SCIENCE NEWS
THE WEEKLY NEWSMAGAZINE OF SCIENCE

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third primate genome
lucy pushed to sidelines
protein from *t. rex*
quick dna sequencing

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silk specs

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Cover Despite years of research, scientists still can't make a material as tough as the silk found within a spider web. To improve their silk-replication efforts, some researchers are now studying how a spider spins its threads. (iStockphoto) Page 231

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Primate's Progress

Macaque genome is usefully different

A group of 35 labs this week unveiled a draft of the genome for the rhesus macaque, the most widely used laboratory primate and a close cousin to people.

"The big question here is, 'What makes us human?'" says Richard A. Gibbs of the Baylor College of Medicine in Houston, who led the DNA-sequencing project.

The rhesus macaque is the third primate to have its genome described. Scientists reported the detailed human sequence in 2003 (*SN: 4/19/03, p. 245*) and a draft of the chimpanzee genome in 2005 (*SN: 9/3/05, p. 147*). With the macaque, human, and chimpanzee sequences now in hand, researchers can triangulate to learn what genes primates share and what genes are uniquely human. "Just seeing differences in chimpanzees and humans, it's been hard to say what's on the chimpanzee side and what's on the human side," says Gibbs.

Chimps share 98 percent of their DNA with people. The consortium reports in the April 13 *Science* that 93 percent of the macaque genome resembles that of people and chimps.

Chimps are so genetically close to people that it's been difficult to tell whether a similarity indicates a sequence valuable enough to persist through evolutionary history or just a happenstance of a shared family background. The macaque's extra bit of difference could help scientists make that distinction, says Gibbs.

The macaque also offers a deeper view into primate history. The chimp and human lineages split some 6 million years ago. Rhesus macaques had diverged about 19 million years earlier.

The rhesus macaque (*Macaca mulatta*) ranges widely across Asia. It's one of 22 species of macaques, all of which are classified as Old World monkeys.

The draft DNA sequence, which the research consortium deciphered in about 2 years, covers about 98 percent of the macaque's genome. As in the human and chimp genomes, about half the DNA consists of genetic elements that don't encode proteins and can insert extra copies of themselves.

J. MOGLIA/SCIENCE

THIRD COUSIN **Like people and chimps, the rhesus macaque has now had almost all of its genome sequenced.**

In an early comparison of the three available primate genomes, the consortium notes human-specific features. For example, there are additions in one of the human-DNA sequences for keratin, a component of hair.

The new sequence information already indicates that some normal macaque genes look like human versions associated with diseases. For example, macaque versions of several enzyme genes look like ones that cause phenylketonuria, a condition that causes mental retardation in people.

"The macaque-genome sequence will have an important impact on both biomedical research and basic research," comments Michele Cargill of the company Affymetrix in Santa Clara, Calif. She has compared the chimpanzee and human sequences but wasn't a member of the macaque consortium.

Cargill predicts that the new genome will advance the study of mechanisms underlying infection and immune responses and will boost progress in vaccine development.

The new genome offers opportunities for testing ideas about gene regulation, says geneticist Alan Baxter of the Comparative Genomics Centre at James Cook University in Townsville, Australia, and not in the consortium. "It is likely that many of the differences between man and the closely related primates lie not so much in gene sequence but in the regulation of the expression of those genes," says Baxter. —S. MILIUS

Bug versus Bug

Insect virus makes a viable flu vaccine

A new influenza vaccine churned out by caterpillar cells prevents the flu, researchers say. The advance might eventually revolutionize the manufacture of flu vaccine, now produced in chicken eggs in a long, cumbersome process prone to contamination and other failures.

After successful safety tests, "this is the first time this ... vaccine has been shown to protect people against the flu," says John J. Treanor of the University of Rochester (N.Y.) Medical Center, who led the study reported in the April 11 *Journal of the American Medical Association*.

During the 2004–2005 flu season, none of 151 recipients of a high dose of the new vaccine caught the bug. Two of 150 people receiving a low dose came down with the flu, while 7 of 153 people receiving a sham vaccine got sick.

The study "absolutely showed protection," says Doris Bucher of New York Medical College in Valhalla, whose lab grows the seed strains of influenza virus for conventional vaccines.

The new vaccine is produced by caterpillar cells infected with a genetically modified baculovirus. In its normal form, this virus prolifically produces a protein called polyhedron, which coats and protects the virus particles as they rest on leaves before being eaten by a caterpillar.

The vaccine developers replaced the polyhedron gene with the gene for hemagglutinin, an influenza protein. Lab-grown insect cells infected with the modified baculovirus then churned out large amounts of hemagglutinin, which elicited flu-fighting antibodies when injected into people, according to the new findings.

Each strain of influenza carries a slightly different hemagglutinin gene, and each year public health officials make an educated guess as to which strains will emerge around the globe. Vaccine makers then target the predicted strains. If the officials guess wrong, as they did in 2003, the vaccine produced offers little protection.

But with the new method, says Treanor, the appropriate hemagglutinin gene could be quickly inserted into baculovirus, speeding production of effective vaccines.

Each year, influenza kills some 36,000 people in the United States and hospitalizes another 226,000, according to the Centers for Disease Control and Prevention in

Atlanta. Three manufacturers annually produce 100 million doses of flu vaccine for the United States in a process that takes 6 months from identification of emerging strains in Asia to putting vaccine in vials.

Daniel Adams, president and chief executive officer of Protein Sciences Corporation of Meriden, Conn., which developed the new vaccine and funded the study, says that the company's process could cut production time to 2 months.

Such an acceleration could save lives. Treanor says, "We know that even a few weeks of saved time ... can make a big difference."

However, Bucher cautions that researchers haven't yet demonstrated large-scale vaccine production from insect cells.

Gary Nabel, director of the Vaccine Research Center at the National Institutes of Health in Bethesda, Md., agrees. "Overall, I'd say it's encouraging. [But] is it ready to swoop in tomorrow and replace conventional vaccines? No." —B. VASTAG

Ancient Extract

T. rex fossil yields recognizable protein

New analyses of a *Tyrannosaurus rex* leg bone reveal that the fossil, which is 68 million years old, preserves substantial remnants of proteins. The chemical makeup of the protein fragments adds to earlier evidence that modern birds are closely related to dinosaurs.

Most animal fossils include only hard body parts, such as teeth and bones, and until recently, few paleontologists dared hope that soft tissues could survive in long-dead remains. Recently, however, a team of researchers—including Mary H. Schweitzer, a paleontologist at North Carolina State University in Raleigh—extracted soft, pliable tissue from the fossilized leg bone of a *T. rex* (*SN: 3/26/05, p. 195*).

Now, further analyses of samples from that leg bone have identified small fragments of the long, fiber-forming protein collagen, the major nonmineral component of living bone.

Several lines of evidence point to collagen, says Schweitzer. First, microscopic images of bone samples showed structural features spaced about 70 nanometers apart, matching the scale of tiny structures that collagen forms in living creatures. Second, the chemical analysis of bone samples identified many of the amino acids found in collagen. The most common of those substances, glycine and alanine, appeared in a 2.6-to-1 ratio, similar to the 2.5-to-1 ratio of the substances in the collagen of chickens.

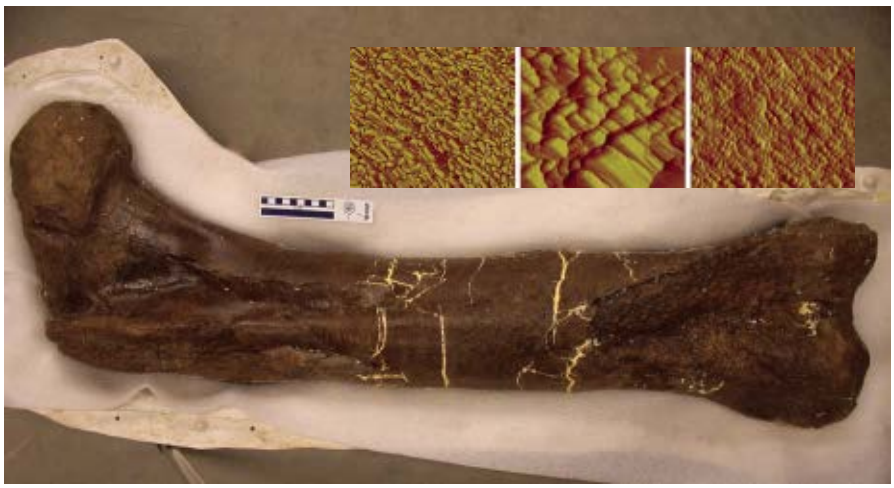
Finally, antibodies that react with a certain type of chicken collagen also reacted to a powdered and purified sample of the *T. rex* bone, says Schweitzer. She and her colleagues report their findings in the April 13 *Science*.

The chemical composition of collagen varies from species to species, says coauthor John M. Asara, an analytical chemist at Harvard Medical School in Boston. However, even in disparate creatures, the specific sequences of the amino acids in some types of collagen can be remarkably similar. For example, 97 percent of the amino acid sequence in human collagen matches that of the cow.

Asara, Schweitzer, and other team members used mass spectrometry to identify the sequence of protein fragments in collagen from the *T. rex* fossil. That was a difficult challenge, since each 30-to-40-milligram tissue sample had just a few nanograms of collagen, says Asara. Nevertheless, the researchers identified seven sequences of between 10 and 20 amino acids that matched those found in the collagen of modern-day creatures.

The amino acid sequences of the *T. rex* collagen more closely resembled sequences found in chickens than those found in the other current animals that the team examined. In contrast, sequences of amino acids from collagen extracted from a mastodon skull that's between 160,000 and 600,000 years old are more similar to those of mammals than to those of other current animals, says Asara. The researchers report these results in the same issue of *Science*.

Analyses of fossils from many different geologic periods will reveal whether protein preservation is exceptional or commonplace, says paleontologist Derek E.G. Briggs of Yale University. If such preservation is far more frequent than paleontologists have expected, discerning the amino acid sequences in ancient proteins "has enormous potential" for revealing evolutionary relationships among ancient creatures, he adds. —S. PERKINS



CLOSE LOOK Pattern and spacing of features seen in microscopic images (insets) of samples of a 68-million-year-old *Tyrannosaurus rex* leg bone provide evidence of preserved collagen.

Female Stem Cells Flourish

Sex difference could affect therapies

When it comes to stem cells, sex matters. Muscle stem cells taken from female mice repair damaged tissues better than male stem cells do, according to a new study.

It's the first demonstration that the regenerative abilities of stem cells depend on their sex. Currently, researchers don't typically document whether the cell lines that they study came from males or females.

"[Scientists] could have biased results if they're only looking at one gender of the cells," says Bridget M. Deasy of the University of Pittsburgh.

She and her colleagues began looking into the role of gender in stem cell performance after they realized that the cell lines that they had been using for years, which they had chosen because those cells regenerated well, were all female. "We really were unaware of it," she says.

To isolate the influence of the cells' sex, Deasy and her colleagues cultivated stem cell lines derived from the healthy muscle tissue of 15 female and 10 male mice. Unlike more-controversial embryonic stem cells, muscle stem cells come from adult animals' tissues and can be extracted without killing the animal.

The researchers implanted the muscle stem cells into mice that had a condition

similar to human muscular dystrophy. Two weeks later, the team counted the healthy muscle fibers generated by the stem cells. Only one of the male cell lines produced more than 200 new fibers, while six of the female lines did, the researchers report in the April 9 *Journal of Cell Biology*.

"It is a new idea in stem cell research," comments Barbara D. Boyan of the Georgia Institute of Technology in Atlanta, who examines sex differences in mature body cells. It makes sense that the sex of stem cells should matter, she says.

Deasy says, "It should come down to some kind of difference in the X and Y chromosomes, but the truth is that we just don't know yet." The exact mechanism behind the difference could take years to decipher, she adds.

In the recent work, Deasy's group found that certain stress-response genes were more active in the implanted female cells than in the male cells. Transplantation stresses cells, so the researchers suggest that sex differences in stress response might explain the performance gap.

Understanding the mechanism behind the male-female difference might be useful if doctors eventually transplant stem cells in therapies to repair damaged tissues, as many scientists expect. For example, researchers might find a way to impart the female trait to male stem cells, thereby improving the success of future therapies that would alter and then reimplant a man's own stem cells. —P. BARRY

Quantum Capture

Photosynthesis tries many paths at once

Quantum physics plays a larger role than scientists had expected in plants' capture of light. New findings could explain life's uncannily efficient use of solar energy, researchers say.

In organisms ranging from blue algae to giant sequoias, complicated assemblies of molecules of the pigment chlorophyll absorb sunlight's photons and channel their energy to enable the plants to turn water and carbon dioxide into oxygen and sugars.

The efficiency of photosynthesis, as this process is called, has long astounded scientists. Virtually every photon absorbed by chlorophyll initiates a photosynthetic reaction. Plants use up to 90 percent of the light that strikes them, whereas commercial solar panels use less than 30 percent.

The absorption of a photon causes a chlorophyll molecule to enter an excited state, in which one or more of its electrons hop to a higher energy level. The traditional view was that chlorophyll molecules within a complex swap excitations until that energy finds its way to a reaction center, where it initiates a chemical reaction. But at each exchange between molecules, the excitation might dissipate as waste heat, so scientists didn't understand how the process could be so efficient.

Instead of bouncing from one molecule to another, excitations move like waves do, reports a team of chemists at the University of California, Berkeley and the Lawrence Berkeley National Laboratory. In a new experiment, Greg Engel and his colleagues found that groups of chlorophyll molecules spend a surprisingly long time in a so-called superposition of states—a quantum phenomenon in which many molecules share excitation energy and so are simultaneously excited and relaxed. The mixtures of different states can show wavelike behavior. For example, they can cancel each other or add up, like waves on a pond do.

In the experiment, the team froze chlorophyll complexes from blue algae and shot them with sequences of ultrashort laser pulses, each lasting just 40 femtoseconds, or millionths of a billionth of a second. Three pulses excited the molecules, and a fourth pulse detected interference patterns.

The complexes stayed in a superposition of states for more than 600 femtoseconds after receiving the pulses. During that interval, "the system is exploring all areas at once without having to visit each place individually," Engel says. The paths that transfer energy to the reaction center are energetically favored over those that turn it into waste heat, he proposes.

The team's results appear in the April 12 *Nature*.

The recent Berkeley experiment overturns 50 years of thinking about photosynthesis, says Rienk van Grondelle, a biophysicist at the Free University of Amsterdam. Previously, scientists thought that the energy wanders randomly. "Here, it moves in a very specific manner," van Grondelle says.

Blue algae have relatively simple molecular machinery, van Grondelle notes. He says that the researchers' next challenge will be to perform a similar experiment on the more intricate chlorophyll complexes of plants. —D. CASTELVECCHI

Agents of Metastasis

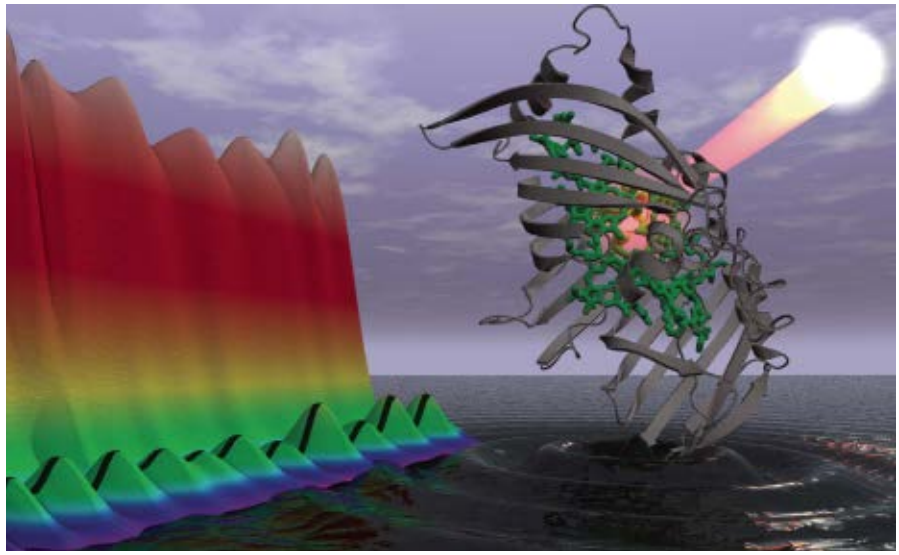
Four proteins conspire in breast cancer spread

While scientists have made significant progress in finding and combating the perpetrators of cancer growth, they've had less success in nailing down the proteins that facilitate the spread, or metastasis, of cancer.

Scientists working with mice have now demonstrated that four proteins appear to work in concert to both grow and spread tumor cells. The proteins had turned up previously in metastatic tumors.

The rogues' gallery includes an inflammatory enzyme called cyclooxygenase 2 (COX2), a protein known as epiregulin that's involved in cell growth, and two enzymes that have been implicated in the growth of new blood vessels that nourish tumors.

To test the proteins' roles, the researchers implanted metastatic human–breast cancer cells into healthy breast tissue in mice. The team had genetically engineered the cells going into some animals so that the tumors would fail to produce some or all of the proteins.



ENGEL/U.C. BERKELEY

WAVES OF GREEN Like ripples on water, energy absorbed from sunlight moves through the photosynthetic complex (gray-and-green molecular structure) with a wavelike motion. In this artist's rendering, that motion creates interference signals that are analyzed in a spectrum (left).

Rapid growth occurred in tumors with the full complement of proteins. But tumors lacking one or two of the proteins showed slow growth, and growth stalled completely in tumors lacking all four.

In further tests, tumors lacking the proteins developed short blood vessels with few branches, while tumors producing the proteins grew highly branched, leaky vessels, the researchers report in the April 12 *Nature*.

Such leaks provide avenues for cancer cells to escape into the blood. However, metastasis requires more than just travel. Tumor cells must take root in an unfamiliar organ and grow there.

A separate test of breast cancer cells injected intravenously into mice showed that curtailing production of all four proteins inhibited lung colonization, says study coauthor Joan Massagué, a molecular biologist at the Howard Hughes Medical Institute and Memorial Sloan-Kettering Cancer Center in New York City.

The researchers also analyzed mice in which breast cancer cells with the full complement of proteins had migrated to the lungs. Some of those animals received a set of drugs that suppress the proteins. Those that didn't showed tumor growth in the unfamiliar tissues within 24 days, whereas drug-treated mice had only what the team called micrometastases, which remained trapped in lung capillaries rather than spreading into the lung.

The experiments reveal new details of metastasis and identify specific proteins that act in its many stages, says Gerhard Christofori of the University of Basel in Switzerland in an accompanying *Nature* commentary.

However, "people have cured cancer in mice before," says molecular biologist Rene Bernards of the Netherlands Cancer Institute in Amsterdam. While innovative, the new tests lasted only a few weeks—a time frame in which many people also respond well to treatment for metastases, says Bernards. He also points out that the cancer burden placed on the animals was proportionately much smaller than a person with breast cancer might face.

Nevertheless, Bernards says, "singling out a subgroup [of proteins] to see how relevant they are in the metastasis process is an extremely powerful approach."

The drugs that can squelch the four implicated proteins include two medications already on the market: cetuximab (Erbitux), an anticancer agent, and celecoxib (Celebrex), an anti-inflammatory. A drug that inhibits the other two proteins has been tested in people but isn't on the market. —N. SEPPA

Disinherited Ancestor

Lucy's kind may occupy evolutionary side branch

About 30 years ago, African excavations yielded the 3.2-million-year-old partial skeleton that became known as Lucy. The find, along with other fossils unearthed soon after, belongs to the species *Australopithecus afarensis*. Many scientists regard these creatures as ancestors of both the lineage that led to modern humans and of another, now-extinct evolutionary lineage known as robust australopithecines.

However, an analysis of an *A. afarensis* jaw from a skull discovered in 2002 near Lucy's site in Ethiopia supports a long-standing minority viewpoint that Lucy's kind occupied only a side branch of human evolution. *A. afarensis* evolved into the relatively small-brained, large-jawed robust australopithecines but didn't contribute to the evolution of modern people, says anthropologist Yoel Rak of Tel Aviv University.

Rak and his coworkers base their conclusion on the size and shape of a horizontal bone that connects the lower jaw to the upper jaw. This bone, called the ramus, looks much the same in *A. afarensis*, in a roughly 2-million-year-old robust australopithecine species known as *Australopithecus robustus*, and in modern gorillas, the researchers report in an upcoming *Proceedings of the National Academy of Sciences*.

All other primates, including chimpanzees and fossil members of the human-evolutionary family, share a different ramus configuration, the team asserts.

These findings "cast doubt on the role of *A. afarensis* as a modern human ancestor," Rak says.

Rak's team examined 146 jaws from modern primates: 41 people, 31 gorillas, 29 pygmy chimps, 29 common chimps, and 16 orangutans. The researchers obtained 20 size and shape measurements from digital images of each ramus. They then used a computer program to calculate an average ramus contour for each primate group. People, chimps, and orangutans displayed a similar contour.

In the newly unearthed *A. afarensis* jaw and in a handful of previously discovered partial jaws from the same species, the ramus closely resembles that of the gorilla, Rak says. Key traits include an especially wide upper ramus and a relatively small notch where the bone attached to the upper jaw.

Two *A. robustus* specimens that retain part of the ramus also show a gorillalike pattern, the investigators hold. So does a 2.5-million-year-old South African fossil that had been attributed to *Australopithecus africanus*, in Rak's view. That's evidence that *A. africanus* was another robust australopithecine, he says.

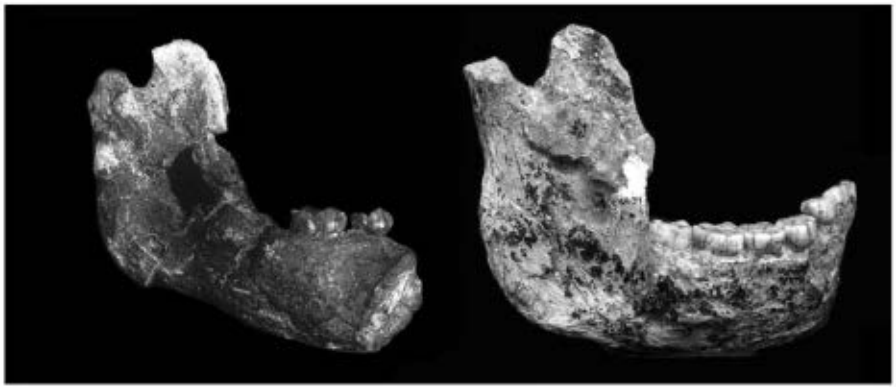
Fossils from ancient *Homo* species, as well as those from a nearly 4.5-million-year-old human ancestor dubbed *Ardipithecus ramidus*, display a ramus configuration like that of modern chimps.

Rak theorizes that a chimplike ramus appeared in the first members of the human evolutionary family and then in later species. However, Lucy's kind independently evolved a gorillalike ramus that was passed on to robust australopithecines, he asserts.

Other researchers disagree. The ramus doesn't offer enough information for scientists to reconstruct broad evolutionary relationships among Lucy's kind and other ancient species, remarks anthropologist Tim White of the University of California, Berkeley.

"Rather than trying to use the top edge of this jaw in such a dubious manner, [Rak's group] would have done better to describe and analyze the important new skull that goes with it," White says.

Donald C. Johanson of the Institute of Human Origins in Tempe, Ariz., and a codiscoverer of Lucy's skeleton, had no comment on Rak's report. —B. BOWER



RAK

JAW LINKS In fossils from Lucy's kind (left) and *Australopithecus robustus* (right), the contours in the bone at the back of the jaw resemble those of a gorilla.

TAKEN FOR A SPIN

Scientists look to spiders for the goods on silk

BY AIMEE CUNNINGHAM

To illustrate the amazing properties of spider silk, Nikola Kojic offers an arresting example. Imagine a circular web with a diameter of 100 meters—about the length of a football field—spun from a silk thread about a centimeter thick. Concentric circles 4 cm apart attach to the web's spokes, also 4 cm apart. This larger-than-life web "could stop a jumbo jet in midflight," says Kojic.

Impressive—as would be the jumbo spider that one could imagine crawling over to the jet. But beyond the monster-movie possibilities, the scenario demonstrates what scientists covet most about spider silk: its exceptional capacity to absorb kinetic energy. Scientists would like to exploit that property in items ranging from bulletproof vests to suspension cables for bridges.

Spiders store tiny amounts of silk. Harvesting the material from the animals isn't practical, says Kojic, a biomedical engineer at the Massachusetts Institute of Technology (MIT).

Instead, scientists have focused their efforts on making synthetic versions of spider silks, but they haven't yet produced a material as tough as the original. The best industrial fibers, such as Kevlar, don't absorb as much kinetic energy as spider silk does. Their manufacture, moreover, is not environmentally friendly because it requires organic solvents and high temperatures and pressures.

In contrast, natural spider silk is produced at room temperature with water as a solvent, says Chris Holland, a zoologist at the University of Oxford in England. "It's made in the spider, and with the spider eating flies. That produces a fiber that we can't even come close to."

Some researchers are considering silk from the spider's perspective. This research is providing insights into the roles that the threads play in spiders' lives. But a focus on the spider may also offer the best chance at replicating the material. New studies examine the flow of the material during the spinning process to learn how a spider makes a thread.

At the center of these pursuits lies the winning formula. "Until we know the full system," says Holland, "we won't be able to make a silk as well as the spider can."

BLACKLEDGE

NICE THREADS — An orb web spun by *Cyclosa simplicauda* on the Big Island of Hawaii. This species of spider, showing an uncommon touch, weaves its egg sacs (the beige bulges) onto the top spoke. More often, spiders hide their egg sacs in nearby vegetation.

PROPERTY VALUES When researchers talk about mimicking spider-silk production, they are usually referring to dragline silk. Orb-weaving spiders, which spin circular webs with characteristic wagon-wheel spokes, use dragline silk for the web's outer rim and spokes. This thread is also the animal's lifeline when it drops from a height.

Researchers prize dragline silk for its strength and its toughness, two distinct properties, explains Todd A. Blackledge, a behavioral ecologist at the University of Akron in Ohio. The more stationary weight a rope can support, the stronger it is.

In contrast, toughness refers to the amount of kinetic energy that a material can absorb without breaking. To lasso a running horse, for example, the rope needs to be tough. Bulletproof vests, which protect the wearer by halting an oncoming slug, are tough.

"Dragline silk is as strong as steel, but not as strong as Kevlar," says Blackledge. "But [this silk's] toughness is far superior to either of these."

The orb weavers spin five fibrous silks and two adhesive silks. Among the fibrous silks is dragline, or major-ampullate silk. Orb weaving spiders build the spirals on their webs with minor-ampullate and capture-spiral silk. The spiders wrap their captured prey with aciniform silk and construct their egg sacs primarily from tubuliform silk.

When building a web, "what a spider is doing is spinning a little miniature environment," Blackledge says. From mating to catching food to protecting the animal from the elements and predators, a web affects various aspects of a spider's life. The properties of silk become relevant, for example, when investigating how a particular type of web catches prey. "You can't really ask that question without understanding the material being used to spin that web," Blackledge says.

Researchers are most familiar with the mechanics of dragline and capture-spiral silk, which is sticky, extremely stretchy, and tough. The properties of these two silks make webs effective for trapping flying insects, explains Blackledge. The dragline frame of the web absorbs the brunt of an insect's energy. The capture-spiral silk absorbs some energy but sticks to and stretches with the insect, so that it decelerates slowly and doesn't bounce off the web.

To learn about the lesser-known silks, Blackledge and his colleague Cheryl Y. Hayashi of the University of California, Riverside studied the five fibrous silks of the orb-weaving silver garden spider, *Argiope argentata*. They collected two of the silks directly from the spiders and the other silks from webs, wrapped prey, and egg sacs. They extended the fibers and measured the silks' mechanical properties using a tensile-testing machine.

In the July 1, 2006 *Journal of Experimental Biology*, Blackledge and Hayashi reported that the silks make up a diverse toolkit of fibers "that seem fine-tuned for particular ecological functions." For example, in keeping with its prey-capturing role, the capture-spiral silk is 10 times as stretchy as the other silks. Meanwhile, the tubuliform silk of the protective egg sacs is the stiffest.

Furthermore, the researchers found that aciniform silk, the threads that the spider uses to wrap and secure freshly captured—and still wriggling—prey, is two to three times as tough as the other silks, including dragline.

For a materials scientist interested in a high-performance fiber that absorbs kinetic energy, notes Blackledge, "the prey-wrapping silk may be a better model to study than the dragline."

GOTCHA — An adult female *Argiope aurantia* injects venom into a honeybee caught in an orb web. The spider first wrapped her prey in aciniform silk. She will soon cut the prey from her web, bring it to the center, and have her meal.

Blackledge is interested in the extent to which shifts in spider behavior have influenced the performance of silks. "When the silk is used in a new ecological context, what happens to the material properties?" Blackledge asks.

MATERIAL DIFFERENCE Silk's mechanical properties primarily derive from two critical factors: the proteins that make up the material and the spinning process that transforms the liquid generated inside a spider into a solid fiber.

Randolph V. Lewis, a molecular biologist at the University of Wyoming in Laramie, and his coworkers have determined the amino acid sequence of several silks. They've found distinct amino acid motifs that contribute to different silks' properties.

For example, the two major proteins in dragline silk contain frequently occurring stretches of the amino acid alanine. Lewis says that these alanine repeats give the fiber strength by permitting one protein chain to snap tightly to another, much as Lego blocks combine. Minor-ampullate silk, which is not as strong as dragline, has shorter stretches of alanines.

Meanwhile, capture-spiral silk has a motif, based on a sequence of five amino acids that's repeated up to 68 times in a row (*SN: 2/21/98, p. 119*). Lewis speculates that this sequence introduces a series of spiraling molecular springs into the protein, which may explain the silk's extreme stretchiness.

Lewis' group has built artificial silk genes and inserted them into the common bacterium *Escherichia coli* to make proteins that are shorter than the natural versions. The researchers add the resulting proteins to organic solvents, spin this material into fibers with a commercial spinning machine, and test its mechanical properties. If the researchers increase the number of capture-spiral-silk motifs, for example, the elasticity of the fiber grows, although not in direct proportion to the number of motifs.

While scientists know a lot about the sequence of individual chains and a bit about the chains' interactions with each other, higher levels of structure are "basically completely unknown," Lewis notes. A silk thread contains hundreds of thousands of protein chains, each of which folds on its own and also arranges itself among other chains in the fiber, he says. He and his colleagues have begun nuclear magnetic resonance studies to explore these structural details.

"The spider hasn't given us all the secrets," Lewis says.

GO WITH THE FLOW Silk's transformation to a solid fiber from a thick liquid containing primarily protein and water begins in specialized glands, one for each type of silk. In each gland, a structure called the tail secretes the starting solution, or spinning dope, into a storage sac. When the spider is ready to spin, the dope moves into a duct. The diameter of the duct narrows as it reaches a nozzle from which the thread exits the spider.

To understand the characteristics of the spinning dope, some scientists have turned to rheology, the study of how materials deform and flow. Silk dope has properties intermediate between those of typical liquids and solids, explains Gareth H. McKinley, a mechanical engineer at MIT. Such viscoelastic materials are thick rather than runny. They're also elastic: After being stretched, they return to their original states. Silly putty and uncooked egg white are two familiar examples of viscoelastic materials, McKinley says.

The handful of previous rheology studies of dope used samples that had been diluted to make their volumes large enough to be tested. But machines that can work with small samples of material are now available, notes Holland. Scientists can test tiny amounts of silk dope that have been extracted from a spider. Reports on freshly obtained dragline-dope samples were published last fall by an Oxford team, led by zoologist Fritz Vollrath and including Holland, and by McKinley's team, which includes Kojic.

An important concept in rheology is shear, the sliding motion of adjacent layers of material. Silk dope experiences shear forces as it moves through the spinning duct. McKinley's group built a microrheometric device that measures how the viscosity of the dope changes in response to shear forces. The researchers place the sample—a drop of dope the size of a pen tip—between two plates. The lower plate remains stationary as the upper plate moves back and forth. The machine's action is much like rubbing a drop of lotion between thumb and forefinger to gauge its slipperiness, says McKinley.

The researchers found that the faster the upper plate moves, the more readily the dope flows. Shear forces align the proteins in the dope, Kojic says, "and as the proteins align, it becomes easier for them to move relative to one another." Adds McKinley, "Take a big bucket of spaghetti. If you keep stirring it clockwise, it gets easier because the spaghetti strands are lining up."

This effect explains how the thick dope can progress through the narrowing duct in an energy-efficient manner, Kojic notes. The team calculated that overall, the viscosity of the dope decreases 10-fold as it flows through the duct.

BLACKLEDGE

Vollrath, Holland, and their colleagues examined shear viscosity by using a commercial rheometer. Like McKinley's team, they found that the dope flows more easily as the shear rate increases.

To learn how a spider spins a continuous fiber, McKinley's group developed another microrheometric device that measures the dope's resistance to stretching, its extensional viscosity. The device's operation is akin to a saliva-dabbed thumb and forefinger pulling apart rather than sliding. A laser determines the diameter of the resulting silk.

The researchers found that the dope's extensional viscosity increases 100-fold as the dope is pulled into a thread. This change prevents the thread from breaking before it solidifies. The researchers reported their results in the Nov. 1, 2006 *Journal of Experimental Biology*.

"Hopefully, [the findings] give you guidelines on how you would want to formulate a synthetic equivalent," says McKinley.

By testing an artificial silk in a similar way, "you can see whether you match these properties," adds Kojic.

SITTING PRETTY — An adult female *Neoscona hentzi* spider sits at the center of her orb web. Some spiders stay on their webs for extended periods, while others come to the web only to collect captured prey.

FLOWING FARTHER Vollrath's team also compared the rheology of the dragline dope with that of silkworm dope. Spiders and silkworms evolved the capacity to spin silk independently of each other, Holland says.

The dopes contain different proteins, and the resulting fibers have distinct properties. Yet "what we see is that the flow properties are very similar," Holland says. Despite their differences, the spider and silkworm "use similar tricks," he continues. "This gives fantastic insight into how silk production has evolved and how the production of an energy-efficient, high-performance fiber is made by nature."

Moreover, Holland and his colleagues reported in the November 2006 *Nature Materials*, both the spider and silkworm dopes behave like melted polymers. This is "a most welcome observation," they say, because well-developed theories of polymers can be used in studies of silk dope.

With rheology proving to be "a valuable tool in showing how silk is physically processed," says Holland, scientists can now move forward in an area that was largely absent from previous attempts to replicate silk.

As scientists working to make artificial silks apply new information about dope and how spiders spin it, perhaps they should take a longer-range view of success. As Blackledge notes, "Spiders have been spinning these silks for almost 400 million years." ■

BLACKLEDGE

FASTER, CHEAPER, BETTER

Easier genetic sequencing could make personalized medicine a reality

BY CHRISTEN BROWNLEE

Imagine that you have the flu. After spending a couple of days with a hacking cough, a blazing fever, and muscles aching to the core, you finally head to the clinic. There, your primary care physician takes notes as you list your symptoms. As your monologue of complaints grinds to a halt, she pulls a page from the middle of your chart and nods. "It's just as I suspected. Your genes make you especially vulnerable to this year's strain of flu virus," she says.

After reviewing a summary of your unique genetic sequence, she continues, "I'd give you the standard flu drug, but you have a mutation that makes you unable to metabolize that medicine." However, you're in luck—your doctor adds that a new drug developed specifically for people with your genetic profile has just entered the market. As she hands you the prescription, you marvel at the wonders of modern medicine.

Does this scenario sound too good to be true? For the moment, it is. The current cost of sequencing your genome is beyond your insurance company's willingness to pay—on the order of millions of dollars. And the sequencing process is months too slow to be useful against this year's flu virus.

Methods now in the works could remove this roadblock over the next several years by making the sequencing process quicker and less expensive. Then scientists can get down to the business of designing medicines and care that is specific to each person's genes.

TRIED, TRUE, TIRED The method that researchers currently use to sequence the genomes of people and other organisms is the same one, give or take a few tweaks, that's been in place for the past 3 decades. That method, created in the mid-1970s by Frederick Sanger of the Medical Research Council in Cambridge, England, starts with the isolation of long strings of double-stranded DNA from cells. Each string contains pieces called bases—chemical units that go by the names adenine, thymine, guanine, and cytosine. Researchers typically refer to the bases by their initials: A, T, G, and C.

Once researchers have separated DNA from the rest of a cell's innards, they use vibrations, high-pressure jets of water, or other forces to break those strings in random places into tiny pieces of approximately the same size—about 1,000 bases long. The scientists place these pieces one by one into bacteria that, as they divide, replicate an introduced DNA chunk as they would their own chromosome. Such replication gives researchers plenty of copies of the DNA pieces to work with.

Next, within each fractured-DNA solution, researchers split the double-stranded material into single strands and add them to lab dishes or test tubes containing two ingredients: a protein called DNA polymerase and a supply of the four bases.

In cells, the protein normally crawls along single-stranded DNA and adds bases one at a time to make the second strand and thereby return the DNA to its double-stranded form. At each step, DNA polymerase adds the base that complements the one already in place in the single strand. A pairs with T, and G pairs with C.

In the lab's sequencing setup, DNA polymerase does the same thing, but the mix of bases includes a few that researchers have made easily detectable by tagging them with radioactivity or fluorescence. Those altered bases also carry chemical groups that will, once within DNA, halt the addition of more bases.

The rebuilding DNA strand then occasionally incorporates one of the tagged, full-stop bases instead of its unaltered brother. By looking for signs of these tagged bases in pieces of various lengths, researchers can figure out where each of the base types—A, T, G, or C—lies in the DNA strand.

Each step along this pathway takes just a few minutes. However, the human genome is made up of more than 3 billion pairs of bases, notes project manager Jeffrey Schloss of the National Human Genome Research Institute, which is part of the National Institutes of Health in Bethesda, Md.

"Right now, it takes months and months for a very large operation to sequence a human genome," Schloss says. He adds that deciphering a sequence, while minimizing errors, costs about $5 million. That amount pays for skilled technicians, expensive chemicals, automated machines, and sometimes high-power cameras to detect tiny light flashes.

> "Right now, it takes months and months for a very large operation to sequence a human genome."
>
> — JEFFREY SCHLOSS, NATIONAL HUMAN GENOME RESEARCH INSTITUTE

SHEDDING LIGHT To reduce the time and cost of gene sequencing, Schloss explains, NIH is funding the development of several new approaches. Some of these strategies miniaturize and streamline the Sanger process. Others take different routes to a person's genetic sequence.

One of these novel approaches uses light to indicate the order of bases in a string of DNA.

Several years ago, Mostafa Ronaghi of Stanford University in Palo Alto, Calif., and his colleagues discovered that a chemical called pyrophosphate is released each time DNA polymerase adds a base to a single strand of DNA. Next, an enzyme normally present in cells uses the two phosphate ions in each pyrophosphate molecule to make adenosine triphosphate (ATP), a chemical in which cells store energy.

To take advantage of this activity, Ronaghi and his colleagues prepped a test tube with ready-to-replicate DNA and a chemical that uses ATP to generate light. They then added a solution containing only one base. If that base was the one that the DNA was ready to incorporate, the subsequent reaction released pyrophosphate and the solution glowed. If the base wasn't right, the researchers washed it out and added other bases, one at a time, until the solution glowed again. A computer recorded the sequence detected.

Now, working with a company called Biotage, based in Uppsala, Sweden, the researchers are automating the technology and miniaturizing it to put on a tiny chip. Although the current system still takes months to read a human-size genome, Ronaghi says that he expects, within the next 3 years, to streamline the process to sequence a person's genome in a single day. He estimates the cost for such a service would be about $10,000—still expensive, but much lower than current prices.

With further tweaks that the company is contemplating, he says, "we might even have the opportunity to get it down to $1,000."

Schloss says that other teams, such as the group led by Stephen Turner of Protea Biosciences in Morgantown, W. Va., aim to take a slightly different approach to sequencing a person's genome. Rather than having a single light flash indicate that DNA polymerase has added a base to a lengthening DNA strand, these scientists use chemical reactions that would generate a different color of light for each base. This method would make it possible for a color-reading device to quickly register each time that DNA polymerase added a base to the DNA strand.

POKING HOLES While their developers expect these technologies to reach the market within a few years, others in earlier experimental stages might make DNA sequencing faster and cheaper still. A team of researchers led by Reza Ghadiri of the Scripps Research Institute in La Jolla, Calif., is building its method around tiny holes called nanopores.

Other researchers noticed in the early 1990s that an enzyme called alpha hemolysin pokes nanosize holes into the cell membranes of organisms that some bacteria have infected. Because each DNA base is slightly smaller than an alpha hemolysin–created pore and has a characteristic shape, Ghadiri and his colleagues reasoned that they might distinguish the bases on a DNA strand moving through membrane pores.

The scientists placed a salt solution on each side of the membrane. Then, they threaded a single strand of DNA through a nanopore. The researchers monitored the flow of salt ions traversing the hole as each of the DNA bases squeezed through in sequence.

In the team's initial experiments, the DNA passed through the hole too quickly to let the researchers read out differences in ion flow.

The researchers have since developed several ways to avoid that problem. For example, the team recently placed chemical groups that act as stoppers on each end of the DNA strand to be analyzed. Rather than slipping out of the pore, says Ghadiri, the DNA strand moves back and forth. "It goes in and out like you're playing the cello," he explains. After observing numerous passes of a sample DNA strand through a pore, the team distinguished the order of the bases.

In more-recent experiments, Ghadiri's team tested a method to control the movement of the DNA strand. The researchers added DNA polymerase to one end of a strand that's threaded through the pore. The polymerase is too wide to enter the pore, so as the polymerase crawls along the single strand, adding bases, it pulls through the DNA at a measured pace.

Other teams are developing similar nanopore technology using holes mechanically drilled through silicon and other materials.

Ghadiri says that "the jury is still out" on whether biological nanopores, such as the one he's developing, or those in synthetic materials will be better for sequencing genomes. While organisms such as bacteria could eventually be engineered to develop pores with advanced capabilities—such as generation of a different electrical response for each of the bases within a string of DNA—synthetic nanopores wouldn't need care and feeding as an organism does.

Regardless of which pore material wins out, Ghadiri says that the technique could dramatically lessen the time and cost of genome sequencing. It doesn't require expensive chemicals and equipment. Ghadiri estimates that sequencing a person's genome using nanopores will eventually take only hours and will cost less than $1,000.

DANGLING CARROT A new competition could speed the development of faster sequencing techniques. The X Prize Foundation, a Santa Monica, Calif.–based group, runs private competitions promoting projects ranging from low-cost space travel to the invention of ultraefficient cars. The foundation announced last October that it would award $10 million to the first group to develop a way to sequence at least 100 people's genomes in 10 days at a cost of no more than $10,000 per genome.

> "The solution to this problem could involve technologies outside current activity and may come out of left field."
>
> — LAURENCE KEDDES, X PRIZE FOUNDATION

Three teams with sequencing experience are already on the roster of competitors for the prize, says Laurence Keddes, scientific director of the X Prize for Genomics.

"The solution to this problem could involve technologies outside current activity and may come out of left field. We want to have a big-enough carrot out there" to draw more than the usual genomic researchers, Keddes says.

He notes that several other scientists from both academia and industry have expressed interest in the contest.

Schloss says that both the new X Prize and further government funding increase the odds that patients will eventually have a routine genetic sequence in their medical records. Even then, he says, researchers have much work to do before such information can guide a doctor's care. Scientists still don't understand the function of most genes in the human genome.

Sequencing a person's genome "will be relatively easy," Schloss says. "We will soon have the ability to collect genome sequences on individuals faster than we'll be able to interpret them." ■

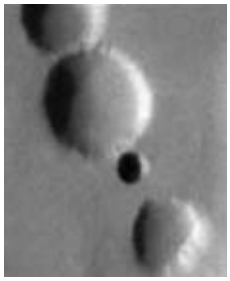
OF NOTE

PLANETARY SCIENCE

Cavernous findings from Mars

Images taken by a Mars-orbiting spacecraft show what appear to be cave entrances on the Red Planet. By sheltering organisms from such hazards as ultraviolet radiation and micrometeoroid bombardment, caves "could be among the only places on Mars to find evidence of past or present microbial life," says Glen Cushing of the U.S. Geological Survey in Flagstaff, Ariz.

He and his colleagues identified seven possible skylight entrances to caverns in pictures recorded by a visible-light-and-infrared camera on the Mars Odyssey spacecraft. They presented the findings in March at the annual Lunar and Planetary Science Conference in Houston.



CUSHING ET AL., NASA

HIDEAWAYS? The small, dark, circular feature in this Martian image could be the skylight of a cave. Larger, lighter circles are craters.

The dark, circular structures, 100 to 250 meters across, lie on the flanks of a volcano called Arsia Mons. The high-altitude region is riddled with sunken features, but the dark circles are distinct, Cushing says.

It's possible that the structures aren't deep, Cushing acknowledges. But the nearly constant temperatures of the structures—different from temperatures of nearby surfaces—suggest that they're openings to caverns, he asserts.

His team is now conducting a planetwide search for other caves, especially at lower elevations, where higher atmospheric pressure could allow water to exist as a liquid. —R.C.

BIOMEDICINE

Augmenting the good cholesterol

A reconstituted version of good cholesterol may lessen the amount of plaque that accumulates in coronary arteries and might render the plaque that's already there less dangerous, researchers find.

High-density lipoprotein (HDL) molecules are protein shells that ferry excess cholesterol out of blood, artery walls, and other tissues for safe disposal. But some people make too little HDL, permitting a buildup of cholesterol in problematic low-density lipoprotein (LDL) shells. Researchers tested an experimental drug formed by merging a body compound, called apolipoprotein A-1, and a soybean compound. The combination works like HDL to remove LDL from the blood.

Cardiologist Jean-Claude Tardif of the University of Montreal and his colleagues gave 89 people four weekly infusions of the combination drug, while 47 other patients received placebo infusions. All the volunteers already had some atherosclerosis, and nearly all were taking a statin drug to lessen LDL.

Over 7 weeks, those getting the combination drug experienced plaque shrinkage of 3.4 percent, whereas those getting a placebo had only a 1.6 percent drop.

Furthermore, plaques in volunteers getting reconstituted HDL showed characteristics that make the plaques unlikely to lead to dangerous blood-clot formation, Tardif says. The report appears in the March 26 *Journal of the American Medical Association*.

The findings contrast with bad news regarding the once-promising HDL increaser torcetrapib (*SN: 5/1/04, p. 285*). Tardif and others report in the March 29 *New England Journal of Medicine* that that drug failed to shrink arterial plaques and hiked blood pressure. —N.S.

NEUROSCIENCE

Rats take fast route to remembering

People call on a rich background of relevant experiences to organize and remember new material. Rats do the same, and with surprising speed, say Dorothy Tse of the University of Edinburgh and her coworkers.

Prior studies, which have focused on task learning unrelated to preexisting knowledge, indicate that a brain region called the hippocampus incorporates new facts and events into memory. The hippocampus gradually yields to another structure, the neocortex, as new memories become stronger. This process typically takes at least 1 month in rodents and a few years in people.

Tse's team trained groups of rats to associate six flavors, including banana and bacon, with six designated spots within a laboratory-test area. Rats received food with a particular flavor in one of four entries to the area and then could obtain more of it by going to the correct location. The animals learned all six flavor-place associations in 1 month.

Further experiments indicated that the animals had also developed a framework of knowledge about relations between places and flavors that enabled them to learn new pairings remarkably quickly. The rats remembered novel flavor-place associations after just one trial and retained this information for at least 2 weeks, the scientists report in the April 6 *Science*.

The rats' formation of a knowledge framework spurred the neocortex to integrate new information into memory in record time, the scientists propose. Surgical removal of the hippocampus 48 hours after the rats had rapidly learned new flavor-place associations left those memories intact, a sign that the neocortex had already taken charge of the material. —B.B.

EPIDEMIOLOGY

Even outdoors, generators pose risks

A portable generator is frequently the culprit in domestic carbon monoxide poisonings—even when the device sits outside the home.

The Centers for Disease Control and Prevention in Atlanta and the Florida Department of Health collected data from 10 Florida hospitals on people diagnosed with unintentional carbon monoxide poisonings between August and October 2004. Four major hurricanes pounded the state during that period, causing power outages.

The researchers identified 167 people treated for nonfatal poisonings. The illnesses stemmed from 51 incidents, 46 of which involved portable generators.

Using medical records and interviews, the team found that 22 of the generators were outside the house and garage. The generator was in the garage in 15 incidents, inside the house in 7 of them, and in an unknown location in 2 others. Outside generators were, on average, 7 feet from a dwelling.

"We've come to think that people are being poisoned because they are putting generators inside," says team member David Van Sickle, now at the University of Wisconsin–Madison. But even people trying to use the devices safely are getting poisoned, he says.

Generator manufacturers and public health agencies should determine a safe distance for the devices, the team says in the April *American Journal of Preventive Medicine*. Future generator technologies might reduce carbon monoxide emissions. —A.C.

CHEMISTRY

Enzymes release caged chemicals

A new controlled-release system relies on enzymes to unshackle chemicals only when and where they're needed. Scientists at the Netherlands Organization for Applied Scientific Research in Zeist are developing what they're calling bioswitches for a number of applications, such as a germ-killing plastic wrap for meats.

The researchers encapsulated lysozyme—a natural antibiotic—within a cage of chemically linked starch molecules and seeded the complexes onto the wrap's surface. Any bacteria contaminating a piece of meat would view the starch as a snack, explains project manager Hans Boumans, a biochemist. Once the microbe starts feasting on the starch cage, it opens holes and releases the killer lysozymes. "It's like a Trojan horse," says Boumans.

Contact lens cleaners offer another application. Wearers are supposed to soak their dirty lenses for 7 minutes in dilute hydrogen peroxide and then neutralize the chemical with the enzyme catalase. However, impatient consumers often neutralize the solution too soon, cutting short the disinfection step.

The Dutch researchers developed a catalase-releasing bioswitch that can be added to the peroxide at the same time as the lenses are. Boumans' team engineered the bioswitches to release a starch-degrading enzyme—amylase—that slowly breaks apart the cage that contains it. They tweaked the cage design so that it would degrade after only 7 minutes of soaking.

The team is also tailoring edible bioswitches to protect expensive and unstable flavoring molecules until they contact enzymes on the taste buds, Boumans says. Other complexes would bypass the tongue and carry certain foul-tasting nutrients to the stomach, where enzymes would release the molecules. —J.R.

BIOMEDICINE

New agent to spy clogged arteries

High-density lipoproteins (HDLs) are referred to as the good cholesterol because they can penetrate artery-clogging plaque and carry away some of the bad cholesterol. Now, researchers in New York City have designed a nanoparticle, modeled on HDL particles, to improve the detection of such arterial plaques.

Like HDLs, the new contrast agent enters fatty deposits on vessel walls. Under magnetic resonance imaging (MRI), the new molecule shines brightly and highlights cholesterol buildups in partially blocked arteries.

Current MRI contrast agents "have no affinity for the cholesterol plaque," notes medicinal chemist David Cormode of the Mt. Sinai School of Medicine. His team created the new plaque-seeking agent by binding atoms of gadolinium—an excellent MRI contrast agent—to a shortened, synthetic analog of the HDL protein. The researchers canceled gadolinium's normal toxicity by attaching other molecules to the metal.

In tests on seven mice, the new agent improved the detection of arterial plaques by almost 80 percent, compared with MRI using a conventional contrast agent. Within a few weeks, the agent will be tested in rabbits.

If the synthetic HDL works as well in people, Cormode says, the new contrast agent will improve physicians' ability to track the effectiveness of plaque-busting treatments. —J.R.

MATERIALS SCIENCE

Color-tunable sunglasses

Some people want their sunglasses dark green. Others prefer brown or deep-blue shades. Engineers have developed a way to change eyewear lenses from blue back to clear—at the flip of a switch. Future glasses may switch among any of a series of colors.

The changeable shades rely on novel polymer films sandwiched between layers of glass. Depressing a switch on the frames sends a tiny current from a watch battery to the polymer in each lens. Applying the current once turns this electrochromic polymer a dark color. Hit the switch again and the color goes away. Once the film becomes transparent or assumes a color, it needs no further power to stay that way—at least for 30 days.

The prototype switches only between dark blue and clear, reports Chao Ma of the University of Washington's Center for Intelligent Materials and Systems in Seattle. Adding more colors will require multiple sandwiched polymer films. How dark any polymer becomes will depend on its chemical formula and on the electrical potential applied by the circuit.

The novel lenses could become "the fashion statement of the future," says program leader Chunye Xu. —J.R.

COLOR—OR NO? A first-generation prototype of new, switchable sunglasses resembles designer lab goggles.

XU

CHEMICAL ENGINEERING

Gene dispensers

Researchers have developed a new means for transferring genes to treat diseases. The gene therapy method relies on a nanoscale architecture with many alternating layers of polyester and DNA. Once this material is inside the body, water degrades the polyester layer by layer, for a slow, controlled release of genetic material to nearby tissues.

The technology has shown preliminary success in transferring genes both to isolated cells grown in the lab and blood vessels in rabbits, reports David M. Lynn of the University of Wisconsin–Madison.

Key to the new system are novel, water-soluble polyesters that carry a net positive charge across their surfaces. Thin films of the material make ideal platforms for negatively charged DNA molecules.

The multilayered-film strategy could be useful in arterial stents, says Lynn. Surgeons mechanically unclog arteries and then use the tiny mesh tubes to prop open the vessels. Because arteries fitted with stents can begin reclogging shortly after surgery, researchers have been looking to coat the tubes—or a sleeve inserted inside them (*SN: 3/18/06, p. 163*)—with clog-inhibiting genes (*SN: 11/24/01, p. 328*).

Lynn's layer-cake approach offers more flexibility than earlier systems did because different genes can be incorporated into different layers, and the polyester's recipe can be customized, layer by layer, for different breakdown rates.

Although the material's longest gene-release period thus far has been 3 months, Lynn says that the system could be designed to shed genes for a year. Moreover, he notes, the layers could coat injectable particles that could carry DNA to a target tissue via the bloodstream. He predicts that none of these new systems will be ready for human trials for at least a decade. —J.R.

Books

A selection of new and notable books of scientific interest

FLOWER CONFIDENTIAL: The Good, the Bad, and the Beautiful in the Business of Flowers

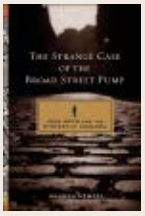
AMY STEWART

The cut flowers that people purchase every day as tokens of affection and gratitude have more often than not traveled a long road to reach the consumer. Not only have they been shipped over hundreds of miles, but some have also been genetically engineered to bloom out of season or to display colors more vivid than those found in nature. Stewart reveals the workings of the floral industry and the intensive efforts being put into breeding, growing, and selling flowers that look beautiful in a vase and remain so for long periods. Stewart, an author and a journalist, recounts how the flower trade evolved from a cottage industry involving only growers and their local customers to a big business importing flowers from South America and Africa for U.S. consumers. The author explains the science behind blooming and how breeders have made winter bloomers out of flowers that normally bloom in summer. In an epilogue, she takes a look at the floral frenzy of Valentine's Day, the industry's busiest day of the year. ***Algonquin Books, 2007, 306 p., hardcover, $23.95.***

THE STRANGE CASE OF THE BROAD STREET PUMP: John Snow and the Mystery of Cholera

SANDRA HEMPEL

In three great 19th-century pandemics, cholera indiscriminately infected the populations of cities across Europe and Asia. Along with it, fear and confusion spread, as doctors struggled to determine the cause of the illness. Hempel, a journalist, recounts officials' and doctors' efforts to conquer the disease. She profiles physician John Snow, a disciplined loner who had little status among the medical establishment. He proposed that cholera was being spread through contaminated drinking water. In what is now known as Snow's "grand experiment," he identified a contaminated pump and disabled it by removing its handle, dramatically beginning the defeat of the disease. Hempel also chronicles the development of germ theory, the debunking of spontaneous generation, and other advances in medical science that occurred during Snow's time. ***Univ. Calif. Press, 2007, 321 p., b&w images, hardcover, $24.95.***



THE LIE DETECTORS: The History of an American Obsession

KEN ADLER

Since its development in the early 20th century, the polygraph test has been administered to countless suspected criminals, employees, government officials, and others in attempts to sort liars from truth tellers. But the scientific validity of lie detector machines has never been confirmed, writes Adler, and the justice system has discredited their use in recent years. Indeed, the polygraph machine never caught on outside of the United States. Why, then, do people continue to believe that it can reveal guilt and innocence? Adler, a professor of history, examines the science behind the machine He also describes John Larson, a police officer with a Ph.D., and Leonarde Keeler, a charismatic promoter. Larson, seeking to bring science to crime solving, devised the first lie detector. It repeatedly read a person's blood pressure and breathing rate during interrogation. Keeler had an interest in forensics and an unrelenting faith in Larson's invention. While Larson became wary of the way in which his creation was being used, Keeler saw a business opportunity in the machine. Adler also examines current research into lie detection, which today employs methods as varied as magnetic resonance imaging and readings of fleeting facial expressions. ***Free Press, 2007, 334 p., b&w plates, hardcover, $27.00.***

FLOWERING PLANT FAMILIES OF THE WORLD

V.H. HEYWOOD, R.K. BRUMMITT, A. CULHAM, AND O. SEBERG

Originally released in 1978, this reference has remained the definitive guide to flowering plants for amateur and professional gardeners and students. This new edition is updated with the latest classification information, compiled by an international team of plant experts. The book starts with a glossary of plant terminology, including illustrations depicting the common forms of flowers, fruits, leaves, and reproductive structures. It then presents detailed descriptions of plant families—including common names, geographic distribution, physical description, classification, and economic uses. Small maps indicate where the plants are native. ***Firefly, 2007, 424 p., color illus. hardcover, $59.95.***

ANIMAL ARCHITECTS: Building and the Evolution of Intelligence

JAMES R. GOULD AND CAROL GRANT GOULD

Engineering is not strictly a human pursuit. Animals of all types, from birds to nonhuman primates, routinely build structures and dwellings to meet the challenges of their particular habitats. The Goulds, who are animal-behavior specialists, present the diverse array of animal engineering. They find that animals build to shield themselves from the elements, protect themselves from predators, and attract mates. The authors describe caterpillars and spiders that build with silk and tell about bees, ants, and wasps that build colony structures complete with air conditioning. Finally, the authors profile beavers. The book ends with a comparative look at animal and human uses of tools, physical principles, and logic. ***Basic, 2007, 324 p., b&w illus. hardcover, $26.95.***

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LETTERS

Heated comments

I am disappointed in your article on the latest Intergovernmental Panel on Climate Change (IPCC) summary ("From Bad to Worse: Earth's warming to accelerate," *SN: 2/10/07, p. 83*). It was a political summary, not the 1,500 page report that's due in May 2007. How often have you seen a scientific summary published 3 months before the final report? I am concerned that you do not appear to be publishing any other valid climate-change hypotheses, such as solar cycles, long-range historical data on climate changes, the possible role of cosmic rays and the sun's magnetic field on climate cooling, global warming on Mars, etc. You owe your readers a balanced viewpoint on climate change.

JIM CUDAHY, KNOXVILLE, TENN.

While I agree that the planet is warming, it is not manmade warming. We had a mini–ice age from 1300 to 1850 that produced glaciers, helped reduce sea level, and generated the migration of people. We have a sun in a solar maximum dumping more heat on the planet. There are more important and real pollution problems that need to be addressed than this bogus global-warming problem. We can stop estrogen imitators and other chemical pollution without destroying our economies.

DONALD R. LASTER JR.,
WEST LONG BRANCH, N.J.

I guess you haven't thought that the solar cycles are more aligned with global warming than is man's expelling of carbon dioxide into the atmosphere. Besides, volcanoes contribute much more.

GREG HACKNEY, FREEPORT, TEXAS

*For a review of how variations in the sun's magnetic field and other aspects of the solar cycle affect Earth's climate, see "Pinning Down the Sun-Climate Connection" (*SN: 1/20/01, p. 45*), which is available at* www.sciencenews.org/articles/20010120/bob10.asp. *The IPCC report does note that changes in solar irradiance since 1750 have boosted global temperatures slightly. However, the planet-warming effects of greenhouse gases generated by human activity during that period are more than 20 times as strong as those due to solar variations, the scientists estimate.* —S. PERKINS

Correction *"Ticket to Ride: Astrophysicists mull a return to the moon," (*SN: 3/24/07, p. 185*) incorrectly placed researcher Dan Lester at the University of Arizona instead of the University of Texas at Austin.*

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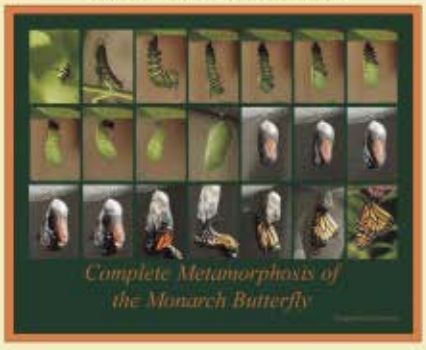

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"You Are Here" Poster
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The Periodic Table of the Elements - Poster
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