTORIA

OF NOTE

Although it remains unclear how NCP-tazopsine works, the findings suggest that it might prevent malaria from causing illness in newly infected people, such as travelers, soldiers, or others passing through malarial zones, the researchers say.

But before it's given to people, NCP-tazopsine must pass tests in chimpanzees against *P. falciparum*, the parasite strain that causes the most-severe malaria. The researchers also are planning tests of whether the compound eradicates parasites lying dormant in monkeys' livers, says study coauthor Dominique Mazier, a parasitologist at Pierre and Marie Curie University in Paris. —N.S

ENERGY

Gas tanks could guzzle half of U.S. corn yields

In his Jan. 23 State of the Union Address, President Bush called for ramping up production of biofuels, such as ethanol from corn, to help cut U.S. dependency on foreign oil. A new report describes an ethanol-industry expansion already under way that is poised to boost corn-ethanol production by 160 percent within 2 years.

However, such an increase may carry a high cost, says the report's author, agricultural economist Lester Brown of the Earth Policy Institute in Washington, D.C.

The 116 existing U.S. ethanol-fuel distilleries now use 53 million tons of corn. The 90 distilleries under or planned for construction would boost that demand to 139 million metric tons of corn, half of the projected 2008 U.S. harvest.

U.S. farmers produce 40 percent of the world's corn and export 55 million tons. Brown argues that any change in the crop's availability for food and feed will propel world grain prices—including those of wheat and rice—"to levels never seen before." He explains, "These three crops compete for much of the same land." —J.R.

MATERIALS SCIENCE

Microstructures make a beetle brilliant

Engineers looking to make a variety of surfaces whiter and brighter could learn a few things from a lowly beetle, a new study suggests.

The tiny scales that cover several beetles in the *Cyphochilus* genus of southeastern Asia are much whiter than natural substances such as milk and tooth enamel and are almost as bright as a sheet of paper, says Pete Vukusic, a physicist at Exeter University in England.

Microscopic analyses of white *Cyphochilus* scales show that their brilliance isn't a result of any pigment. Indeed, the scales are made of a translucent material called chitin. The whiteness of the 5-micrometer-thick scales stems from their internal microstructure—a loosely packed, chaotic network of chitin filaments. The random orientation and spacing of the 250-nanometer-diameter fibers causes the scales to reflect all visible wavelengths equally, making them appear white.

LOVELY The white scales that cover some *Cyphochilus* beetles owe their brilliance to an internal network of tiny, randomly oriented fibers.

VUKUSIC/UNIV. EXETER

Manufactured materials that duplicate the microstructures in *Cyphochilus* scales could have a variety of uses, Vukusic and his colleagues suggest in the Jan. 19 *Science*. Such substances might replace some or all of the tons of minerals used each year to brighten the surface of paper, or they could be incorporated into tooth-whitening veneers. Also, engineers could use the material to line the inside of light fixtures, making them more energy-efficient. —S.P.

PHYSICS

The mystery of the missing mass

Particles inside a nucleus weigh slightly less than the same particles in free space, new research shows. The experiment is a step toward understanding what determines the masses of particles.

Most of these particles' masses come not from the quarks of which they're made, but from the strong forces that hold those quarks together. Within a nucleus, a particle's internal forces are weakened by interference from forces exerted by its neighbors, so the particle has been expected to have slightly less mass there.

Attempts to measure this difference have yielded ambiguous results. But the new research, performed by Hideto En'yo and his colleagues at the KEK accelerator in Tsukuba, Japan, detected the mass lost within a nucleus by the phi meson, which consists of two tightly bound quarks.

En'yo and his colleagues measured the particles' masses by firing protons at targets of either carbon or copper, creating showers of particles that included phi mesons. The particles decayed quickly, and by carefully measuring the energies of decay products, the scientists calculated the phi mesons' masses. Those that decayed inside a nucleus had 3.4 percent less mass than phi mesons decaying outside, the team reports in the Jan. 26 *Physical Review Letters*.

If experiments confirm mass loss for all nuclear particles, "it's a paradigm shift in the way you view nuclear structure," comments Anthony Thomas, a nuclear theorist at the Thomas Jefferson National Accelerator Facility in Newport News, Va. In a sense, the nucleus would no longer be made of protons and neutrons, but rather variants of these particles whose masses have been altered, he says. —P.B.

GENETICS

Plastics ingredient disrupts fetal-egg development

A common estrogen-mimicking chemical can damage eggs while an animal is still in the womb, researchers report.

Bisphenol A is found in polycarbonate plastics—those used to make baby bottles and hard-shell water bottles—and in the lining of food cans. The chemical also turns up in human tissues at concentrations of several parts per billion.

Earlier research had linked bisphenol A to reproductive problems in male and female mice. In 2003, molecular geneticist Patricia A. Hunt of Washington State University in Pullman and her colleagues exposed female mice to doses of the chemical typical of environmental concentrations. This increased the likelihood that eggs would have abnormal numbers of chromosomes (*SN: 4/5/03, p. 213*).

But "the process of making an egg is incredibly long," notes Hunt. Egg development begins in the female fetus, stops before birth, and then resumes just before ovulation. To look for effects of exposure during the earlier developmental phase, Hunt's team implanted bisphenol A pellets in pregnant mice. The pellets released the same dose used in the group's earlier experiment.

The researchers compared eggs from the female offspring of these pregnant mice with eggs from mice whose mothers had carried a placebo pellet. Up to 40 percent of the eggs from females exposed to bisphenol A as fetuses had abnormal numbers of chromosomes, the group reports in the January *PLoS Genetics*. Only about 3 percent of the placebo group showed that abnormality.

"The mother's exposure is influencing the genetic quality of her grandchildren," says Hunt. —A.C.

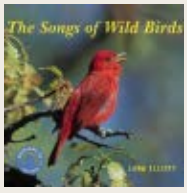
Books

A selection of new and notable books of scientific interest

THE SONGS OF WILD BIRDS

LANG ELLIOTT

Birds communicate with other members of their species through a wide array of sounds made both by singing and by using their feathers and other body parts to flutter, tap, and scrape out their messages. In this combination book and compact disc, Elliott, a nature-sound expert, introduces readers to the songs and other sounds of 50 birds that are native to the United States.

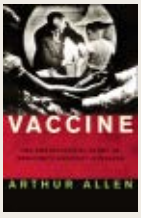


The book comprises short, detailed essays that describe Elliott's experiences in the field while collecting recordings from such birds as the great horned owl, mourning dove, green warbler, and, perhaps, the ivory-billed woodpecker. Each essay is accompanied by full-color images of the featured bird and graphical representations of its sounds. The 65-minute compact disc includes samples of each call and the author's narration. ***Houghton Mifflin, 2006, 128 p., color images, paperback, $19.95.***

VACCINE: The Controversial Story of Medicine's Greatest Lifesaver

ARTHUR ALLEN

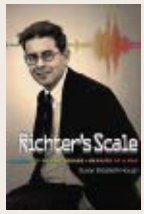
Although vaccines have saved many thousands of lives, their history is fraught with controversy. Allen, a journalist, tells the story from the turn of the 20th century and the development of the smallpox vaccine. He describes the wartime governmental campaigns to protect children against the ravages of typhoid fever, diphtheria, and yellow fever and explains the legendary rivalry between Jonas Salk and Albert Sabin and their respective polio vaccines. Allen documents the trial-and-error effort that created the MMR—for measles, mumps, rubella—vaccine during the mid 20th century. Allen also looks at the politics surrounding vaccination programs, such as the rising costs of vaccines, the resurgence of childhood diseases such as measles, the potential link between vaccines and autism, and the reluctance of some parents to have their children vaccinated. The author accuses the Bush administration of hyping the potential of smallpox as a terrorist weapon. ***Norton, 2007, 523 p., b&w plates, hardcover, $27.95.***



RICHTER'S SCALE: Measure of an Earthquake, Measure of a Man

SUSAN ELIZABETH HOUGH

It's probably safe to say that only one seismologist is a household name. Charles Richter developed the now-standard system of measuring the strength of an earthquake. However, the man himself has been an enigma. Hough draws on a wealth of documents left behind by Richter at the California Institute of Technology, where he spent his professional career, to chronicle his rise to fame and explain his place in the history of seismology. Richter was an intensely private person who originally was more interested in astronomy and physics than in seismology. But once he was recruited to join a seismological laboratory in Southern California, he became fascinated with earthquakes. Hough details how Richter and his colleague Beno Gutenberg developed methods for locating earthquakes and assessing their magnitude. The author describes Richter's tumultuous upbringing, his penchant for nudism, and his prolific writing of poems—many included in the book. ***Princeton, 2007, 335 p., b&w photos, hardcover, $27.95.***



OPPENHEIMER: The Tragic Intellect

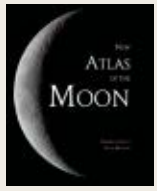
CHARLES THORPE

Because he directed the U.S. effort to develop the atomic bomb, physicist J. Robert Oppenheimer at the height of World War II became a new kind of icon among select scientists. Perhaps never before in history had a scientist held so much power. Oppenheimer's development and oversight of the Los Alamos National Laboratory changed the dynamics of physics research and scientific ethics. Thorpe paints an illuminating picture of this charismatic teacher and researcher and documents his downfall in the aftermath of his work at Los Alamos. Thorpe notes that Oppenheimer's and his fellow scientists' concerns about the morality of developing the bomb were eclipsed by their focus on technical issues. Later, Oppenheimer became a staunch critic of the continuing development of nuclear weapons and thus made himself a target of government scrutiny. The FBI eventually accused him of being an enemy agent. ***Univ. Chicago Press, 2006, 413 p., b&w photos, hardcover, $37.50.***

NEW ATLAS OF THE MOON

THIERRY LEGAULT AND SERGE BRUNIER

The moon, Earth's lone natural satellite, is at once familiar and alien. Astronaut Buzz Aldrin described its surface as "magnificent desolation." This oversized atlas reveals the intricate and interesting features of the moon that may go unnoticed by the casual Earth-based observer. Part one features large photographs and detailed descriptions of the moon's day-by-day phase changes. Each description details the moon's position in the sky and the major topological features that are revealed as the phases change. Transparent overlays provide markers for these features on the moon's surface. Each daily description is accompanied by a sidebar with abundant facts about the moon, including why it appears white when full, the history behind lunar nomenclature, and details of the U.S. and Russian exploratory missions. Part two of the atlas is a guide to lunar cartography and provides in-depth descriptions of lunar features and the best times to observe them. The atlas ends with a section describing lunar events, including eclipses, and a practical guide to telescopes and binoculars for observing the moon. ***Firefly, 2006, 128 p., b&w and color images, $55.00.***



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LETTERS

All together now

It is not only the scientific literature that documents the unexpected "doughnut" pattern in swarms ("The Mind of the Swarm," *SN: 11/25/06, p. 347*). Italo Calvino's fictional Mr. Palomar observed (rather more lyrically) about the flocking of Roman starlings, "Finally a form emerges from the confused flutter of wings, advances, condenses: it is a circular shape, like a sphere, a bubble, the balloon-speech of someone who is thinking of a sky full of birds ... " (*Mr. Palomar*, 1985, Harcourt Brace).

J. POUND, WORCESTER, MASS.

The article argues that reaching a consensus for movement is more complicated in humans than in animals, requiring "fancy cognitive skills." However, in an airport or on a busy sidewalk, simple rules linked to crowd density and speed of walking may emerge to influence behavior in a rather mindless way.

TIM SCHALLERT, AUSTIN, TEXAS

Since it is a hallmark of most humans not to stick out from their crowd, a surprisingly large number of behaviors and thought processes in people are defined no differently than they are in the fish school. This includes religion, music and movie taste, fashion, and choosing to love or hate some group or individual.

BARRY P. SKEIST, WAVERLY, N.Y.

Inside story

Your article "Cancer Link: Gene regulates progesterone effect on breast cells" (*SN: 12/2/06, p. 355*) made a common mistake in characterizing the mechanism of steroid-hormone receptors. These receptors are not "proteins on the cell surface" but rather, and uniquely, positioned intracellularly. Steroid hormones pass directly from the bloodstream to the cytoplasm, where they induce changes in the receptor proteins, enable movement into the nucleus, and activate specific genes.

MAC BLACK, SEATTLE, WASH.

Big is bountiful

Regarding "Stone Age Role Revolution: Modern humans may have divided labor to conquer" (*SN: 12/2/06, p. 358*), economists would suggest that population growth allowed the division of labor. Notice that the most advanced economies are those with the largest populations, allowing for specialization in production. As Adam Smith wrote in 1776, "The division of labor is determined by the extent of the market."

JIM KLEIN, SAN FRANCISCO, CALIF.

Science Mall shopping

www. sciencemall-usa.com

EMR Chart

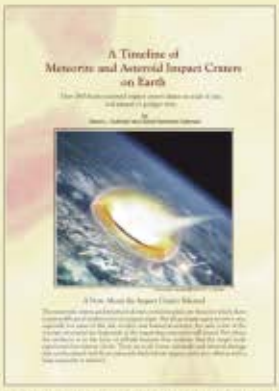
This chart includes all known ranges of EMR including: gamma rays, X-rays, ultraviolet light, visible light, infrared, microwaves, radio waves (ULF, VLF, LF, MF, HF, long, short, HAM, VHF, UHF, SHF, EHF), cosmic microwave background radiation and brain waves, all organized by octaves. The audio frequency spectrum is also included. Descriptions are included for all ranges and properties of EMR, including reflection, refraction, LASER, television, gravity waves, emission and absorption. There is also a chart of SI unit prefixes ranging from yocto to yotta. All items are placed on the graph using custom programmed formulas. Great chart on a difficult subject! Size: 24" X 36," Laminated Order #EMR - 1020, Cost $19.95

FREE Human Genome Poster with every order over $45

A Free Ancient Universe Guide with every order over $130

The Grand Tour of the Periodic Table in Minerals Collection

The Grand Tour of the Periodic Table (in minerals collection) - Ideal for use in chemistry, physics and the earth sciences. The 350 page in-color teacher's guide covers topics such as cosmic abundance in earth and sky, history of discovery, commercial uses, and more. The 60 specimens contain the element highlighted. High quality pieces and the huge in-color Teacher's edition makes the periodic table not only interesting but fascinating. Order #JPT-3057; Cost: $720



Timeline of Meteorite/ Asteroid Impact Craters on Earth - Asteroid/meteorite/ cometary impacts have occurred throughout Earth's history. Some of them seem to have been large enough to cause environmental changes and extinctions. This laminated, double-folded, 10 1/2" X 22" timeline features 6 panels of information, charting these important events. Over 160 craters have been verified, with all of them plotted to scale in size and placed upon a geologic timeline. Along with craters, geologic ages are shown, and known major extinctions are correlated. Attractive and easy-to-use. ***Order #JPT-7890, Cost: $16.95, 2 for $30 (#JPT-7890-2)***

The Age of the Earth - Specimen Display Set

The Age of the Earth - Specimen Display Set - Information on the display talks about the age of certain rocks and minerals and how they relate to the age of the Earth and our solar system. Physical samples shown are: chondrite meteorite, Allende meteorite, Barberton Greenstone, and Acasta gneiss. A Jack Hills zircon is pictured, and the product comes with information. This unusual product will be available *only as long as supply lasts.* A superb addition to any earth science class, or for the avid earth science enthusiast. Plastic display case size with matching hinged see-through lid is 7 1/2" L X 5" W X 1/2" D. ***Order #JPT-48401, Cost: $68***

Periodic Table in Earth & Sky

Finally! A colorful poster presentation of the elements in our Universe. Featuring 117 razor-sharp color photos and graphics, this tour-de-force of the elements shows samples of minerals and crystals containing the element in question. Printed on heavyweight stock paper. Comes with an in-color 11" X 17" information sheet, and 8 1/2" insert for teaching with study questions. Laminated. 38.5"W x 27"H Order #*JPT-7200 $28.95; or #JPT-7225, 2 for $50.*

Rocks, Minerals and Gems of the World Collection - New! - This collection comes in an attractive walnut display case that contains 102 samples. It comes with 11 pages of information which discusses which of 3 rock groups the sample is from. Two Keys for locking the case is provided. It is ready for wall hanging and is the perfect collection for anyone who loves earth science. Walnut case comes with a see-through quality protective glass. Contains: Kimberlite (diamond pipe), anorthosite (comprises lunar crust), 2 meteorites, manganese nodule from Pacific Ocean floor and much more! Order#JPT-78131, Cost: $275. *Designed by an earth scientist for the earth sciences.*

Vitamins Poster ***New!***

Vitamins poster - Covers all the major vitamins. Size: 26.75" X 38.5" Order #JPT-vita12, Cost: $15.95, Laminated; 2 for $30. ***Order #JPT-vita124***

Gibeon Meteorite Pendant - *Square* The Gibeon meteorite is an iron meteorite from Africa. Each has a pattern that is different, but similar. Comes with a sterling silver 20" chain, information and authenticity. Pendant size: 18mm X 12mm X 7mm Comes in an attractive black velvet jewelry case with info. Order#JPT-gibeon142, Cost: $65

Gibeon Meteorite Pendant - *Triangle* - The Gibeon meteorite is an iron meteorite from Africa. Each has a pattern that is different, but similar. Comes with a sterling silver 20" chain, information and authenticity. Pendant size: 18mm X 14mm X 8mm Comes in an attractive black velvet jewelry case with info. Order#JPT-gibeon142, Cost: $55

Jewelry with a Story

Exceptional Pallasite Meteorite Pendant - 14K Gold **(left)** - Pallasites are the most beautiful form of meteorite jewelry. They contain yellow to green olivine crystals mixed in an iron matrix. Pendant size: 1 1/8" set in an outstanding, intricate 14k gold filigree style pendant. Comes with information, gold chain and authenticity. All look similar and are of excellent quality. Order#JPT-00223, Cost: $650

Allende Diamond Meteorite Jewelry **Pendant (right)** - Scientists think that the composition of the Allende meteorite contains the first matter to have crystallized (called CAI's) when our solar system was first formed. Pendant size: 3/4" across. Contains six real diamonds, one each in the star at the top of the pendant and one in the moon. The pendant depicts the Sun, Moon, and Stars. Comes with authenticity in a black velvet jewelry box. Order #JPT-4317, Cost: $425

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