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SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

universal baby pictures
connect the quantum dots
e. coli as cancer fighter?
boobies behaving badly

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wing tales

DECODING BUTTERFLY SPOTS

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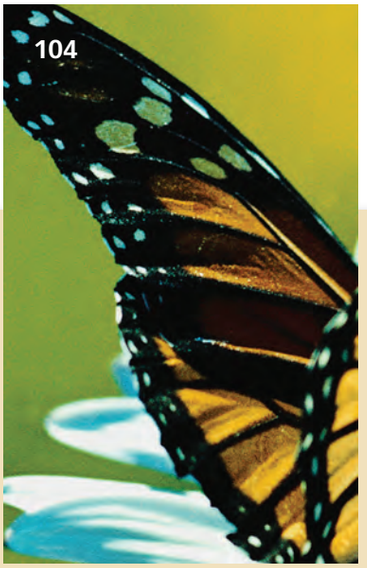

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Cover Biologists have been saying that the tale of evolution is written on the wings of butterflies. At last, scientists studying these insects across a wide range of disciplines are beginning to decode it. Page 104

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Don't drink alone Drinking alcohol outside of meals increases the risk of certain cancers. See Janet Raloff's Food for Thought.

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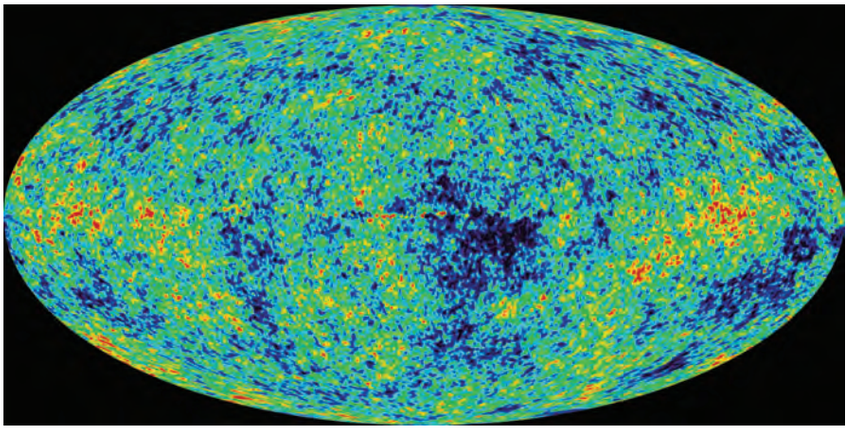
Cosmic Revelations

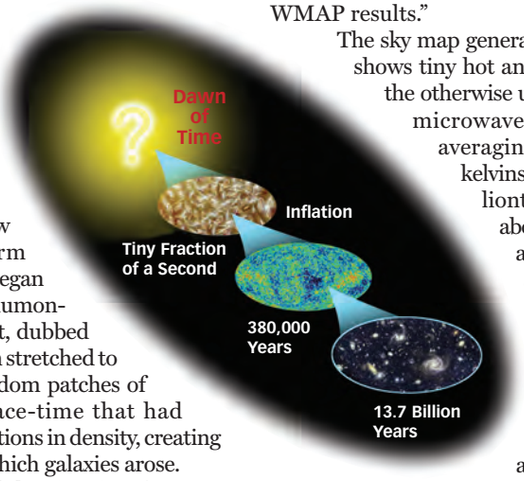
Satellite homes in on the infant universe



HOT AND COLD Hot (red) and cold (blue) spots in the cosmic microwave background, as seen by the WMAP satellite. This is the sharpest portrait of the universe ever made.

Like beaming parents showing off pictures of their newborn, astronomers this week proudly unveiled the sharpest snapshot of the baby universe ever taken. The scientists had a lot to smile about.

Their infant portrait, revealed by the remnant glow from the Big Bang, pegs the universe's age to an unprecedented accuracy of 1 percent. Rather than using more approximate numbers, astronomers can now say the universe is 13.7 billion years old, the researchers report. The new data also confirm that the universe began with a brief but humongous growth spurt, dubbed inflation. Inflation stretched to cosmic scales random patches of the fabric of space-time that had minuscule fluctuations in density, creating the lumps from which galaxies arose.



COSMIC JOURNEY **Lumps in the otherwise smooth infant universe were amplified during a growth spurt known as inflation. The cosmic microwave background, which carries information about these lumps, first streamed into space 380,000 years after the Big Bang. These lumps became the seeds from which galaxies grew.**

The images of the Big Bang's afterglow, known as the cosmic microwave background, also delineate the cosmos' composition: 4 percent is ordinary matter; 23 percent is invisible stuff called cold dark matter, which prompted the galaxies to coalesce; and 73 percent is so-called dark energy, which has accelerated the rate at which the universe expands (*SN: 5/25/02, p. 333*).

What's more, the data recorded by the Wilkinson Microwave Anisotropy Probe (WMAP), a NASA satellite, reveal that the universe had already made an abundance of stars when it was only 200 million years old. That's about one-fifth the age that many cosmologists had predicted.

NASA; NASA

At a NASA press briefing on Feb. 11, Charles L. Bennett of NASA's Goddard Space Flight Center in Greenbelt, Md., and David N. Spergel of Princeton University presented the snapshot from WMAP, launched in June 2001.

"For cosmology, this announcement represents a rite of passage from philosophical uncertainty to precision science," comments John N. Bahcall of the Institute for Advanced Study in Princeton, N.J. "Every astronomer will remember where he or she was when they first heard the WMAP results."

The sky map generated by WMAP shows tiny hot and cold spots in the otherwise uniform cosmic microwave background averaging a frigid 2.73 kelvins. Just a few millionths of a degree above or below the average, the hot and cold spots reveal the earliest phases of clumping of photons and matter. Viewing the fluctuations with 45 times the sensitivity and 33 times the spatial resolution of its predecessor, the Cosmic Background Explorer satellite, WMAP has nailed down several key cosmological parameters.

WMAP measured the age of the universe by detecting the size of the hot and cold spots as seen from Earth. The older the universe, the smaller these spots would appear.

By measuring the peaks in temperature fluctuations on different spatial scales, WMAP has essentially measured the contents of the universe. Although the microwave background was generated during the Big Bang, telescopes see the radiation as it appeared when it first streamed freely into space a few hundred thousand years later. Before that, the universe was so hot that there were no neutral atoms, only ions and electrons that trapped the cosmic microwave background radiation.

Imprinted on that radiation are acoustic oscillations, generated by the primal tug-of-war between the gravitational pull of matter and the outward pressure exerted by photons while they were still trapped. These oscillations created regions of slightly higher or lower pressure, generating places that were slightly hotter or colder than average.

The satellite has also measured the polarization of the cosmic microwave background. This measurement of the tendency for light waves to vibrate in a particular direction is a major technical feat—the polarization signal is one-hundredth the strength of the tiny temperature fluctuations.

Photons become polarized when they scatter off free electrons. That's why polarization dates two important epochs of the universe. The first is the time—380,000 years after the Big Bang—when the last free electrons became bound to atomic nuclei, permitting radiation to stream into space.

The second epoch marks the time when stars first lit up the universe and reionized atoms into nuclei and free electrons. From the polarization measurements, Spergel's team deduced that the cosmos became a star-making factory only 200 million years after its birth.

Where there were hordes of stars, there were probably also quasars and galaxies. Yet the most distant known galaxies and quasars date to when the universe was 800 million years old. "We're saying there's a lot of objects farther out that we haven't seen," says Spergel.

Still, he notes, the most profound result is that "everything fits" with the current

cosmological model. "For the first time, we are making measurements with such precision that we have a standard model for the evolution of the universe, in the same way that particle physicists have a standard model" of the subatomic world, says Spergel. —R. COWEN

Dirty Story

Farming has increased flow of soil onto reef

Ever since European settlers brought agriculture to Australia, soil has been deposited on the Great Barrier Reef at an accelerated pace, according to new research. The study suggests that the introduction of farming near coastlines can have rapid and continuing consequences offshore.

Eroded sediments that wash down rivers and out to sea can block out sunlight, interfere with corals' feeding, and introduce pathogens to reef communities (*SN: 1/30/99, p. 72*). To understand how such processes have affected the Great Barrier Reef, Malcolm McCulloch of Australian National University in Canberra and his colleagues drilled cores of coral about 150 kilometers from the mouth of the Burdekin River in Queensland, Australia. Today, periodic floods spew plumes of sediment onto this portion of the reef.

The cores, at up to 5.3 meters long, record reef growth from about 1750 to 1998, say the researchers. They attempted to gauge sediment deposits over that period by measuring core-layer fluctuations in the ratio of barium to calcium. Growing corals incorporate these metals in proportion to their presence in the surrounding water. The barium-calcium ratio is normally low in seawater and therefore in coral, but it rises when erosion sweeps barium-rich terrestrial soils into the ocean.

The researchers compared the barium-calcium ratios in the coral with detailed logs of the Burdekin River's flow since 1921. Each flood during that period temporarily boosted the barium-calcium ratio in proportion to the increase in the river's flow, the scientists report. The team concludes that the barium-calcium ratio accurately reflects the amount of sedimentation.

Looking back farther into the coral record, McCulloch and his colleagues found that the barium-calcium ratio in the reef rose by about one-third soon after European colonists settled in the river basin in 1862. Moreover, seasonal flooding of the river after farming began caused exaggerated spikes in sediment flow onto the reef.

SUBTLE SOILING Land-use changes in Australia have spilled sediments onto the Great Barrier Reef.

Within 1 to 2 decades after the arrival of European settlers in northern Queensland, there were already "massive impacts" on the waters of the inner reef, the team says in the Feb. 13 *Nature*.

The researchers "have cleverly developed a history of sedimentation on [the reef] by quizzing the corals themselves," says Julia Cole of the University of Arizona in Tucson in a commentary accompanying the new study. They've also shown that sedimentation increased dramatically after European settlement, she says.

Research in the western Indian Ocean suggests that reefs there were similarly affected by the advent of European-style agriculture in Kenya in the early 20th century, Cole adds. —B. HARDER

Montezuma's Welcome Revenge?

Bacterial toxin may fend off colon cancer

Some microbes that cause diarrhea may have important beneficial consequences. Researchers have found that the illness-inducing toxin from some strains of the common gut bacterium, *Escherichia coli*, stifles the growth of cancerous intestinal cells. This discovery may help explain why colon cancer strikes people less often in regions of the world where disease-causing *E. coli* infections are more common. The finding also suggests promising new directions for treating the cancer.

Each year, about 150,000 people are diagnosed with colon cancer in the United States alone. Although the disease is the fourth-leading cause of cancer-related mortality worldwide, few people living in developing nations contract the illness. That led clinical pharmacologists Giovanni M. Pitari and Scott A. Waldman of Thomas Jefferson University in Philadelphia to suspect environmental factors.

Infectious strains of *E. coli* lurk in the water and food in many developing regions in Africa, South America, and elsewhere. The bacteria-produced enterotoxin interacts with intestinal cells to spur diarrhea. Pitari and Waldman wondered whether enterotoxin might also stunt the proliferation of cells in the intestine, thereby protecting against cancer there.

To find out, the researchers provided a synthetic version of enterotoxin to human colon cancer cells growing in lab dishes. In a forthcoming *Proceedings of the National Academy of Sciences*, they report that this treatment halved the rate of cell proliferation.

In their experiments, Pitari and Waldman also observed that the toxin's stifling of cell division depends on a cascade of molecular events culminating with an influx of calcium into the cells. That result jibes with research suggesting that dietary calcium can thwart colon cancer. The team is now planning animal studies to test the toxin's cancer-fighting potential.

If those experiments pan out, the toxin could become the basis of new treatments for colon cancer, the researchers say. Enterotoxin's penchant for intestinal cells indicates that as a drug, it would focus on just those cells and leave others alone. If injected into the blood, it might even specifically combat colon cancer cells that had migrated to other parts of the body, thereby derailing metastasis, a serious problem in this cancer. Pitari and Waldman predict that such a drug would have few, if any, side effects except for diarrhea.

"That's not a bad tradeoff," remarks infectious disease expert Stephen L. Carrithers of the University of Kentucky Markey Cancer Center in Lexington. Molecular biologist Ferid Murad of the University of Texas at Houston says the finding will spark "lots of ideas" for the treatment of colon cancer.

"What's really cool," adds oncologist Mark J. Ratain of the University of Chicago Hospital, is that the trail to enterotoxin's anticancer potential originated from the global pattern of the incidence of colon cancer, not from a detailed understanding of cancer biology. —K. MORGAN

Natural Healing

Nanothread mesh could lead to novel bandages

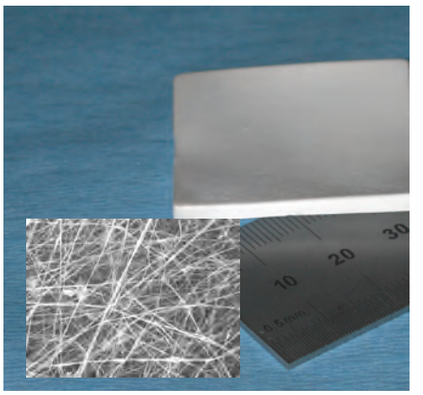
By recasting clot-promoting protein fibers found in blood into a fine meshwork, researchers have devised a wound covering that may speed healing and never need removing.

Gary L. Bowlin and his coworkers have produced mats of the protein, called fibrinogen, containing fibers just 80 nanometers thick. That's comparable in thickness to natural fibrinogen fibers in people's blood, says Bowlin, a biomedical engineer at Virginia Commonwealth University in Richmond.

Other researchers previously coated gauze bandages with fibrinogen or formed the protein into brittle, sponge-like materials (*SN: 6/19/99, p. 396*). In contrast, the new fibrinogen mats would become integral parts of a wound. Unlike standard gauze bandages, these strong, flexible mats actively promote blood clotting.

Bowlin and his coworkers created their mats from human or cow fibrinogen by modifying a process, called electrospinning, that's long been used in textile manufacturing. After dissolving the protein in a solution, the researchers applied an electric field that forced the fluid through a narrow nozzle toward a metal plate. While in the air, the fibrinogen threads dried and twisted, landing on their metal target like a delicate network of spaghetti. Increasing the protein concentration of the initial solution made the mats' threads thicker; decreasing the concentration made the threads thinner.

Bowlin and his collaborators describe the mat-making process and the mats' strength, flexibility, and nanoscopic structure in the Feb. 12 *Nano Letters*. Preliminary tests on rats have shown that the mats initiate clotting within seconds, says Bowlin.



BOWLIN/VCU

NO MORE OUCH **A fibrinogen bandage (white) is made of a network of threads just 80 nanometers thick (inset).**

The scientists now aim to determine the mats' optimal mesh characteristics for specific medical uses, Bowlin says. One type of mesh might be best to prevent soldiers from bleeding to death on the battlefield while awaiting transport. Another might be most useful for stopping minor bleeding during surgery. What's more, Bowlin suggests, fibrinogen mats might serve as scaffolds for tissue growth to treat damaged organs or replace lost body parts.

One concern with other fibrinogen wound-healing technologies is that one part of the multistep clotting process remains slow and incomplete, says biochemical engineer William Velander of Virginia Tech University in Blacksburg. Bowlin and his colleagues have yet to show they've overcome this obstacle, says Velander. However, because scientists suspect that greater surface area would boost the clotting process, the large surface area of the new mats "certainly is an encouraging first step in that direction," he says.

The fibrinogen mats' advantages and disadvantages in animals and people are still speculative, says chemist Glenn Prestwich of the University of Utah in Salt Lake City, but he finds the material "intriguing." If their large surface area can be combined with sufficient elasticity and strength, they could become highly attractive for treating wounds, he says. —J. GORMAN

Light Splash

Transparent pipes shape microstructures

A little high-tech plumbing and colored water may change how engineers make miniaturized fluid-carrying structures.

A team at the University of Washington in Seattle has added a new twist to the light-blocking patterns, or photomasks, used like stencils in microchip manufacturing. They've invented photomasks containing tiny, transparent pipes into which the engineers have injected dyes that dim the ultraviolet (UV) radiation passing through. Where less UV light penetrates the photomask, there's less breakdown of the photosensitive coatings, called photoresists, that cover chips during processing. The coating left behind forms a structure of varying heights that can serve as a mold.

With their additional control over UV exposure, the researchers have patterned polymeric materials with microscopic ramps, stairs, and other complex shapes. Such graded 3-D polymer structures may go into microfluidic devices—networks of microscopic pipes, pumps, and valves that can function, for instance, as teeny chemistry labs (*SN: 9/28/02, p. 198*).

Bioengineer Albert Folch says that these new masks, which are themselves microfluidic devices, could be used to create improved miniature fluid networks. Such devices would have channels of various depths and find uses including medical diagnostics, testing drugs in cells, and sensing biological agents.

Folch, Chihchen Chen, and Danny Hirdes describe their microfabrication method in the Feb. 18 *Proceedings of the National Academy of Sciences*.

Tiny 3-D structures are tough to construct with conventional photomasks, which generally yield flat components, notes Folch. Typical masks are made of metal patterns deposited on glass and have no internal plumbing. They project only all-or-nothing light patterns onto a photoresist, resulting in microstructures of uniform height. To make variable-height structures, engineers now use multiple exposures of multiple stencils, all of which must be in perfect register.

To develop an alternative approach, Folch and his colleagues laid down ridges of photoresist on a silicon wafer. They coated these ridges with the transparent polymer polydimethylsiloxane and permitted the material to cure. Then they peeled the polymer skin, now laced with channels, from the silicon to use as their adjustable photomask.

To then make molds for microfluidic devices with channels of varying depths, the team filled the new mask's channels with dye solutions of differing concentrations. Under intense light, the mask rendered ridges of photoresist in various heights on other wafers.

Engineers can quickly change the dye configuration in such a mask to make a different device, points out David Beebe of the University of Wisconsin–Madison. By adding this new technique to a growing toolkit, "we could now make almost any microscale structure as fast as you can [design] the mask on the computer," he says. —P. WEISS

Huntington's Advance

Drug limits disease effects in laboratory mice

A compound that inhibits enzymes that act as stop signs for genes counteracts the movement disorders brought on by Huntington's disease, a mouse study suggests.

In this hereditary disease, a genetic mutation results in oversized versions of the so-called huntingtin protein, portions of which stack up in the nuclei of brain cells. Patients develop impairments of thought, movement, and emotions for which there is no treatment or cure.

The mutant version of the huntingtin protein inhibits the action of indispensable enzymes, called acetyltransferases, in brain cells (*SN: 4/28/01, p. 271*). Responding to chemical signals, acetyltransferases normally work with other cellular chemicals to switch on genes as needed. Counterpart enzymes, called deacetyltransferases, reverse the process and shut off the genes once they've done their job.

As chunks of mutated huntingtin proteins aggregate in cell nuclei and bind to acetyltransferases, they jam the gene-regulatory system, says Joan S. Steffan of the University of California, Irvine. Whether this aggregation directly causes Huntington's disease or is part of a more complex process is an open question, she notes.

One potential approach to keeping Huntington's disease in check is to leave already-activated genes turned on longer by incapacitating the deacetyltransferases that put the brakes on them. Earlier work in fruit flies suggested that inhibitors of one such enzyme, called histone deacetyltransferase (HDAC), improved survival and lessened brain-cell loss (*SN: 11/24/01, p. 332*).

In the new study, Steffan and her U.S. and British colleagues added an HDAC inhibitor called suberoylanilide hydroxamic acid to the drinking water of young mice genetically engineered to make mutated huntingtin protein. These mice showed significantly less movement loss during the 8-week study than similar mice getting plain water did, the researchers report in the Feb. 18 *Proceedings of the National Academy of Sciences*.

James M. Olson of the Fred Hutchinson Cancer Research Center in Seattle says he has been surprised that an HDAC inhibitor could work without damaging cells. After all, he explains, the powerful chemical alters a fundamental gene activity.

Mark W. Becher of the University of New Mexico in Albuquerque rates the mice's retention of movement as encouraging. This result suggests that suberoylanilide hydroxamic acid is targeting a deficit in the brain-muscle connection, which ideally would translate into treatments that improve the quality of life for Huntington's patients, he says. The HDAC inhibitor might be paired with experimental treatments that reduce protein aggregation in cell nuclei, he says. —N. SEPPA

Sibling Desperado

Doomed booby chick turns relentlessly violent

The first known case among nonhuman vertebrates of so-called desperado aggression—relentless attacks against an overwhelming force—may come from the underling chick in nests of brown boobies.

An unusual experiment that tucked junior chicks into the nests of a related species let the youngsters live long enough to show their stuff, says Hugh Drummond of the Universidad Nacional Autónoma de México in Mexico City. These chicks ferociously attacked their older foster sibs, and almost half of the relocated chicks became "uncontrollably aggressive," Drummond and his colleagues report in an upcoming *Behavioral Ecology and Sociobiology*.

The work could bring more respect for the influence of the underdogs in driving the violence at the top of a hierarchy, Drummond predicts. "The message is that [at the top] you can't afford to be generous if the little guy is going to turn into a whirlwind of violence," he says.

The Pacific seabirds called brown boobies lay two eggs but hardly ever fledge more than one chick. In nests where both eggs hatch, the older one pecks and pushes the younger one and almost always eventually expels it from the nest. However compared with related species, brown booby adults aren't unusually aggressive.

Those younger chicks have been a challenge to study in the nest. "They tend to be either underneath the parent or they're being beaten up on by a sibling that's trying to kill them," says Drummond.

SIBLICIDE **The older, larger chick pushes its younger sibling toward the edge of a brown booby nest. Later, the older chick expelled the younger one, and the parents didn't rescue it.**

J.L. OSORNO

To observe the underchicks, he and his colleagues went to San Pedro Mártir in the Sea of Cortez, one of the rare places where brown boobies nest in sync with blue-footed boobies. In the latter species, the chicks work out a less-violent hierarchy and both often survive when food is adequate. Drummond's team observed nine brown booby underlings and nine blue-footed underlings that the researchers had transferred into foster nests. Each underling joined a blue-footed chick, approximately 5 days older, in the new nest.

As underlings to a blue-footed chick, five of the brown boobies delivered about the same number of pecks and shoves as the underling blue-footed sibs did. Four of the brown booby chicks, however, turned extraordinarily violent—making 100 to 700 attacks per hour on the resident chick, which was nearly twice their size. In one case, a youngster actually drove the older chick out of the nest. The researchers stopped the experiment after 18 days to save the blue-footed booby chicks.

Unlike blue-footed booby underling chicks, the browns "didn't learn to be submissive," says Drummond.

The ferocity of the brown booby youngsters strikes Drummond as an example of the desperado aggression that a theorist predicted decades ago. "Since they're doomed, they're prepared to go for bust," Drummond says.

That sounds plausible, agrees bird ecologist Scott Forbes of the University of Winnipeg in Manitoba. "There's a myth that families ought to be harmonious, but we're finding that conflict is a large part, a very natural component, of family relationships." —S. MILIUS

HOW THE BUTTERFLY GETS ITS SPOTS

And what they tell us about fate

BY SUSAN MILIUS

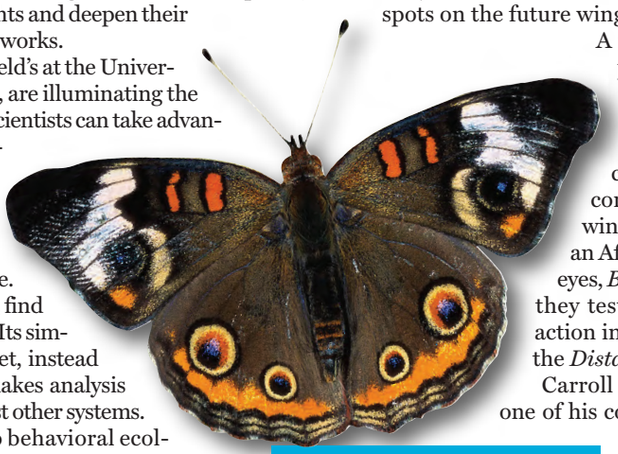
Paul Brakefield is a world authority on spots. His laboratory team delves into wide-ranging questions about the circles and dots on butterfly wings: What genes change the spots' size? Do different spots evolve separately or in concert? What kinds of spots wow the opposite sex? Brakefield argues that butterfly wings, particularly their freckles, offer science a rare opportunity. They're good for experiments in an unusually wide range of scientific disciplines, so researchers can combine insights and deepen their understanding of how evolution works.

Several labs, including Brakefield's at the University of Leiden in the Netherlands, are illuminating the genetics of wing patterns. These scientists can take advantage of findings in a less picturesque but thoroughly studied insect—the fruit fly. One group is even making progress on creating transgenic butterflies with fluorescent proteins in their tissue.

Developmental biologists, too, find the butterfly wing a great subject. Its simplicity as a two-dimensional sheet, instead of a three-dimensional organ, makes analysis more straightforward than in most other systems.

The beauty of the butterfly to behavioral ecologists, says Brakefield, is that its wing spots, bands, and other splotches play dramatic roles in mating, outwitting predators, and other matters critical to the insect's evolution.

Eventually, butterfly scientists expect to trace the workings of evolution from the folds of a molecule to the breadth of a continent. They have been saying for years that the tale of evolution is written on the wings of a butterfly. Now, they're beginning to decipher it.



SEE SPOT GROW — The buckeye butterfly's bold spots enabled researchers to discover that the location of the adults' bull's-eyes is determined while the insect is still a caterpillar.

BASIC SCALES Most of the world's 17,000 butterfly species sport distinctive wings, some as patterned as embroidery samplers, some so iridescent that that a butterfly's bright flash at ground level has caught the eye of passengers in small airplanes overhead. This plethora of wing designs comes from tiny scales decorated by two sets of artists' tools. On the scales' surface, microscopic structures—some shaped like tiny Christmas trees—create color by playing tricks with light. However, analysis of their genetics lags far behind that of the other source of color, pigment-based wing displays.

Much as computer screens form images, butterfly wings use tiny, single-color flecks that add up to the big pattern. Each minuscule, colored scale comes from a single cell, which dies after it's made its pixel. The colors come from mixtures of pigments—flavonoids, melanins, and pterins—that are widespread among organisms.

Caterpillars already carry disks of future wing cells, including those that will lay down the colorful design. In the 1970s, H. Frederik Nijhout of Duke University in Durham, N.C., performed miniature transplant surgeries, switching around bits of caterpillar tissue to see when the fates were determined for various wing parts. He worked with the buckeye butterfly (*Precis coenia*), which has bold bull's-eye spots on its fore and hind wings. Nijhout showed that before the caterpillar retires into its chrysalis to transform into a butterfly, the position of the spots on the future wings has been established.

A milestone in the genetics of wing pattern came in the early 1990s when Sean Carroll of the University of Wisconsin–Madison and his colleagues searched for butterfly counterparts to the genes known to control formation and patterning of wings in fruit flies. They worked with an African species that also has big bull's-eyes, *Bicyclus anynana*. Most of the genes they tested played a role similar to their action in fruit flies. But then came a test of the *Distal-less* gene (*Dll*).

Carroll still remembers the Friday when one of his colleagues called him to look at the latest results. The team had finally found a gene that decorates a butterfly wing. In fruit flies, *Dll* influences limb formation, but in the caterpillar, *Dll* also defines the center point of each of the bull's-eyes on *B. anynana*'s wings.

Suddenly a world of possibilities opened for testing pattern genetics. "You only need a few days like that and you can put up with years of frustration," Carroll recalls.

VARIATIONS ON A GENE Geneticists now know of several other genes that flicker on during formation of patterns such as the bull's-eye's rings. Still, *Dll* remains a favorite in genetics labs.

Patrícia Beldade, now at the University of California, Irvine, and her colleagues have tested whether there are variations in *Dll* that might provide raw material for natural selection, creating fitter and less-fit individuals that will prosper or fail as evolution grinds along.

Not every gene has to contribute to measurable variation among individuals, says Beldade. For example, extensive variants may not have evolved because a gene plays such a vital role that any alteration kills the organism. Beldade says that *Dll* did look valuable

UNCOUPLED — These wings of *Bicyclus anynana* at the end of an artificial breeding experiment show that it's possible to push the evolution of spots on the same wing in opposite directions.

C. BRUNETTI, J. SELEGUE, CARROLL

because it shows up with similar functions in insects that have followed divergent evolutionary paths. "Maybe you don't want to mess with it," she says.

To see whether *Dll* varies, Beldade and her Leiden colleagues worked with a laboratory colony of *B. anynana*. For nine generations, the scientists intervened in the insect's breeding to create a lineage with big bull's-eyes and another with small ones.

When Beldade analyzed various crosses of these lineages, she found specific forms of the gene associated with either large or small bull's-eyes. Variety in *Dll* itself or in a companion stretch of DNA powers spot variation, she and her colleagues reported in the Jan. 17, 2002 *Nature*.

In the real world, of course, a spot must be considered in the context of the entire organism. Just how the fate of one feature tugs at that of the others has intrigued Antónia Monteiro, now of the University at Buffalo, New York. Her lab is now developing transgenic butterflies with fluorescent pigments for future genetic tests.

In the early 1990s, she and her colleagues turned to the spots of *B. anynana* to explore the tangled fate of traits. She, too, began a butterfly-breeding program. She focused on maximizing the size of a particular wing bull's-eye. As that spot grew in succeeding generations, she found that other bull's-eyes enlarged, too.

Later, Beldade considered just how tightly the fates of all those spots are coupled. Maybe genes forced all of a butterfly's spots to stay in lockstep, either all getting larger or all dwindling. She and her colleagues selectively bred *B. anynana* to see if they could simultaneously drive the evolution of two spots on a wing in opposite directions. For 17 insect generations, the researchers selected for lineages according to mixed-and-matched spot size, such as a big front spot and a small rear spot.

"After a few generations, I knew it was possible," says Beldade. In the lineages that her team created, spot size at one location had indeed uncoupled from the size at the other, she and her colleagues reported in the April 25, 2002 *Nature* and the Oct. 29, 2002 *Proceedings of the National Academy of Sciences*.

These papers dashed the notion that butterfly-spot size represents an example of a trait that's evolved under such a strong constraint that some forms, such as one big spot and one little spot, never develop, according to Beldade. Other proposed examples of traits that can't evolve certain forms include the number of neck vertebrae in mammals—seemingly always seven—and the number of leg-bearing segments of centipedes—seemingly always odd. These examples have all been controversial.

WHAT WINGS SAY Does all this variation in spottiness make a difference to the butterflies? Brakefield and his Leiden colleague Casper Breuker decided to test how wing decoration affects the sex life of *B. anynana*.

The researchers set up cages and offered females a choice of two or three males whose spots the researchers had altered in different ways. Biologists have evidence suggesting that females of some animal species respond to how symmetrical a male is, but these female butterflies did not seem to show a preference for males with or without same-size spots on each side, the researchers reported in the June 22 *Proceedings of the Royal Society of London B*.

Likewise, the female butterflies failed to show any pattern of response to a male's wing size. They did respond to spot sizes,

Fights on the Wing

If all butterflies do is flutter, how does the winner win?

If you can't punch, kick, stab, shoot, bite, squash, or even touch some jerk, how can you fight him? Yet male butterflies of many species manage this feat all the time, says Darrell Kemp, now at Arizona State University in Tempe. Male butterflies disagree over the usual things—territories, females—yet fight duels that eventually send one contestant flying, all without physical contact.

To figure out this remarkably unbloody warfare, Kemp worked in Australia on the feisty *Hypolimnas bolina*, or common egg fly. Males compete relentlessly to claim a territory where unmated females are likely to waft by. A female only mates once, but males mate as often as possible. So, in a given part of a forest, all the males are ready to go, but "95 percent of all the females aren't receptive," says Kemp. "It's a scrap-fight over the remaining 5 percent."

When one male intrudes on another, the pair starts flying close to the ground in a circle the size of a dinner plate. Typically, one combatant flees in a few minutes, but battles can last a quarter hour. The departing male flaps off with an unusual gliding rhythm that Kemp suspects is a loser butterfly's submissive slink.

The best predictor of success turns out to be age, says Kemp. He found that males reach their competitive peak during the last third of their 3-month life span. "These older butterflies are run-down. Their wings are really torn. Usually, they don't have much in the way of energy reserves," he says. Yet they triumph.

Kemp has ruled out several hypotheses. He found that body size had no relation to victory. Then he measured various wing and body parameters to see whether flight dynamics could explain the oldsters' prowess. He compared wing area with body weight to see whether flying got easier. He weighed flight muscles and fat to see whether older males had more power or more energy in the bank. The answer is "no" to all of the above, Kemp reported in the July-August 2002 *Behavioral Ecology*.

Now, Kemp proposes his own hypothesis: The male that persists in the face of risks wins. Butterfly duels probably bring some low-level risks, such as wing rips from brushing a twig or general wear on the wings, he notes in the July 7, 2002 *Proceedings of the Royal Society of London B*. "A young guy has his whole life ahead of him," Kemp points out. He proposes that the older guy wins because he has less to lose. —S.M.

though, preferring the guys with big bull's-eyes.

Carol Boggs at Stanford University is exploring how the sexiness of wing pattern interacts with other butterfly concerns, like survival. She and Jacintha Ellers, now at the Institute of Ecological Science in Amsterdam, analyzed coloration of clouded sulphur butterflies (*Colias eriphyle*) in Colorado's Rocky Mountains. The sulfur-yellow background of the wings carries a smattering of dark spots near the edges.

Across their hind wings, females develop more black pigment than males do and so take on a smoky cast, Ellers and Boggs reported in the April 2002 *Evolution*. When the researchers checked butterflies living on mountainsides at elevations from about 1,800 meters to 2,900 m, they found that the darkening tends to intensify with elevation.

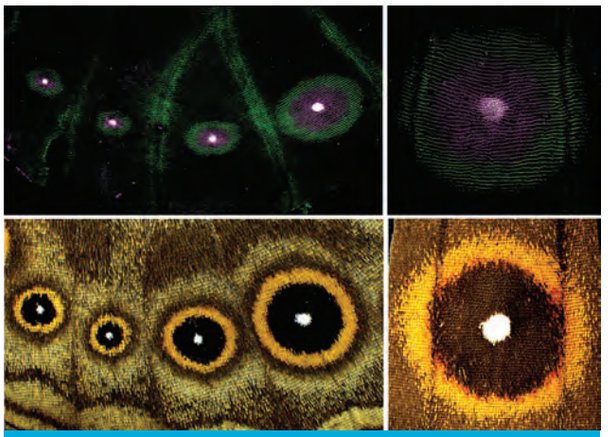
Boggs proposes an advantage of the smokiness. Darker wings can help a butterfly warm up and move faster by absorbing extra sunlight, she explains. Butterflies are at the mercy of their environment for body heat, so a heat bonus might bring important benefits—especially at cooler elevations. Females, which at times lug around weighty eggs, could find that dark-wing advantage of special importance.

The story is about to get more interesting, Boggs predicts. A report she and Ellers will publish soon in *Evolution* shows that males, regardless of location on the mountainsides, prefer lighter-winged females to darker ones, says Boggs. Too bad if lighter females suffer chilling disadvantages. The butterflies therefore present an example of a clash between what's good for survival and what's good for attracting a mate.

The study of evolution has turned up these clashes before. In most of these, such as the classic example of the peacock's tail, sexiness dominates although it's limited by such survival disadvantages as slower escape from predators. But Boggs suspects that the butterfly story will have an unusual ending because the female clouded sulphurs do darken as their home altitudes rise. Boggs says that she bets that the clouded sulphurs will provide an example of survival value dominating, limited by the demands of sex appeal.

That's just one of the evolutionary issues a scientist can test with butterflies, and Boggs says that plenty of others will appear in a 700-page tome on butterfly research that she and two of her colleagues edited for publication later this year.

The promise of the field reminds her of the words of 19th-century English naturalist-collector Henry W. Bates. He spent 11 years exploring the Amazon, and his haul of 14,000 species included many butterflies. He wrote that understanding their variety would unveil the forces driving variety in all life and that "the study of butterflies, creatures selected as the types of airiness and frivolity, instead of being despised will someday be valued as one of the most important branches of biological science." ■



SPOT LIGHTS — Glow that shows gene activity (top images) in tissue in a pupa's developing wing foreshadows adult wing-pattern elements (bottom images).

BELDADE, BRAKEFIELD

NANOLIGHTS! CAMERA! ACTION!

Tiny semiconductor crystals reveal cellular activity like never before

BY JESSICA GORMAN

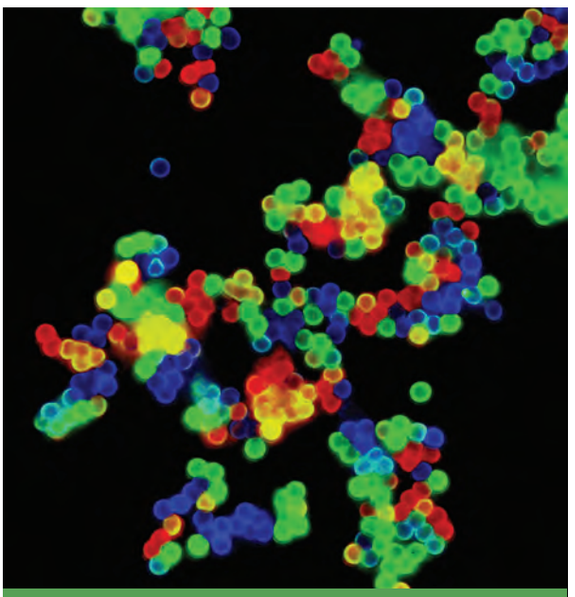
Last December, Sanford Simon attended a cell biology meeting where researchers presented picture after picture of cells colorfully highlighted by organic dyes or fluorescent proteins. Speakers also debuted movies—featuring proteins as cellular action heroes. In these little dramas, often lasting only seconds, viewers witnessed the complicated molecular actions underlying cancer, diabetes, and other human diseases.

Such colorful demonstrations pervade biology research, says Simon, a biologist at the Rockefeller University in New York, where he does plenty of cellular photography of his own. Pick up almost any molecular biology journal and there's a gorgeous cell on its cover, glowing brightly in green or red or an entire rainbow of colors. "Part of this [imaging] is intellectual curiosity and part of it is a real hope of understanding more about human physiology and pathology," says Simon.

But the widely used dyes and proteins, called fluorophores, have drawbacks. They fade quickly, and only two or three colors can be used simultaneously to label different cellular components. Biologists would prefer to see all the machinery of a cell operating at once in Technicolor over days, months, or even years.

That's where quantum dots come into the picture. Most often touted for their potential roles in computing and data storage, these nanoscale particles of semiconductor can be made to fluoresce in any color for months and perhaps years. In 1998, two landmark publications heralded quantum dots as labels for cells and proteins. "It seemed they had the potential for solving all sorts of problems we were having with imaging in biology," says Simon, who has done fluorescent imaging for years.

Now, 4 years later, a landslide of new research is showing that the initial enthusiasm for dots in biology wasn't simply hype. They just might be the next stars of biological imaging.



RAINBOW BEADS — Polymer beads embedded with quantum dots fluoresce in five different colors.

NIE

A BETTER BEACON Shuming Nie images cells primarily to determine whether a tissue sample contains markers of a particular cancer. Quantum dots could provide faster, more sensitive, and maybe cheaper imaging than conventional fluorophores do, says Nie, a researcher at the Georgia Institute of Technology and director of cancer nanotechnology for the Winship Cancer Institute at Emory University in Atlanta. Eventually, sensitive, long-duration imaging might even reveal precisely how wayward proteins or cells—such as those involved in Alzheimer's disease or cancer—behave in the body.

Says Nie: "I think this quantum-dot thing is going to be the first example of nanotechnology that can really have some practical applications."

Four years ago, while working at Indiana University in Bloomington, Nie and Warren C.W. Chan published one of the two simultaneous reports that showed how semiconductor quantum dots could tag cells with microscopic beacons of light. The other report was by A. Paul Alivisatos and his colleagues at the University of California, Berkeley.

The semiconductor particles that researchers are grooming for biological imaging are generally made of a cadmium selenide core surrounded by a shell of zinc sulfide. Their diameters measure in nanometers. When hit with light, the quantum dot emits a particular color based on its size. Smaller dots fluoresce at shorter wavelengths, such as blue, while larger dots emit longer wavelengths, like red.

Quantum dots have significant advantages over earlier techniques. Typically, researchers can view no more than three colors at once with ordinary fluorescence labeling using proteins, such as green fluorescent protein, or organic dyes, such as rhodamine. Each of the fluorophores must first be excited with a specific wavelength of light, which can block the emitted color of a second or third fluorescent tag. To overcome this problem, researchers can mark multiple proteins in a cell with several different colors, photograph them at different times, and then superimpose the pictures. Or researchers can tag one protein in one cell and another in a similar cell.

Simon likens the problem to that of watching his kids play games of Monopoly on consecutive days, but only seeing his daughter's first turn on the first day, his son's second turn on the second day, and so on. "What you want to do is see both of them playing at the same time in the same game," he says.

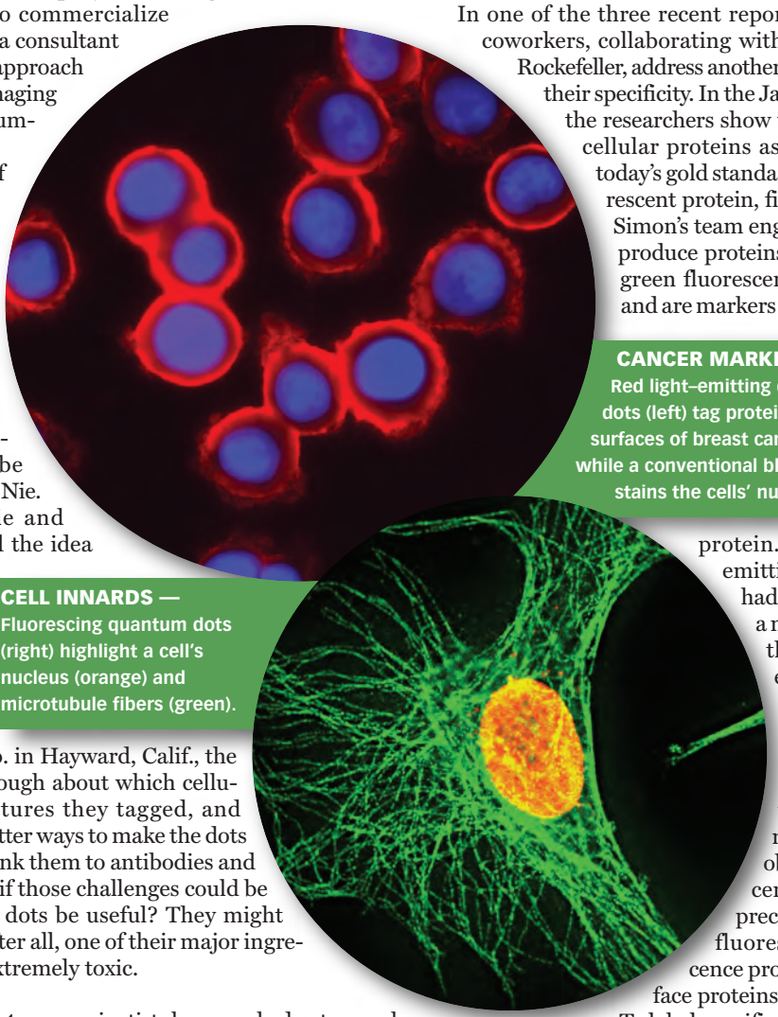
With quantum dots, scientists can simultaneously view many

different markers in the same cell. All quantum dots light up when hit with the same wavelength of light, no matter how many different dot sizes—and therefore colors—are in a sample. The dots' colors are also very specific, so they don't generally overlap one another, and many different colors can be used at once.

To create an even larger palette of colored labels, Nie recently embedded hundreds of dots in a single micronwide polymer bead. Each of Nie's beads is chemically linked to an antibody that can home in on and stick to a particular protein, and the intensity of a bead's emission increases proportionately with the number of dots it carries. A year-old company in Pittsburgh called Bioplex Corp. aims to commercialize these beads, says Nie, a consultant to the company. This approach could give biological imaging a huge pool of quantum-dot labels, he says.

Another limitation of conventional fluorophores is their short life span. They can fade in a couple of hours. In contrast, quantum dots remain stable for days to months. Potentially, a tissue sample with quantum-dot labels could be archived for years, says Nie.

In 1998, when Nie and Alivisatos first floated the idea of using quantum dots for studying cells, the technology was still young and rife with problems. For instance, says Xingyong Wu of Quantum Dot Corp. in Hayward, Calif., the dots weren't picky enough about which cellular proteins or structures they tagged, and researchers needed better ways to make the dots water soluble and to link them to antibodies and other molecules. And if those challenges could be met, would quantum dots be useful? They might disrupt or kill cells. After all, one of their major ingredients, cadmium, is extremely toxic.



CANCER MARKERS — Red light–emitting quantum dots (left) tag proteins on the surfaces of breast cancer cells, while a conventional blue dye stains the cells' nuclei.

CELL INNARDS — Fluorescing quantum dots (right) highlight a cell's nucleus (orange) and microtubule fibers (green).

WU/QUANTUM DOT CORP.

BIO DOTS In the past 4 years, scientists have worked out enough of the kinks in quantum-dot technology to make it ready for roles in biological imaging, says Nie. A trio of new studies has shown that researchers can chemically link an antibody or a specialized molecule to a dot so that it binds only to specific proteins in a cell or a tissue sample. Scientists have also learned to inject dots directly into a cell or permit cells to engulf the particles. Then, researchers can track the cell through an organism's development.

"These three papers clearly represent a milestone in the biological applications" of quantum dots, says Nie. "Now, the game is open."

These papers relied on recent advances in quantum-dot surface chemistry. For instance, the dots themselves are hydrophobic, so they resist dissolving in the water that dominates living tissue. Although Nie's and Alivisatos' groups each found a way to make their dots water-soluble, researchers have been striving to invent new methods that are quicker and easier and end up with particles that fluoresce longer and are less likely to poison samples.

What's more, the dots' surfaces need a versatile way to link with a variety of antibodies and other molecules that will target specific cell structures. New coatings include silicon shells, polymer spheres, and self-assembling molecules that tightly pack themselves over a dot.

Instead of coating or encapsulating dots, Hedi Mattoussi of the U.S. Naval Research Laboratory (NRL) in Washington, D.C., and his colleagues chemically replace the water-hating surface of a dot with a new surface that's more tolerant of water. These dots maintain their capacity to fluoresce for more than a year, even when kept in water, says Mattoussi, but he'd like to make dots that are stable forever.

In one of the three recent reports, Mattoussi and his NRL coworkers, collaborating with Simon's research group at Rockefeller, address another problem with quantum dots: their specificity. In the January *Nature Biotechnology*, the researchers show that quantum dots can label cellular proteins as specifically as does one of today's gold standard fluorophores—green fluorescent protein, first found in certain jellyfish. Simon's team engineered mammalian cells to produce proteins on their surfaces that have green fluorescent protein attached to them and are markers for resistance to certain therapeutic drugs.

In one experiment, the scientists exposed cells to antibodies that bind to the drug-resistance protein. Then, they added orange-emitting quantum dots that they had previously linked to avidin, a molecule that readily binds to these antibodies. In another experiment, the team chemically attached the antibody to the quantum dots by way of a linker molecule, protein G, and then put them in dishes with cells. In both experiments, the researchers observed that orange fluorescence from the quantum dots precisely matched the pattern of fluorescence from green fluorescence protein attached to the cell-surface proteins.

To label specific proteins not just on cell surfaces but also in a cell's cytoplasm and nucleus, Wu and his coworkers at Quantum Dot and at Genentech in South San Francisco, Calif., used techniques similar to those of Simon's group. They linked the molecules streptavidin or immunoglobulin G to their dots. With their quantum dots in tow, these molecules then sought out antibodies clinging to proteins on cells. This technique enabled Wu's group to detect and label breast cancer markers on the outside surfaces of cells living in lab dishes.

To investigate the inside of cells, the researchers introduced streptavidin-linked quantum dots into the cytoplasm of specially prepared, dead cells. The dots labeled the actin filaments and microtubule fibers. They also tagged proteins within the nucleus, known as nuclear antigens, that make up the cell skeleton. Whether on the surface or inside the cells, the quantum-dot beacons are brighter and more stable than conventional organic dyes, the researchers note in the January *Nature Biotechnology*.

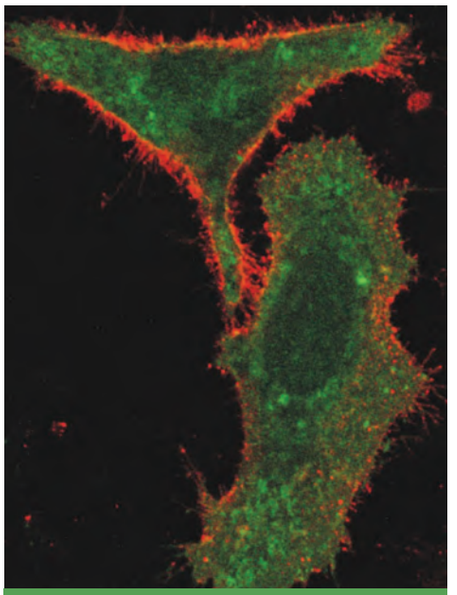
But what about labeling the inside of living cells? To address that

question, Benoit Dubertret of the Laboratoire d'Optique Physique at CNRS in Paris and his colleagues at three U.S. institutions injected solutions of quantum dots into frog embryos and watched the organisms grow for 5 days. The researchers found that when cells divided, quantum dots ended up in the daughter cells. This finding, published in the Nov. 29, 2002 *Science*, enabled the scientists to follow the organisms' development.

Aside from answering basic biological questions about embryo development, this labeling indicates that quantum dots are not toxic to these cells, says Dubertret. If the dots had been toxic, he says, the embryos probably would have become malformed.

Simon's group explored toxicity by testing its quantum dots in both human and slime mold cells. In these cases, the researchers let the cells engulf quantum dots through a natural cellular process called endocytosis. Neither cell type showed any obvious problem, the team reports in its *Nature Biotechnology* paper.

What's more, these results led Simon and his colleagues to investigate an age-old, baffling question about slime mold behavior. When these single-celled organisms are starving, they send out chemical signals that encourage their neighbors to join them in a large multicellular mass. But researchers haven't known whether this is an all-or-nothing response to a nutrient deficiency or a response proportional to how hungry the cells are.



SIMON ET AL.

SELECTIVE LABELS — Antibody-linked quantum dots (red) highlight specific proteins on cells' surfaces just as well as green fluorescent protein does.

Long-lasting quantum-dot labeling gave the researchers a tool to find out. While starving cells for various lengths of time, Simon and his colleagues labeled them with quantum dots. They found that starved cells were just as likely to aggregate no matter how many hours they'd been without nutrients. As expected, cells that hadn't been starved didn't aggregate.

Beyond such basic science, the tags are also now ready for use in laboratory diagnostic tests, Nie suggests. He says that his own lab has demonstrated that quantum dots could effectively label cancer markers in tissues removed from patients. Since certain drugs are effective only for patients with particular marker proteins, doctors can use such information to tailor treatments for particular patients.

Ultimately, scientists might track a cancer cell that moves through the body. But such internal applications of quantum dots will require that rigorous toxicity studies show no harm to patients.

Quantum dots are already poised to join traditional fluorophores as a tool important to biologists. The hundreds of fluorescent images at the cell biology meeting last December indicate that biological labeling has "just exploded," says Simon. "It's both exciting and humbling to see the creative ways scientists are now applying [green fluorescent protein]," he says. "I think you're going to see the same thing now with the quantum dots as well." ■

OF NOTE

EARTH SCIENCE

9/11 ash, and more, found in river muck

Sediment cores pulled from the Hudson River near the World Trade Center site just a month after the Sept. 11, 2001, terrorist attacks contain a thin layer of metal-rich ash and pulverized debris. That's not surprising. What did surprise researchers was the discovery of radioactive iodine—a substance unrelated to the attacks—in the top few centimeters of river silt.

On Oct. 12, 2001, scientists obtained samples of river sediment from two sites within 1.5 kilometers upstream of where the World Trade Center's twin towers once stood. The top 3 cm of silt contained layers with unnaturally high concentrations of copper, strontium, and zinc from the towers, says Sarah D. Oktay, a geochemist at the University of Massachusetts in Boston.

Those layers also included small rods and numerous bundles of fibers that ranged between 40 and 200 micrometers in length, she notes. The minuscule particles, chemically rich in calcium and silicon, probably came from construction materials such as drywall and fiberglass ceiling tiles.

Oktay and her colleagues also found that the sediments contain small but measurable quantities of iodine-131, a human-made radioactive isotope with a half-life of about 8 days. Total iodine concentrations were actually lower in the debris-filled layers, which means the source of the element probably isn't related to the attacks. Also, the iodine probably didn't leak from nuclear power plants upstream because other telltale radioactive isotopes didn't turn up.

Instead, says Oktay, the iodine—which is used in various medical treatments and sometimes carried home internally by patients—probably entered the river through local sewage systems. The researchers report their findings in the Jan. 21 *Eos*. —S.P.

CHEMISTRY

Synthetic molecule may treat anemia

A hormone that regulates the production of red blood cells now comes in a synthetic version. The lab-made hormone could treat anemia in patients with cancer or kidney failure.

Known as erythropoietin (EPO), the natural protein is made in people's kidneys and is already available as a drug. However, most of this supply is made through genetic engineering techniques. Animal studies indicate that the new chemically manufactured EPO variant, called synthetic erythropoiesis protein (SEP), may work better in patients than the genetically engineered drug does, says Gerd Kochendoerfer of Gryphon Therapeutics in South San Francisco, Calif.

OF NOTE

In the Feb. 7 *Science*, Kochendoerfer and his colleagues report that SEP generated more red blood cells in mice than genetically engineered EPO did. Additional studies on rats showed that SEP also lasted two to three times longer in blood. If further trials demonstrate similar results in people, doctors might opt to switch to SEP, says Kochendoerfer.

The researchers created SEP molecules by stringing amino acids into peptide fragments and attaching polymer appendages to them. The scientists then linked the fragments together and made the complex fold into its specific, biologically active form. The technique may also be useful for chemically constructing other proteins, Kochendoerfer says. —J.G.

PHYSICS

Streams plus nanostrands equals electricity

Since the discovery of carbon nanotubes in 1991, scientists have marveled at the structures' superlative strength and their promising electronic and optical properties. Now it seems that the tubes might also serve as tiny hydropower plants.

New measurements by scientists in India show that a dense bundle of so-called single-wall nanotubes—atom-thick sheets of carbon rolled into cylinders (*SN: 1/4/03, p. 14*)—develops a voltage difference along its length when immersed in a slow-flowing liquid. Moreover, that electrical potential, which ranges up to 10 millivolts (mV), increases with flow speed.

This newfound trait may lead to nanotubes' use as exquisitely sensitive flow sensors, feedback components in microfluidics devices, or power sources for micromachines, says physicist Ajay K. Sood of the Indian Institute of Science (IIS) in Bangalore. He and his colleagues report their findings in an upcoming *Science*.

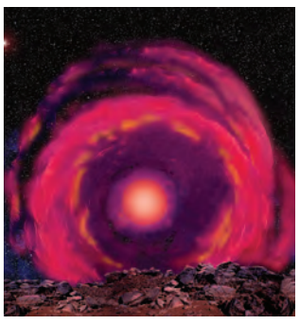
In its experiments, the team studied a sesame-seed-size nanotube bundle containing an estimated 50 trillion tubes. The researchers mounted the bundle between metal electrodes inside a glass conduit and then measured the voltage generated as various liquids flowed over the bundle.

The scientists observed that hydrochloric acid, which contains many ions, produced a voltage about five times that produced by water, which contains relatively few ions, and nearly 60 times that of methanol, the least-ionized of the tested liquids. Given the apparent influence of ion concentrations, Sood and his colleagues propose that transient imbalances between positive and negative charges in the passing liquids affect charges in the tubes, causing voltages to develop. —P.W.

ASTRONOMY

Starry eruption on a grand scale

For nearly a decade, astronomers have patiently watched Rho Cassiopeiae, a bloated, relatively cool star 500,000 times brighter than the sun. They knew it was just a question of time before the star would erupt, but the scientists were still astonished at the fireworks they witnessed about 2 years ago.



STELLAR TANTRUM
Illustration of the unstable hypergiant star Rho Cassiopeiae.

Visible to the eye even though it resides 10,000 light-years away, the star first dimmed for several months as its outer atmosphere collapsed, heated, and then shot upward. This eruption hurled the equivalent of 10,000 Earths into space, which is more mass than has been expelled by any other stellar explosion ever observed, report Alex Lobel of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and his colleagues in the Feb. 1 *Astrophysical Journal*.

By monitoring the star's convulsions, Lobel and his colleagues believe they have solved a stellar riddle: Why are there no cool stars more than a million times brighter than the sun? Using the new data, the team calculated that Rho Cassiopeiae and other so-called yellow hypergiant stars periodically blow out gargantuan amounts of mass. These explosions raise the surface temperature of the stars and their luminosity, preventing cool stars from becoming any brighter than a million suns, Lobel suggests. —R.C.

BIOMEDICINE

Worms offer the skinny on fat genes

Microscopic worms that feasted on genetically engineered bacteria might shed light on why people gain weight. Biologists used this bacterial diet plan to turn off individual genes in the worms in order to identify ones that influence the animal's fat.

Investigators recently engineered around 17,000 strains of the bacterium *Escherichia coli* so that each strain makes an extra RNA strand that corresponds to a specific worm gene. When a worm consumes a particular *E. coli* strain, the additional RNA shuts down the corresponding worm gene through a phenomenon called RNA interference (*SN: 10/19/02, p. 254*).

Gary Ruvkun of Massachusetts General Hospital in Boston and his colleagues used this library of bacterial strains to search for worm genes that could reflect human genes involved in obesity. With the help of a dye that marks fat droplets in living worms, the scientists monitored the fat storage of worms as they gobbled up the various *E. coli* strains. Through this strategy, the scientists inactivated genes one by one and found 305 cases in which the RNA-fed worms stored more fat and 112 instances in which they stored less.

Of the 417 fat-regulating genes thus identified, about 100 have known human counterparts, Ruvkun's group reports in the Jan. 16 *Nature*. Some of these genes have previously been implicated in human obesity, but most haven't. These latter genes "may point to ancient and universal features of fat-storage regulation and identify targets for treating obesity and its associated diseases," the researchers conclude. —J.T.

NEUROSCIENCE

Gene found key to brain chemical

The story of serotonin, a brain chemical associated with depression and anxiety, just became more complicated. German scientists have found that the mouse brain doesn't use the expected enzyme to create the neurotransmitter.

The previously known serotonin-making enzyme is tryptophan hydroxylase, or TPH. Recently, Diego J. Walther of the Max Delbruck Center for Molecular Medicine in Berlin-Buch and his colleagues created mutant mice that lack this enzyme. Surprisingly, the rodents still made serotonin in their brains. In other tissues, however, the chemical was almost nonexistent.

The investigators soon discovered the explanation—mice have a gene encoding a second form of TPH, as do people. It's this version of TPH that's responsible for serotonin synthesis in the brains of mice and, presumably, people, the researchers report in the Jan. 3 *Science*. The many past efforts to link the original THP gene to psychiatric disorders now must be reevaluated, Walther and his colleagues suggest. —J.T.

D. A. AGUILAR/CFA

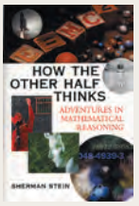
Books

A selection of new and notable books of scientific interest

HOW THE OTHER HALF THINKS: Adventures in Mathematical Reasoning

SHERMAN STEIN

"This is a book of mathematics, not a book about it," declares Stein, as he presents eight problems that

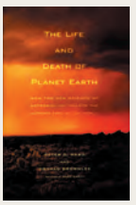


exercise analytical thinking skills and require no mathematical prowess beyond knowing basic arithmetic. Each problem is posed, illustrated, and eventually solved for the reader. For instance, readers tackle the paradoxes of infinite sets, contemplate the ambiguities of voting and elections, and consider the randomness of the Los Angeles Dodgers' wins and losses during their perfect .500 season of 1993. Originally published in hardcover in 2001. ***McGraw, 2003, 177 p., b&w illus., paperback, $10.95.***

THE LIFE AND DEATH OF PLANET EARTH: How the New Science of Astrobiology Charts the Ultimate Fate of Our World

PETER WARD AND DONALD BROWNLEE

Nothing lasts forever. One day, Earth will be annihilated as our sun goes through its own death throes. Scientists are drawing heavily on a new field of study called astrobiology—a synthesis of biology, astronomy, and paleontology—to glean information

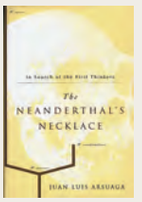


from our past and from the life and times of other planets in order to establish what the future might hold. Geologist Ward and astronomer Brownlee are at the fore of this exciting new field and join forces here to illuminate likely scenarios for the end of Earth. They accord that Earth's biodiversity peaked 250 million years ago and that we are living today in the second half of our planet's lifespan. After analyzing how Earth evolved to this point, the authors speculate that we will return to a hot world where life is less diverse, less complicated, and less abundant than now. They believe a supercontinent will once again coalesce before plant and animal life ends and the oceans disappear. In the process of making their grim, yet fascinating case, they present a vast amount of data and a solid introduction to a stirring new field. ***Times, 2002, 240 p., b&w photos/illus., hardcover, $25.00.***

THE NEANDERTHAL'S NECKLACE: In Search of the First Thinkers

JUAN LUIS ARSUAGA

Paleoanthropologists used to believe that if a Neandertal male put on a suit and tie, he could pass as a rider on the New York City subway, though he might not be able to figure out which stop he needed. Arsuaga, a paleoanthropologist working on excavations at Sierra de Atapuerca in Spain, turns this idea entirely around. He presents evidence that Neanderthals actually looked more like nonhuman primates yet were far more intelligent than we give them credit for. Taking readers back 40,000 years, when Cro-Magnons migrated

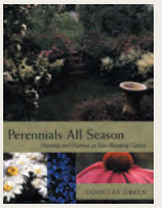


into Neandertal territory in northern Europe, Arsuaga details the evolutionary struggle between the two groups and speculates on what characteristics led to the Neandertals' demise. Cro-Magnons possessed language and were clearly more intelligent, the author argues. Therefore, Neandertals were unable to keep pace with Cro-Magnons' toolmaking techniques and adaptability to their changing environment. Originally published in Spanish in 2001. ***Four Walls, 2002, 334 p., b&w illus., hardcover, $25.95.***

PERENNIALS ALL SEASON: Planning and Planting an Ever-Blooming Garden

DOUGLAS GREEN

One of the most elusive traits of a garden is a constant show of blooms from the first of spring through early autumn. Green argues that the three essential components to establishing a perennial garden as good as those pictured in this book are design, plant selection, and plant arrangement. Design is key. He argues that the way in which the bed is laid out will determine how lush it will look.



Clearly, if all the assembled plants bloom in spring, the bed won't be much of a sight come fall. In this beautiful book, Green outlines the tricks of the trade, such as use of color. The perennial encyclopedia that makes up two-thirds of the volume lists plants according to the time of the year when they bloom. It provides facts about each specimen's height, color, flower, and requirements regarding soil, sun, and space. There are also recommendations of varieties, as well as propagation tips. ***Contemporary, 2003, 296 p., color photos/illus., hardcover, $34.95.***

THE SOLAR HOUSE: Passive Heating and Cooling

DANIEL D. CHIRAS

Americans spend about $54 billion a year to heat and cool their homes. In addition to the financial costs, one-fifth of the nation's total fossil fuel energy production goes to maintaining the environment in our homes. Chiras illustrates the ways in which natural conditioning can be an alternative.

Natural conditioning is the age-old art and science of heating, cooling, lighting, and ventilating a building without the need for fuel. Using four basic strategies—passive-solar heating, passive cooling, daylighting, and natural ventilation—this system relies on clean, renewable energy. Chiras outlines design principles and tackles region-specific passive-solar designs. He also explores the pros and cons of each strategy he discusses. Details of how to build, maintain, and incorporate back-up systems are also covered in detail. ***Chelsea Green, 2002, 274 p., b&w photos/illus., paperback, $29.95.***

LETTERS

Thinking ahead

I found "Trust That Bird? A bit of future-think lets jays cooperate" (*SN: 12/14/02, p. 373*) quite fascinating. In 1973, my colleagues and I showed that rats would respond with the future in mind. Specifically, rats will make a response that results in one immediate electric shock, as long as that punished response is instrumental in avoiding five identical shocks programmed to occur 10 seconds later. It would be interesting to find out whether birds would cooperate in a similar manner to reduce the overall levels of pain in their lives.

JOSEPH V. LAMBERT, UNIVERSITY OF THE SCIENCES, PHILADELPHIA, PA.

On the waves

"Waves," or crenulations, occur not only on water icicles ("Icicle waves go with the flow," *SN: 12/14/02, p. 381*), but also in caves on dripstone and flowstone speleothems composed of calcite, epsomite, goethite, and even mud. All of these formations display "wavelengths" of around 1 centimeter. The origin of these crenulations is due not to heat, but to greater evaporation and carbon dioxide loss from thin liquid-water films flowing over slight surface protrusions.

CAROL A. HILL, ALBUQUERQUE, N.M.

Heroes and bilirubins

I read "Bilirubin: Both villain and hero?" (*SN: 12/14/02, p. 381*) about bilirubin protecting cells from free radicals and possibly cancer and heart disease. People with Gilbert's syndrome, which affects 5 percent of the population, have higher-than-normal amounts of bilirubin in their blood. Has any study been conducted to ascertain whether people with Gilbert's syndrome have a lower incidence of cancer and heart disease?

BRUCE WEINSTEIN, RIVERDALE, N.Y.

Yes, says Solomon H. Snyder of Johns Hopkins Medical Institutions: "An excellent study [referenced in our paper] shows a five-fold reduction in ischemic heart disease in Gilbert's patients." —J. TRAVIS

Not a super model

"Contrails forecast on the horizon" (*SN: 12/21&28/03, p. 400*) reports that 223 out of 243 aircraft in the study produced contrails and that the researchers produced a model that predicts contrails correctly 92 percent of the time (but doesn't predict their duration). Based on the article, I propose the simplest possible model: Always predict a contrail. You'll be right 223/243 (92 percent) of the time.

JOHN GILBERT, PASADENA, CALIF.