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SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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This Week

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Of Note

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Cover The lush flora that dazzles visitors to the Hawaiian Islands mostly comes from plants that are tourists themselves. They're overshadowing or outright replacing the natives, such as this *Hibiscus kokio*. (D. Ragone/National Tropical Botanical Garden) Page 88

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Virus Shield

Ebola vaccine works fast in monkey test

A one-shot version of a vaccine against Ebola fever provides protection after just 1 month, tests in monkeys show. If it proves safe to use in people, the fast-acting vaccine, deployed promptly, might help contain future Ebola outbreaks, scientists say in the Aug. 7 *Nature*.

Ebola is a highly contagious and often lethal viral infection. Including the first cases reported in 1976, nine outbreaks have sickened or killed hundreds of people in central Africa, according to the Centers for Disease Control and Prevention (CDC) in Atlanta. Wild primates are also susceptible.

Earlier, researchers tested a vaccine that entails three injections of Ebola DNA over 2 months, followed 12 weeks later by a booster shot of an adenovirus modified to carry genes for Ebola virus proteins. The adenovirus cannot replicate, but the Ebola proteins it makes grab the attention of the immune system, which were primed by the earlier exposure to Ebola DNA (*SN: 12/2/00, p. 358*).

While that two-step vaccine fostered impressive immunity in monkeys, it took several months to take hold, says Gary J. Nabel, a virologist at the National Institute of Allergy and Infectious Diseases in Bethesda, Md.

For the typical Ebola outbreak, that's too slow, he says. So, Nabel and his colleagues injected eight cynomolgus macaque monkeys with an intramuscular shot of the genetoting adenovirus. As a control group, five monkeys received an inert injection. A month after being vaccinated, the monkeys were injected with live Ebola virus.

All eight vaccinated animals survived; the other five monkeys died.

"This is real progress," says virologist Joseph B. McCormick of the University of Texas Health Science Center in Brownsville. "The difference is quite clear between the controls and the vaccinated animals" in virus concentrations in the blood, as well as in overall survival.

Nabel hopes to test both vaccine strategies on people by the end of 2004. If a single-shot adenovirus vaccine proves safe to administer and engenders a potent immune defense, it might be useful in a ring-vaccination approach, he says. Vaccinations would be given to people exposed to an infected person and also to others who spend time with those contacts.

While the vaccine appears "quite promising," it may not work in immune-compromised people with HIV, a group that includes a vast population in central Africa, says immunologist Manisha Gupta of the CDC.

Also, the time between exposure to the virus and the onset of Ebola fever's flulike symptoms and internal hemorrhaging is 7 to 21 days. Nabel says that animal tests are needed to reveal whether the vaccine derails Ebola virus if given during this time.

Ebola has a knack for popping up without warning, making it a public health nightmare, says William B. Karesh, a veterinarian at the Wildlife Conservation Society (WCS) in Bronx, N.Y. In an attempt to predict where new outbreaks will occur, WCS is training officials in central Africa to monitor deaths in wild primates and, when possible, to analyze the carcasses—using extreme precautions. Infected ape carcasses were found near the sites of two of Gabon's four outbreaks seen since 1994, WCS biologist David S. Wilkie and his colleagues reported earlier this year. The outbreaks may have started after people ate infected ape meat.

Vaccinating wild gorillas and chimpanzees might seem a good way to slow the spread of Ebola but would be virtually impossible, says Wilkie. "Even trying to dart gorillas is hard," he says, much less delivering an intramuscular injection. —N. SEPPA

Winning Bet

Horse and mule clones cross the finish line

Given Funny Cide's thrilling attempt at the Triple Crown and Seabiscuit's reign at the movies, this is arguably the year of the horse. Cloning researchers would agree. Following hard on the hooves of news that a U.S. research team had cloned a mule, an Italian group this week reports the first cloning of a true horse. The female foal, dubbed Prometea, is actually a clone of the mare that gave birth to it.

Artificial reproduction in the equine family is notoriously difficult—there have been just two horse foals created using standard in vitro fertilization techniques—so Prometea's cloning by Italian scientists has drawn praise even from competitors. "They've made a huge advance," says Gordon Woods of the University of Idaho in Moscow.

About 2 months ago, in a *Science* report online, Woods and his colleagues described how they created a mule, named Idaho Gem, through cloning. Mules, typically the result of breeding a male donkey with a female horse, are usually sterile. Woods' team harvested mature eggs from horse mares and replaced each egg's DNA using a nucleus from a fetal mule cell. Immediately after chemically triggering the eggs to start dividing, the scientists surgically

G. LAZZARI/NATURE

ALL IN THE FAMILY Prometea, the first cloned horse, and her genetically identical mother.

implanted the resulting embryos into the oviducts of horse mares.

Of more than 300 embryos transferred, just 21 lasted as long as 2 weeks. Only three of them went to term; on May 4, Idaho Gem was the first to be born.

Like several other groups, Woods' team has also been racing to clone a horse. In the Aug. 7 *Nature*, Cesare Galli of the Consortium for Zootechnical Improvement in Cremona, Italy, and his colleagues claim victory by reporting Prometea's birth on May 28.

In contrast to the mule work, the Italian team obtained immature horse eggs from ovaries obtained at a slaughterhouse. The eggs matured in laboratory dishes before investigators replaced each egg's DNA using a nucleus from skin cells of a male Arabian thoroughbred or of a female Haflinger, an Austrian breed.

After triggering more than 800 eggs to begin dividing, Galli's group permitted the resulting embryos to grow to a stage at which the researchers could non-surgically implant the 22 surviving embryos into the uteruses of surrogate mares. Four detectable pregnancies resulted, but only one went full term. By chance, the mare that provided the DNA for Prometea also gestated her. Genetically speaking, this makes Prometea a twin of her own birth mother.

Since Prometea was created from DNA of an adult horse, her birth sets the stage for the cloning of prized show and racehorses. Moreover, the Italian's group strategy is much more practical than the costly and complex approach used to create Idaho Gem, notes Katrin Hinrichs of Texas A&M University in College Station.

Beyond the commercial potential of cloning horses, Prometea's birth from a genetically identical mother seems to challenge the hypothesis that spontaneous abortion occurs when a mother's immune system doesn't recognize a fetus as genetically different, suggests Galli. —J. TRAVIS

Three Species No Moa?

Fossil DNA analysis yields surprise

Analyses of genetic material from the fossils of large flightless birds called moas suggest that three types of the extinct birds may not be separate species after all.

Moas weren't merely flightless; they're the only known birds with no wings whatsoever. The creatures, whose weight ranged from that of a large turkey to that of a small cow, lived exclusively in New Zealand and were hunted to extinction soon after people permanently settled on the islands around 1310. Although the last moas probably died less than 2 centuries later, plenty of their bones remain, many in heaps left over from ancient feasts.

Scientists currently recognize 11 species of moa. Other than slight differences in some skull features, the three presumed

BIG BIRD In this 1877 photo, British paleontologist Richard Owen, who described the first moa fossils, stands next to a reconstructed moa skeleton.

Dinornis species have been distinguished only by their size, says Alan Cooper, a paleontologist at the University of Oxford in England. *Dinornis struthoides* stood around 1 meter tall and weighed up to 115 kilograms. *Dinornis novaezealandiae* measured about twice that height and weight. *Dinornis giganteus*, the largest of all moas, stood as much as 3 m tall and weighed up to 270 kg. Members of all three types were found on both of New Zealand's major islands, Cooper notes.

Now, genetic analyses by Cooper and his colleagues hint that these species designations should be revamped. The team's studies of 30 adult *Dinornis* specimens suggest that all of those from New Zealand's North Island are genetically identical. So, they're a single species. Similarly, the *Dinornis* specimens from South Island are genetically identical to one another, although their DNA differs substantially from that extracted from the North Island fossils.

What's behind the dramatic size differences that led investigators to suggest several *Dinornis* species? In part, it's a matter of gender, says Cooper. Detailed analyses of the moa fossils' DNA show that all the remains from *D. struthoides*, the smallest *Dinornis* moa, came from males and that the other remains came from females.

The disparity between small and large females probably stemmed from diet. The specimens now designated *D. novaezealandiae* were recovered from ecosystems that weren't as biologically productive—and thus didn't provide as much nutrition—as those that yielded remains of *D. giganteus*.

Overall, *Dinornis* moas exhibit a difference between the sexes in average size and weight that outranks that of all other birds and probably that of any terrestrial animal, says Cooper. He presented his group's data last week in Reno, Nev., at a meeting of the International Union for Quaternary Research. The Quaternary period encompasses the last 2 million years.

The new findings indicate that size alone isn't a good way to distinguish species, especially in moas, notes Richard N. Holdaway, a paleontologist with Palaecol Research in Christchurch, New Zealand. Members of one moa species, *Pachyornis elephantopus*, weighed up to 170 kg about 20,000 years ago, at the height of the last ice age, but only 90 kg or so 1,000 years ago. Holdaway speculates that much of that variation derives from responses to temperature differences between the climates of those two periods, but some variation results from declines in the ecosystem's biological productivity. —S. PERKINS

New World Newcomers

Men's DNA supports recent settlement of the Americas

Genetic differences among the Y chromosomes of Central Asian and Native American men bolster the argument that people first reached the Americas less than 20,000 years ago, according to two groups of anthropologists. The new data also support the idea that a single wave of settlers gave rise to all native South Americans, they hold.

Scientists generally agree that the first people to reach the New World crossed from Siberia into North America, but just how and when this immigration unfolded remains controversial. Archaeological data indicate the presence of people in the Americas by about 14,000 years ago. Yet there's evidence of a land bridge between Siberia

NATURAL HISTORY MUSEUM, LONDON

and Alaska thousands of years earlier (*see story p. 94*), and some studies of DNA from cellular structures called mitochondria have suggested that an immigration occurred perhaps 30,000 years ago.

To address this disagreement, anthropologists have turned to variations in DNA on the Y chromosome, which passes from father to son. One such polymorphism, called M3, turns up among most Native American men but is absent in men on other continents. It therefore probably first arose shortly after the earliest colonization of the New World.

To limit how early colonization might have occurred, scientists needed to find and date some polymorphism that arose in Asia and then was carried into the New World.

In an upcoming *American Journal of Human Genetics*, Mark Seielstad of Harvard University and his colleagues describe such a genetic variation. Dubbed M242, it's present in all men with M3 and in a fraction of men in at least 24 Eurasian populations who lack M3. The M242 polymorphism therefore must predate settlement of the New World.

Seielstad's team calculates that M242 arose about 15,000 years ago. Allowing for some uncertainty in their methods, the researchers suggest that people probably arrived in the Americas no earlier than 18,000 years ago. For their calculations, the researchers estimated how many years separated generations of men and how many genetic mutations occurred per generation.

In a separate study reported in the same journal issue, Andrés Ruiz-Linares of University College London and his colleagues used M242 and other genetic patterns on Y chromosomes to argue that migration to the Americas occurred in at least two waves, beginning about 14,000 years ago. In their study, the researchers compared the genetic histories of men in Mongolia, a North American native group, and 23 native groups in South America. All the South Americans seemed to stem from the same wave of migration.

The new studies suggest a relatively late arrival of people to the Americas, says molecular anthropologist Theodore G. Schurr of the University of Pennsylvania in Philadelphia. Ruiz-Linares' evidence is also consistent with linguists' hypothesis that all native South American and many native North American populations descended from a single group of early settlers, Schurr says.

However, random genetic changes rather than multiple immigrations could explain the patterns of genetic variation observed by Ruiz-Linares' team, argues Eduardo Tarazona-Santos of the University of Maryland at College Park.

Further, Tarazona-Santos says, the new estimates of the timing of colonization don't disprove the mitochondrial DNA studies that have suggested an older settlement of the Americas. Factors such as the fraction of men who fathered children or ancient fluctuations in population size might have biased the new results, he says.

More information about whether events during the settlement differently influenced procreation among men and women could help reconcile the different colonization timings now indicated by data from Y chromosomes and mitochondria, Tarazona-Santos says. —B. HARDER

OAR/NATIONAL UNDERSEA RESEARCH PROGRAM

SEA OF PLENTY A mix of large fish, including these tuna, turns up in oceanic centers of diversity.

Shark Serengeti

Ocean predators have diversity hot spots

The first search for oceanic spots of exceptional diversity in predators has turned up marine versions of the teeming Serengeti plains and Amazon rain forests.

Records from fishing boats highlight four areas showing unusual diversity in sharks, tuna, billfishes, and other big predators, says Boris Worm of the Institute for Marine Science in Kiel, Germany. Those "major hot spots" are in waters off the east coast of Florida, south of Hawaii, off the Great Barrier Reef, and near Australia's Lord Howe Island, Worm and his colleagues report.

An overall pattern shows peak diversity in middle latitudes near prominent underwater geographic features, the researchers contend in an upcoming *Proceedings of the National Academy of Sciences*.

The new work "brings up some pretty major issues in conservation," comments shark ecologist Mark Meekan of the Australian Institute of Marine Science near Darwin. The slow reproduction of many large fish renders them especially vulnerable to overfishing when they cluster, he says. Yet preserving a hot spot or two may not adequately protect these creatures, which migrate long distances.

Worm traces his interest in hot spots to work begun in the 1980s highlighting biodiversity centers on land. Norman Myers of the University of Oxford in England and others have inspired widespread efforts to protect such locations as a biggest-bang-for-the-buck conservation strategy (*SN: 8/17/96, p. 101*).

The strategy has been slow to get its feet wet, though. One 1999 study located zones of high zooplankton diversity, but not until last year did researchers designate the top-10 hot spots for coral reef biodiversity (*SN: 2/16/02, p. 100*).

To consider the top of the marine food chain, Worm and his colleagues turned to fishing records, as they have also done to document worldwide declines in fish populations (*SN: 7/26/03, p. 59*). Both the United States and Australia require scientific observers to sail with selected commercial long-line fishing vessels. The observers record the species snagged by the strings of hundreds of hooks.

Analyzing data from the 1990s, the researchers picked out hot spots of predator diversity, where for every 50 creatures caught on a hook, at least 12 predator species showed up, on average. This underwater diversity tended to bloom between 20 to 30 degrees latitude both in the northern and southern hemispheres. Tropical and temperate species mingle there.

Also, Worm says, diversity spikes where big reefs, seamounts, or other features roil the water and kick nutrients up into sunlit zones where many organisms can use them.

Worm and his colleagues used a computer model to forecast effects of hot spot protection on commercial fishing. Safeguarding the hot spot off Florida looks particularly promising, they say, because it's not especially rich in commercial species.

Meekan welcomes the work not just for its conservation implications but for illuminating how big predators survive in the

relatively food-poor waters of the open ocean. "What they're probably doing is trekking like camels from oasis to oasis," he says. —S. MILIUS

Shining True

Marking original documents with a lick of gloss

In the age of desktop publishing, resourceful forgers can readily produce convincing copies of documents such as checks and prescriptions. Now, designers of laser color printers are fighting back with a new antiforgery technology.

Researchers at Xerox in Webster, N.Y., announced last week that they have developed a way to use laser color printers to embed a secondary image—resembling a hologram—in the glossy surface of a document. Because photocopiers and scanners can't reproduce the secondary image, this Glossmark technology offers a novel and easy way of marking original documentation and preventing forgery, comments Nicholas George of the Institute of Optics at the University of Rochester in N.Y.

The technique exploits what is actually a common flaw in color laser printing. Known as differential gloss, this bothersome distraction can interfere with how people see an image. Varying densities of ink give different parts of an image a shiny or matte finish. A person's dark hair will look shiny, for example, while a light T-shirt will have a duller appearance.

JUST THE TICKET Curved to catch the light, a sample game ticket, printed on a color laser printer, reveals a pattern of words (BOWER CUP FINALS) and fine lines in its glossy layer.

The varying gloss imparts a "ghost image," only visible at certain angles, says Xerox researcher Shen-ge Wang. It was while Wang and his colleagues Chu-heng Liu and Beilei Xu were trying to reduce differential gloss that they realized it might be put to good use.

A color laser printer works by applying color dots—either yellow, cyan, magenta, or black—to a page. By depositing dots of various sizes and intensities, the printer can smoothly render thousands of colors in what's known as a halftone image.

The key to making a Glossmark is "controlling the halftone structure—how the tiny ink dots are distributed on the page," says Liu. He and his colleagues wrote software to manipulate the amount of gloss on a print to embed secondary images, such as a company logo or a bar code.

"[The ink] has to be made into a regular, very-fine-scale pattern, so when the light hits it, it'll diffract colors in different ways," George says. "It's operating on the holographic principle."

He adds that making Glossmarks is much simpler than producing rainbow holograms of the type that already appear on credit cards and concert tickets.

So far, Wang and his colleagues have only made Glossmarks using a high-end color laser printer. But they suggest that the process could work on less expensive printers and be used for supermarket coupons, government-issued ID cards, legal papers, or even kids' craft projects.

According to George, however, laser printer ink wouldn't be durable enough for legal tender. —S. MCDONAGH

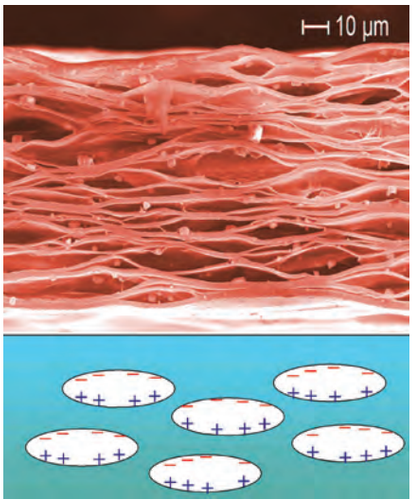
Electric Foam

Scientists uncover basis of material oddball

Some crystals change their size when exposed to an electric current and also generate electric signals when squeezed. These so-called piezoelectric materials, which are usually ceramic, appear widely in ink-jet printer heads, microphones, and some other electronic products (*SN: 3/17/01, p. 167*).

Specially treated polypropylene foam, a mainstay of the packaging industry, can mimic the defining behavior of traditional piezoelectric crystals. Now, researchers have shown that the resemblance extends to other desirable properties.

Finnish researchers 15 years ago discovered that the lightweight foam acquires piezoelectric properties after it's zapped with several thousand volts. Compared to ceramic piezoelectrics, the foam is soft, flexible, and relatively inexpensive. It has already been incorporated into a few products, including key pads and musical-instrument pickups. Because it can cover large areas and conform to irregular shapes, the foam opened new technological prospects, says Siegfried Bauer of Johannes Kepler University in Linz, Austria.



PORE PERFORMANCE High voltage separates electric charges in pores (bottom image) to make plastic foam suitable for sensors and other devices.

XEROX CORP.; BAUER

Investigating how the foam becomes a piezoelectric impersonator, Bauer and his colleagues showed a year ago that air in a pore breaks down into electrons and positively charged ions that cling to opposite walls. Like lightning, visible flashes of light accompany those "microstorms," Bauer says.

Additional research had shown that, like many piezoelectric materials, the foam is ferroelectric. Such a substance harbors an electric field that can be flipped by a voltage.

At a symposium on ultrasound research this October, Bauer and his coworkers plan to present evidence that the similarity between the foam and conventional piezoelectrics extends even further. Both materials can respond to an electric current by simultaneously expanding in some areas and contracting in others. To implement this differential response, scientists take advantage of materials' ferroelectric nature and flip internal fields in some regions but not others. This permits such capabilities as sophisticated ultrasound focusing and hidden piezoelectric bar codes, Bauer says.

The foam loses its piezoelectric quality above 55°C, a temperature sometimes reached in a car's glove box, notes materials scientist Tom Rosenmayer of W.L. Gore in Munich.

If it can be made to retain piezoelectric properties at higher temperatures, the foam could be a "breakthrough" discovery in electrically active plastics, comments Michael R. Wertheimer of the École Polytechnique in Montreal. —P. WEISS

EMERGENCY GARDENING

Labs step in to help conserve the rarest plants on Earth

BY SUSAN MILIUS

There's a rescue helicopter, but it doesn't actually land on the roof of the hospital for the world's most endangered plants. Rather, the tissue culture lab at the National Tropical Botanical Garden on Kauai sits in a trim red bungalow with a peaked roof primarily suitable for butterfly landings. There's still life-or-death drama in the business of botanists working to save the rarest of the rare plants. For example, only one individual plant of *Cyanea kuhihewa*, a gray stem topped by a tuft of straplike leaves, remains in the wild. In May, a select crew traveled by helicopter to the north side of the island of Kauai to visit the plant for a few days.

Waiting in the lab for the helicopter's return was Susan Murch, a biologist who commutes from Toronto, Ontario. She'd come to the lab at 7 a.m. to make sure she was ready when the crew arrived from the airport 15 minutes away. She was awaiting precious cargo: She had asked that the crew members, right before they started home, (gasp) pick a *Cyanea* leaf.

Murch works as a fertility doctor for plants, and she does much the same thing that other fertility specialists do. She brings the latest in hormone chemistry and cell physiology to the aid of faltering reproduction. She deals with extreme cases and has tended to endangered plants in Egypt and Costa Rica, as well as in North America.

This *Cyanea* needs her badly. The botanic garden grows a few of the plants, but they're all offspring of the same parent. That's hardly an ample genetic foundation on which to rebuild a whole species. Even the genetic variation of one more plant, that loner in the wilderness, would help.

Last year, the wild *Cyanea* bloomed, and the botanic garden spent $1,500 to send a helicopter with pollen from a garden plant for the flower. Like so many desperate fertilization attempts, though, this one failed, and the wild plant didn't set seeds.

This year, Murch has been shuttling between Toronto and Kauai as she sets up the lab to help the island's rarest plants have seedlings of their own. When the *Cyanea* rescue team arrived with a zip-sealed plastic bag holding a wet paper towel and one leaf, Murch started disinfecting the leaf and snipping it into bits that she may someday be able to coax into whole new plants.

In the world of mammals, high-tech reproductive successes have made front-page news. Yet when Murch succeeds at creating offspring for species hundreds of times more rare than the recently cloned gaur or mouflon, it's months or maybe a year before even readers of *In Vitro Cellular and Developmental Biology* see how it all turned out.

The projects may be unsung and chronically underfunded, but Murch argues that for the most depressing cases of impending plant extinction, these technologies offer real hope.

REAL HAWAIIANS — This rare haha (*Cyanea coriacea*) grows wild only on the island of Kauai. Today though, botanical bullies and other invaders are crowding out such unique flora.

D. RAGONE/NTBG

SMALL BEGINNINGS Murch explains that, yes, she really is trying to make new plants from a leaf instead of a seed. This approach can work because plant cells are totipotent, meaning that if they are given the right cues, they can grow into an entire new plant.

The effort to find those cues and regenerate whole plants from bits of tissue dates back to the first years of the 20th century. Scientists found that some snippets of leaves and other plant parts maintained in the laboratory could change into unspecialized plant cells. Then researchers demonstrated they could make such blobs of tissue grow into either roots or shoots depending on the ratio of two critical plant hormones, auxins and cytokinins. Later, a pair of research teams demonstrated that providing the right regulatory chemicals to undifferentiated carrot cells could make them start forming an embryo. Once scientists have an embryo, they can coax it into an adult plant.

Today's tissue culture specialists continue to search for the right ratio of the right hormones to trigger development of more and more species. Much effort also goes into maintaining sterile conditions and coming up with the best blend of nutrients to feed particular plants. For example, Murch often adds regular grocery-store sugar, since the first nubbins of tissue that she nurtures may not be up to photosynthesizing efficiently for themselves. B vitamins often go into the mix, too, because many plants normally rely on soil bacteria to supply them.

Since the early days with blobs of carrot tissue, commercial growers of food and ornamental plants have come a long way with these techniques. Lab researchers found tissue culture expands the possibility of studying corn, soybeans, and other crops. Growers have also explored the techniques. Commercial strawberries and potatoes are propagated this way, as are geraniums and African violets.

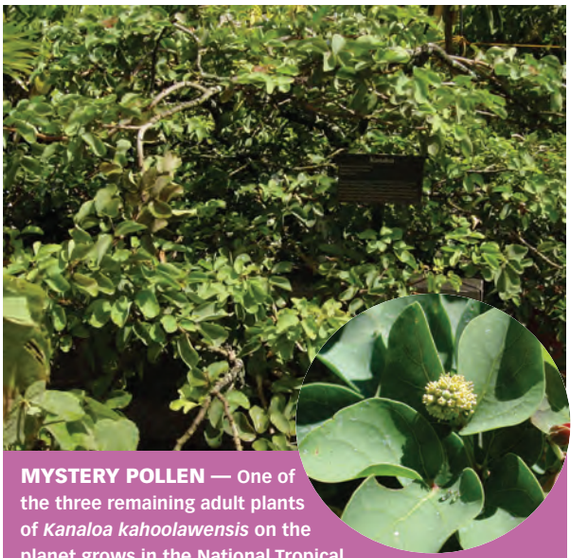
ON THE EDGE "When I first learned about tissue culture, my very first thought was, 'Why do we still have endangered plant species?'" Murch says. It seemed to her that tissue culture labs

should be able to take even the rarest species and create dozens of new plants.

Even though it's turned out to be more complicated than that, Murch remains upbeat, even when she goes to Hawaii. There, the fragile flora evolved without many mammalian or insect predators but has recently been attacked by a multitude of invaders. The state has 292 plants on the federal endangered species list, including 150 species comprising fewer than 50 individuals. And of these, 11 species have fewer than five representatives left on Earth.

Soon after Murch got her lab set up in February, she started with the direst cases, such as the hard-luck shrub called *Kanaloa kahoolawensis*. The last part of its name comes from the Hawaiian island Kaho'olawe, which is 13 miles long and, at its widest, 8 miles across. Goats and other animals introduced by Europeans flourished there, destroying native vegetation, and the U.S. Army and Navy used the island for target practice between 1941 and 1990.

Botanists Ken Wood and Steve Perlman of the National Tropical Botanical Garden were exploring the island in the early 1990s when they discovered two unusual sprawling shrubs on a tall rock just offshore. The shrubs' flowers, in tufts like a mimosa's but the color of cream, bloomed over blunt oval leaves.



MYSTERY POLLEN — One of the three remaining adult plants of *Kanaloa kahoolawensis* on the planet grows in the National Tropical Botanical Garden on Kauai. The cream-colored flowers (inset) release pollen that delights paleobotanists. They'd seen it in samples of ancient soils but never from a living plant, until 1992.

Wood and his colleague taxonomist David Lorence had never seen the plant before, but they consulted a specialist who knew the pollen well. The relatively smooth grains with grooves, typical for a legume, had been turning up in samples of ancient soils all over the islands. Paleontologists had concluded that the mysterious plant releasing this pollen must once have dominated the lowland landscape.

The researchers published the official description of the plant in 1994, declaring it unusual enough not just to be designated as a new species but to have its own new genus. Lorence assigned a generic name that honors the Hawaiian god Kanaloa.

The plants seem to be "mostly male," as Lorence puts it: most of the blooms grow only male parts. But one year, biologists found three seeds from one of the plants. That happy fluke has yielded two shrubs that now sit in a place of honor at the entrance to the botanic garden's rare-plant nursery.

Unfortunately, that burst of luck faded. Horticulturists at the facility have repeatedly failed to propagate the plant by cuttings or grafts. "The greenhouse staff is very excellent," says Murch. Their record glows with innovations in coaxing little-studied species into reproducing, so if they didn't manage, Murch deems the prospects grim.

Waiting for more seeds began to seem unpromising, too. Drought hit Kaho'olawe so hard that in 2001, island managers sent helicopter expeditions out to water the plants. "The helicopter puts one skid down on a boulder about half the size of your desk and you get out—carefully," recalls island restoration manager Paul Higashino. Then the helicopter went back to pick up 400 pounds of 5-gallon water containers. Keeping an eye out for unexploded ordnance on the rocky slope, the emergency-watering crew directed the container drop.

Even with three waterings, one of the plants withered to what a casual observer, or less of a diehard optimist than Higashino, might call dead. "I don't want to say that on my watch one died," he says.

When Murch arrived in Kauai, she approached the problem by observing the two *Kanaloa* plants growing near her lab's front door. From these—by then, two-thirds of the world's *K. kahoolawensis* population—Murch noted details of the leaf–bud structure and other clues to what sort of hormones and nutrients might work. Unfortunately, there were parts of the plants that she couldn't study, such as the root system.

"One of the challenges of working on the last few [plants] is that you can't destroy anything," she says.

She quickly decided that the petioles, the little stems that connect a leaf blade to a twig, looked most promising as a source of unspecialized tissue. However, Murch counted four fungal diseases and three bacterial ailments afflicting the plants, not to mention infestation by an abundance of insects. The last remnants of a species often are sickly, she says.

Murch gave some plucked leaf-stem samples a big wallop of antibiotics and then spent 3 weeks weaning the plant bits from the drugs by reducing the dosage a little every 48 hours. Only then did she expose the tissue to cocktails of hormones and nutrients. A round of tests generally takes 7 to 10 days, after which Murch works out another set of cocktails and tries again. "You just have to work through the possibilities," she says.

The *Kanaloa* bits didn't do much for several rounds of testing, but finally, embryo tissue started to form. What did the trick was a mild auxin mixed with a strong cytokinin, one used commercially for defoliating cotton plants to ease harvesting.

When she saw her success, did she whoop and hug people? "No!" she says. "You don't get excited until you can do it again."

The youngsters aren't out of the climate-controlled growth chamber yet, but the planet now has a new generation of 20 *Kanaloa* seedlings about an inch tall. This summer, Murch is working on repeating the experiment.

GLOBAL COLLEAGUES Among tissue culture specialists, scientists who specialize in discovering the requirements of rare species don't reach anywhere near the numbers of what Murch calls "the corn-and-soybean crowd." Yet the rare-plant specialists have figured out how to grow dozens of rare plants.

The Lyon Arboretum in Honolulu has had at least limited success in figuring out how to culture some 300 rare species, says Nellie Sugii. One of her more dramatic projects began with a batch of little green fruits—they looked a bit like grapes, she says—on a stem delivered by Ken Wood in 1998. He'd visited one of the last half-dozen known members of *Tetraplasandra flynii*, a tropical tree species, and found half-ripe fruit.

Sugii extracted the embryos and nurtured the botanical equivalents of premature babies. After 6 months, with the embryos turning brown, "I was worried," she says. She couldn't bear to throw them away though, and suddenly they began to grow. "Now, in the lab, you can't throw anything away," she says.

The Royal Botanic Gardens, Kew in England also hosts a sweeping effort to propagate rare, fragile, or cantankerous species from around the world. They've been particularly successful with sterile-tissue-culture propagation of arid-zone succulent plants, such as cacti, which tend to rot when disturbed.

Some 30 rare North American plants are now under study by tissue-culture specialists at the Cincinnati Zoo. Endangered

G. TAVANA/NTBG; D. RAGONE/NTBG

species of pawpaw trees in Florida, for example, grow what botanists call recalcitrant seeds, which don't survive drying and freezing in seed banks. "We started with the four-petaled pawpaw—the shoots looked really good, but we couldn't get roots for a long time," says Valerie Pence. She and her colleagues there have now succeeded in culturing three of these pawpaws, she reported in June at the Portland, Ore., meeting of the Society for In Vitro Biology. Her colleague Bernadette Plair also reported a way around the seed-bank problem. For the dwarf pawpaw, the researchers can now pack shoot buds inside gelatin beads, freeze them, and then thaw the plant tissue for culture.

Praveen Saxena, who presides over a test-tube garden of plant tissue from around the world, points out another plant dilemma that culturing techniques might solve. Saxena, a plant physiologist at the University of Guelph in Ontario, is working with Costa Rican scientists to find a trick for culturing their native *Guaiacum sanctum*. The tree's slow-growing wood is so hard that people have used it to make bowling balls and propeller-shaft bearings for ships. Traditional healers have relied on the plant, and modern medical researchers are now testing its potential against asthma. With so many uses and such slow growth, the population has shrunk sadly. Saxena says that, so far, tissue culture for this tree has proved "very difficult," but he's betting the process will produce new plants more quickly than seeds do. In this species, a tree can take more than 200 years to flower.

ULTRARARE — The *Cyanea kuhihewa* (top) in gardens came from only one wild plant—not much genetic diversity—so scientists are trying hard to coax new shoots (inset) from a bit of leaf picked from the last living wild plant.

TAVANA/NTBG; MURCH/NTBG

In other cases, culturing could save a species from overardent collecting and offer health benefits, too.

Saxena and Murch are finishing a study on the endangered goldenseal, a popular North American medicinal herb. The researchers bought bottles of the herbal preparation and sent them for chemical testing. Some samples turned out to carry dangerously high concentrations of lead, accumulated by the plant's root.

Saxena and Murch have now fine-tuned a procedure for tissue culture of the plant that offers herb suppliers an alternative to ravaging the last of the wild supplies and, incidentally, keeps the lead out of the product. Fortunately, the researchers' tests show that an ingredient that's purported to be medicinally active remains high in the cultured version.

Murch can list many more uses for the tissue-culture approach. Her main message, she says, is a bracing counterbalance to a lot of reports of the gloomy state of the planet's botanical resources. "It's not a hopeless situation," Murch says.

And although she isn't ready to celebrate yet, the little bits of *Cyanea* leaf have shoots and are "looking good." ■

LAYERED APPROACH

A simple technique for making thin coatings is poised to shift from curiosity to commodity

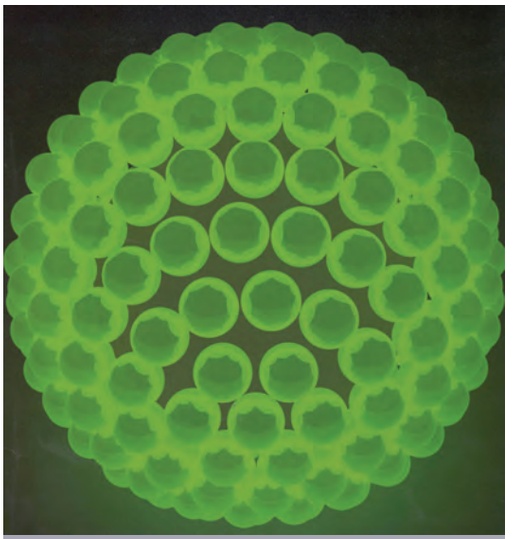
BY JESSICA GORMAN

Wrap an apple in Yasa-sheet and it will stay fresh for weeks. So says Semei Shiratori of Keio University in Yokahama, Japan, who makes this high-tech plastic for preserving fruits and vegetables. To be sure, it's a humble product. But it may be a harbinger of an enormous new class of materials and products created in a startlingly simple process: Thin liquid layers applied one at a time create solid, multilayered coatings that mix and match a wide variety of technologically valuable properties.

As for Yasa-sheet, it's made of alternating layers of chitosan, which is a major sugar-based ingredient of crab shells, and an enzyme -containing liquid extracted from bamboo. The protective wrapper works, according to Shiratori, by suppressing the food's emission of ethylene gas—a naturally produced ripening agent that eventually makes fruits and vegetables rot.

Now, a decade after the layering technique first made a splash among materials researchers, it's serving as the basis for a slew of potential products, including anticorrosion coatings, fuel cells, and biomedical implants. Known as layer-by-layer assembly, the technique is no longer a mere laboratory curiosity.

"This field is reaching the point where we're really starting to harvest some very interesting new technologies based on these materials," says Michael Rubner of the Massachusetts Institute of Technology, where he has championed layer-by-layer assembly techniques for nearly a decade. "This is going to be a very exciting time in the next few years and beyond."



BRIGHT SPOTS — Layers of fluorescent lanthanum phosphate nanoparticles and charged polymers coat a sphere that could eventually find use as a bioimaging agent.

DOUBLE DIPPING Although its roots reach back decades, the layer-by-layer technique started making waves in 1991. Gero Decher, now at the Louis Pasteur University and the Charles Sadron Institute in Strasbourg, France, reported making multilayered films using positively and negatively charged polymers, called polyelectrolytes. These materials readily layer upon each other, and electrostatic forces hold them in place.

Decher demonstrated that he could make thin, high-quality films with a technique that's easy to use, says chemist Nicholas Kotov of Oklahoma State University in Stillwater. After that, Kotov says, research in layer-by-layer assembly experienced "exponential growth."

The technique's simplicity is a big draw. In its rawest embodiment, researchers simply dip a naturally negatively charged substrate, such as a glass slide, in a solution containing a high–molecular weight, positively charged substance. Then they rinse it, let it dry and repeat the steps using a solution containing a negatively charged substance. Each cycle of dipping and drying yields a layer just nanometers or less thick—qualifying the technique and its products to be included in the red-hot research arena of nanotechnology.

Because the layering process is so repetitive, robots often perform it. The possibility of such automation provides an advantage for commercialization.

"The method is very simple, even primitive," says Yuri Lvov, a researcher Louisiana Tech University in Ruston who has studied layer-by-layer assembly since the early 1990s. Even so, he notes, "it allows us to work with organized layers of polymers, proteins, viruses, and nanoparticles."

In fact, says Rubner, "any water-soluble or dispersible element that has either charges on it or hydrogen-bonding capability can be built into these films. People have just put everything but the kitchen sink in there."

The layer-by-layer strategy has additional virtues. It usually uses good old water, rather than hazardous and toxic liquids, as the solvent. The initial surface that's coated can be ceramic, plastic, metal, or of many other materials. And the resulting films are uniform, which opens up many options for imparting the films with electronic, magnetic, structural, and chemical properties.

Says Rubner: "It's really a remarkably simple processing technique that gives you nanoscale control over properties."

THIN-TECH There's no limit to the properties that layer-by-layer assembly can convey to materials. The strength of mother-of-pearl is one property that Kotov is emulating. Using alternating layers of negatively charged clay particles and positively charged polymers, he produced a structure on glass slides that resembles mother-of-pearl in strength and its nanoscale structure (*SN: 6/21/03, p. 397*).

Kotov has had enough success with this and materials that incorporate such celebrity substances as carbon nanotubes that a small Stillwater company, Strala Materials, is now trying to commercialize his materials for body armor, aviation equipment, and artificial bone.

Corrosion resistance is another property amenable to the layering strategy. Joseph Schlenoff of Florida State University in Tallahassee is making anticorrosion coatings with alternating layers of polyelectrolytes known as PDDA and PSS, which are commonly found in shampoo or used to treat wastewater (*SN: 4/13/02, p. 228*).

He hopes that such coatings could prove valuable for protecting water pipes and other metal surfaces that interact with water.

He's also trying to develop membranes for sorting molecules in the pharmaceutical or chemical industries. For example, Schlenoff aims to separate drug molecules that have the same chemical structure but are mirror images of each other—a property known as chirality. The layers in his experimental films are themselves made from chiral amino acids or polymer molecules. In the June 4 *Journal of the American Chemical Society*, Schlenoff reports that the films permit certain molecules to diffuse through faster than their mirror-image siblings do.

As the president of a small Tallahassee company called nanoStrata, Schlenoff pursues another angle that could help the layer-by-layer process gain a foothold in industry. The company, which he founded in 2000, sells a robotic layering system developed at Florida State. Researchers around the world have purchased the system, Schlenoff says.

According to Thomas Mallouk of Pennsylvania State University in State College, the best use of layer-by-layer technology is for assembling very thin films that require only a few precisely controlled layers. These coatings might be used for high-tech products such as light-emitting diodes, solar cells, and chemical sensors.

Currently, Mallouk is attempting to make ultrathin ion-conducting layers for fuel cells that would run at higher temperatures than today's ion-conducting materials can handle. The lower temperatures require expensive platinum catalysts. The new films include 10 or so alternating layers of positively charged zirconium- and aluminum-containing clusters and negatively charged materials called perovskites. Mallouk hopes that this strategy will enable fuel cell makers to use less-expensive catalysts.

Mallouk is also exploring the basic physics of ferroelectric materials made from thin layers of perovskites that are just nanometers thick. Thicker ferroelectric materials are now used in sensors and actuators, but researchers would like to shrink these materials to miniaturize such devices and improve their performance.

Lara Halaoui of the American University of Beirut in Lebanon is also using layer-by-layer assembly to tackle energy issues. She aims to make a new type of solar cell by layering arrays of nanoscale semiconductor particles, called quantum dots, with polyelectrolytes. Scientists predict that quantum dots could convert sunlight into electricity more efficiently than the bulk semiconductor materials used in conventional photovoltaic cells do.

Going a step further in another project, Halaoui has created films with layers of polyelectrolytes and layers hosting quantum dots and platinum nanoparticles that can catalyze the production of hydrogen gas from water. The goal, she says, is to use the energy produced by sunlight to convert water into clean-burning hydrogen fuel.

PRESCRIPTION POTENTIAL Other coatings made with layer-by-layer assembly have biological and biomedical possibilities. Kotov, for one, is aiming to use multilayer structures as scaffolds to grow tissues. The layer-by-layer technique enables him to design surface characteristics that are either inviting or repulsive to cells. The nanoscale roughness of a surface is a particularly important factor in creating a surface amenable to cell adhesion and growth, he notes.

Surfaces made through layer-by-layer assembly can also be chemically tuned to prevent bacterial buildup, blood clotting, or other conditions that commonly plague biomedical devices such as artery-opening stents, says Rubner. Polymer films that absorb a lot of water, for example, aren't good environments for cell growth, so Rubner's lab has been using two oppositely charged polymers, commonly called PAA and PAH, to create layered films that swell with different amounts of water depending on the acidity of their environments. In some cases, he and other researchers are making patterned coatings on which some regions attract certain proteins or cells while other parts resist their adsorption, says Rubner.

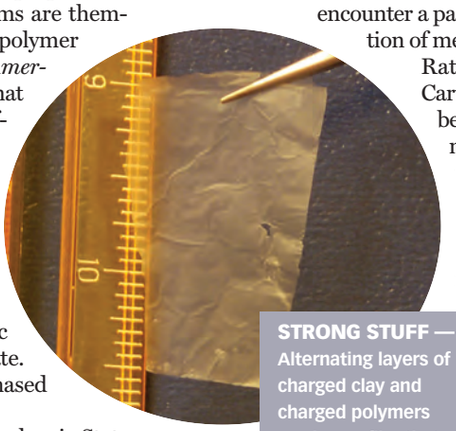
Meanwhile, some scientists are designing multilayered polymer films that might find use in delivering medicines to specific regions of the body. These materials become porous or break apart when they encounter a particular level of acidity or a certain concentration of metal ions (*SN: 3/8/03, p. 150*).

Rather than starting with flat surfaces, Frank Caruso of the University of Melbourne in Australia begins with tiny spheres of latex, gold, and other materials. After using layer-by-layer assembly to give them a permeable coating, he places them in a solution that dissolves the interior spheres but not the coating. The resulting hollow microspheres could be loaded with drug molecules to be released, for example, by heating the spheres with a laser, says Caruso.

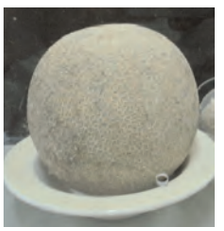
He's also developing coated spheres for use as bioimaging agents in the study of cells or tissue samples. Spheres coated with lanthanum-phosphate particles are luminescent in colors corresponding to the rare earth ions with which the lanthanum-phosphate is sprinkled, or doped.

Depending on the coating applied, tiny spheres can have many more uses, says Caruso. For example, spheres coated with layers that contain enzymes or metal particles might catalyze specific chemical reactions. Or those with coatings containing antibodies might find use in immunoassays that test for the presence of disease-causing agents.

Caruso cofounded the Berlin-based company Capsulution to commercialize these technologies.



STRONG STUFF — Alternating layers of charged clay and charged polymers produce a film that mimics the strength and internal architecture of mother-of-pearl.



FRUIT FUZZ — Melons protected with Yasa-sheet (top) don't rot as quickly as those left to fend for themselves.

KOTOV; SHIRATORI

ON THE SHELF? "We're at a pivotal point," says Rubner. "If we don't start showing some utility from these things—if our industrial partners don't start to actually make some money—then all of the hoopla about the great promise of these materials will dissipate away."

With the emergence of small companies such as Strala Materials, nanoStrata, and Capsulution, momentum toward the industrialization of layer-by-layer processes and products is growing. At least one big company is adding to that force. Although the company remains cagey on details, CibaVision, headquartered in Duluth, Ga., has filed several patents on layer-by-layer assembly of materials for use in manufacturing contact lenses. At an American Chemical Society meeting in Orlando in April 2002, a CibaVision researcher also described the use of layer-by-layer assembly for making the surfaces of contact lenses water-friendly.

Shiratori, a former researcher in Rubner's lab, has already used layer-by-layer assembly to create useful household items in his lab. He also manufactures and markets these items—albeit with an alternative production method—through his company, Shiratori NanoTechnology in Kawasaki, Japan. Besides Yasa-sheet for fruits and vegetables, he's made items such as shoe deodorizers.

With all of these developments, layer-by-layer assembly may soon be moving out of the labs to refrigerator and store shelves everywhere. ■

OF NOTE

PHYSICS

Gluing building blocks with geometry

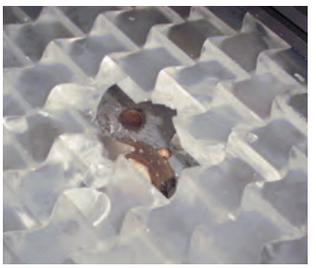
Using simple blocks with shapes like cubes or hourglasses, researchers have found ways to construct strong panels with no fasteners securing most of the blocks. Such constructions remain intact even after losing up to half of their units, says Yuri Estrin, a materials scientist at the Technical University of Clausthal, Germany.

In the June *Philosophical Magazine Letters*, he and his colleagues report making a new version of such blocks that may prove practical in heat shields for space shuttles.

During the past few years, the researchers had been experimenting with interlocking blocks with only straight edges. These arrangements, however, have jagged surfaces that are too rough for some applications. The new blocks have curved edges, which can be put together to form a smoother panel.

In all these schemes, only blocks on a panel's border require a securing mechanism, Estrin notes.

NASA officials say the new structures might be an option for a few difficult-to-tile areas on a space shuttle's surface. However, the monolithic character of the new panels might make maintenance prohibitively difficult, they point out. —P.W.



ESTRIN ET AL./PML

HARD HIT Missing blocks show where a steel shaft struck a test panel of interlocking but unglued epoxy-resin blocks. Outside the impact zone, the panel remained intact because cracks couldn't spread from block to block.

BEHAVIOR

Naps with stages spark learning

Napping shows potential as a way to stimulate learning, at least for volunteers performing a laboratory task that requires visual discriminations. There's a catch, though, say psychologist Sara Mednick of Harvard University and her colleagues. Only naps consisting of both slow-wave sleep and rapid-eye movement (REM) sleep inspire improved performance on the task.

In fact, the volunteers' speed in accurately doing the task increased as much after taking a 90-minute nap that contained both sleep stages as had previously been observed for people granted a full night's slumber (*SN: 7/22/00, p. 55*). The findings appear in the July *Nature Neuroscience*.

In the study, 73 volunteer participants spent 1 hour in the morning learning to identify the orientation of three bars flashed in the lower left quarter of a computer screen against a background of horizontal bars.

In the afternoon, 26 of the volunteers took a 60-minute nap and another 19 snoozed for 90 minutes. The rest went without a nap.

When tested that evening, the 30 nappers who had displayed both sleep stages—as determined by brain wave measurements—required less time to make the same visual discriminations that they had made in the morning. The other nappers took slightly longer to execute the task than they had before. Performance plummeted among those who hadn't napped.

Two-stage nappers maintained their superiority on the task when tested the next morning, after all participants had had a night's sleep. —B.B.

CHEMISTRY

Chemical rings act as a minirotor

Taking a step toward the creation of molecule-scale motors for equally tiny tasks, researchers have made rings of organic molecules on which one or two smaller chemical rings rotate like charms on a bracelet. In the version with two small rings, the scientists can control the direction of the rings' rotation.

David A. Leigh of the University of Edinburgh and his colleagues synthesized the interlocking rings in solutions. Each large ring contains three or four different chemical groups, or stations, where the small rings are temporarily held in place by hydrogen bonding. In the July 10 *Nature*, Leigh and his coworkers report that they can control the small rings' attraction to these stations using light, heat, or chemicals.

In rotors with just one small ring—a molecular system called a [2]catenane—the researchers can direct the small ring to the station they choose. However, the team can't designate which direction the small ring will travel around the big ring.

In a rotor with two small rings, called a [3]catenane, each small ring blocks the other's movement backward on the big ring. The small rings therefore always move in the same direction.

Many researchers are aiming to create molecular motors that can operate, for example, tiny valves, switches, pumps, and other parts in drug-delivery systems or in computer-chip-size laboratories (*SN: 11/9/02, p. 291*). The new catenane structures could be used to make surfaces that change color, stickiness, and other properties depending on the relative positions of the rings, suggests Leigh. —J.G.

BIOMEDICINE

Clot buster attached to red blood cells avoids complications

When a person is rushed to an emergency room with a heart attack or stroke, doctors often prescribe immediate infusions of tissue-type plasminogen activator (tPA). The drug can dissolve clots blocking blood flow to the heart or brain. But because tPA indiscriminately attacks clots throughout the body, it can damage older clots that had repaired blood vessels. In those cases, it can cause internal bleeding.

Researchers now report that attaching tPA to red blood cells in mice and rats reduces this problem by concentrating the drug's clot-busting efforts on newly formed, troublesome clots.

"After we couple tPA to red blood cells, the drug lasts longer and becomes much safer," says Vladimir Muzykantov, of the University of Pennsylvania in Philadelphia. In people, the drug might reduce the amount of tPA that diffuses from blood vessels into the brains of stroke victims, where it can cause neurological complications, Muzykantov says. His group's study appears in the August *Nature Biotechnology*.

The drug might also prove helpful to people recovering from surgery. Such patients need to retain blood coagulation capabilities for healing, yet because they're immobile, they're prone to forming harmful clots.

It remains unclear how long the tPA–red blood cell combination would stay in circulation. The animal experiments lasted only a few hours, but they suggest that the combination outlasts unattached tPA, Muzykantov says. —N.S.

SCIENCE AND SOCIETY

For European lakes, how clean is clean enough?

Decreases in water quality are often associated with modern farming practices, including the use of artificial fertilizers and the practice of keeping many animals in small areas. However, new research on lakes in Denmark suggests that agriculture has been affecting water quality there for more than 5,000 years.

The finding could help determine the background levels of various water pollutants. That's important because the European Union is now developing lake-water quality standards that will be implemented by 2015, says Emily G. Bradshaw, a paleoecologist at the Geological Survey of Denmark and Greenland in Copenhagen.

Bradshaw and her colleagues looked at sediments from Dallund Sø, a 12-hectare lake in central Denmark. That area has been one of the most densely populated and intensively cultivated regions of Europe for at least 6 millennia, says Bradshaw.

The rate of sedimentation in Dallund Sø increased dramatically about 1,000 years ago, a date that roughly corresponds with the founding of a town nearby and a significant change in agricultural practices throughout Denmark. Another spurt in silt accumulation around 2,500 years ago matches a period of rapid deforestation by area settlers. The team's analyses suggest some deforestation also occurred around the lake as many as 6,000 years ago.

Even though modern agricultural practices have caused plant-nutrient concentrations in Dallund Sø to skyrocket, the researchers discovered that the lake has been extremely nutrient-rich for the past millennium. Many algae-nourishing substances probably entered the lake via an ancient agricultural practice known as retting. In this procedure, farmers submerged bundles of hemp and flax in the lake during the winter so that the plants would soften and partially decompose, easing the recovery of fiber from the stalks.

SØ POLLUTED? Sediments from Dallund Sø suggest that the Danish lake has been severely tainted by agriculture for more than a millennium.

A significant boost in zooplankton and aquatic plants in sediments deposited just after the rapid deforestation 2,500 years ago suggests that the nutrient concentrations in the lake jumped considerably at that time. Chemical analyses of sediments deposited immediately after the deforestation hint that each liter of lake water then contained about 50 micrograms of phosphorus, more than twice the amount the water contained only a century before. Today, the lake's phosphorus content varies between 65 and 120 μg/l.

Bradshaw says that the earlier concentrations shouldn't be used as thresholds for the proposed European water standards because the only way to meet those targets would be to depopulate the region. —S.P.

PALEOECOLOGY

A human migration fueled by dung?

When people made their way from Asia to the Americas, the path they took may have been covered in dung.

At the peak of the last ice age, when sea levels were low, a land bridge that's now submerged in many places connected what are now Alaska and northeastern Russia. Although much of the area was dry more than 50,000 years ago, firm archaeological evidence of human occupation in this region dates to only around 14,000 years ago, says David Rhode of the Desert Research Institute in Reno, Nev. Recent genetic data supports this timing (*see story p. 84*). Some scientists have proposed that humans took so long to migrate into this frigid, treeless expanse because there wasn't any wood for heating or cooking.

Rhode and his colleagues, however, contend, people could have burned dried dung.

Today, many residents of the Tibetan Plateau use yak dung for almost all of their heating and cooking needs. A single family living in a 10-square-meter tent requires between 25 and 40 kilograms of dried dung per day in the summer and about twice that in the winter, says Rhode. That adds up to about 20 metric tons of dung per year. Although that sounds like a huge amount, Rhode and his team observed one group of Tibetans collect about a quarter-ton of dung from their yak herd's pasture in just 4 hours. The researchers estimate that one person could gather an entire family's average fuel supply in less than 1 hour per day.

Today's conditions on the Tibetan Plateau match the cold, arid climate of the ancient land bridge's tundra. Scientists believe that the region then supported large populations of herbivores such as bison, mammoths, horses, and wooly rhinoceroses (*SN: 4/19/03, p. 244*). Unless there were far fewer of these animals than currently estimated, there should have been plenty of dung available for fuel, says Rhode. —S.P.

EARTH SCIENCE

Large lake floods scoured New Zealand

Portions of New Zealand's North Island, like many volcanic regions, have experienced immense floods when lakes filling the craters of dormant volcanoes burst through the craters' rims. Now, scientists analyzing signs of erosion in the area have estimated the size of some of those powerful deluges.

Some of the largest such floods originated in Lake Taupo, says Vern Manville, a geologist with the Institute of Geological and Nuclear Sciences in Taupo, New Zealand. That 616-square-kilometer lake occupies the hole left when a volcano erupted about 1,800 years ago. In the decade or so just after that eruption, the surface of the lake rose to an altitude about 34 meters higher than today's level, says Manville. When the water eventually breached a large dam of ash along the crater rim, about 20 km^3 of water rushed out and down the crater's slopes. In just a few weeks, the torrent—estimated to have carried up to 30,000 m^3 of water per second—chewed a 12-km-long spillway and deposited layers of wet ash up to 17 m thick on the surrounding floodplain.

A similar but even larger flood occurred after an eruption 26,500 years ago, when about 60 km^3 of water spilled from the lake, says Manville. That deluge ripped large boulders out of solid rock about 80 km downstream and carried them several kilometers further, suggesting a peak flow rate above 100,000 m^3/s.

Today, the crater of nearby Mount Ruapehu, which last erupted in 1996, holds a rising lake. At current rates of water accumulation, the lake could breach the crater rim by 2007 and release a flood of up to 1.5 million m^3 onto populated areas. But such a catastrophe need not occur if engineers stop the rise by constructing an erosion-resistant spillway in the natural dam, notes Manville. In 2002, engineers in the Philippines did just that at the lake accumulating inside the crater of Mount Pinatubo, which erupted in 1991. —S.P.

J.K. WINTER

Books

A selection of new and notable books of scientific interest

ALPHA AND OMEGA: The Search for the Beginning and End of the Universe

CHARLES SEIFE

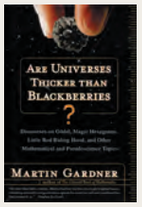
The author of *Zero* now turns his attention to the realm of cosmology, providing readers an overview of several Theories of Everything being postulated today. Beginning with some historical background, Seife explains how the Copernican notion that

Earth isn't the center of universe was spawned by the birth of the telescope. He fast-forwards to a second cosmological revolution led by Edwin Hubble, who launched the Big Bang theory and the concept of an expanding universe. These notions seemed to explain the beginning of the universe but not its end. Next, Seife explores how data from the currently orbiting Hubble Space Telescope have changed our view of the universe once again. Its pictures of supernovas indicate that expansion of the universe is speeding up, not slowing down as previously thought. This leads the author on a tour of the latest wrinkles in modern cosmology, including cosmic-background radiation, dark energy, and supersymmetry. With a look toward the future, the book surveys some of the most daring experiments cosmologists are assembling and considers which of their ideas might prevail. ***Viking, 2003, 294 p., b&w illus., hardcover, $24.95.***

ARE UNIVERSES THICKER THAN BLACKBERRIES? Discourses on Gödel, Magic Hexagrams, Little Red Riding Hood, and Other Mathematical and Pseudoscience Topics

MARTIN GARDNER

At age 89, Gardner continues to be one of the most prolific science writers. His works regularly appear in *The Skeptical Inquirer*, *Scientific American*, and the Los Angeles Times. This compendium of recent articles from those publications reflects



the breadth of Gardner's interests and expertise in math, religion, and literature. The author elucidates Möbius strips, details the ideas of Richard Feynman on time travel, examines the life and times of a modern would-be messiah, and dissects the massive ego and insecurities of Ernest Hemingway. Gardner uses this forum to debunk some claims, including the benefits of therapeutic touch and primal-scream therapy. ***Norton, 2003, 288 p., hardcover, $25.95.***

GALILEO'S MISTAKE: A New Look at the Epic Confrontation between Galileo and the Church

WADE ROWLAND

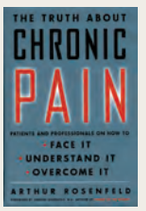
In a defining moment in modern Western culture, the Inquisition convicted Galileo Galilei of heresy in 1633. Rowland argues that the trial centered less on Galileo's defense of the Copernican view of the solar system than on his argument about what truth is and how we know it. Galileo made a critical mistake, Rowland believes, not by contending that Earth revolves around the sun but by insisting that science and only science provides

the truth about reality. In fact, Rowland asserts that many leaders of the Church believed Copernicus' theory to be true. It was Galileo's relentless assault on religion that did him in. Rowland recreates Galileo's trial according to information the author gathered on journeys to Italy. He gives weight to the Church's position in the 17th century and makes a case for the Church's role in the pursuit of truth today. Originally published in Canada in 2001. ***Arcade, 2003, 298 p., b&w plates, hardcover, $26.95.***

THE TRUTH ABOUT CHRONIC PAIN: Patients and Professionals on How to Face It, Understand It, Overcome It

ARTHUR ROSENFELD

With an estimated 25 million to 75 million sufferers, chronic pain has reached epidemic proportions in the United States. Yet Rosenfeld's research and first-hand experience tell him that pain management by health professionals is woefully inadequate. Many people who could be helped are not because of concerns about addiction, side effects ranging from respiratory depression to constipation, and insurance companies' spending caps on medications. Other patients in pain are afraid to ask for help because of the stigma associated with pain medication and the belief that pain is part of life.

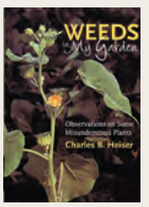


This leads Rosenfeld to question medical ethics in this area and wonder how it is that people can ignore others' chronic suffering. Rosenfeld shares conversations with 40 people, including health-care professionals, ethicists, scientists, religious leaders, and chronic-pain sufferers. That last group includes a former football player with a back injury, an artist who suffers from sickle-cell anemia, and a 15-year-old boy with Marfan syndrome who suffers pain so severe that it causes blackouts. ***Basic, 2003, 299 p., hardcover, $26.00.***

WEEDS IN MY GARDEN: Observations on Some Misunderstood Plants

CHARLES B. HEISER

As a botanist, Heiser appreciates all plants—even those that most gardeners loathe. More than just an identification guide, *Weeds in My Garden* is a



tribute to plants that most people call weeds. Heiser profiles 140 varieties of weeds, detailing the origin of each one's name, where and when it grows, what it looks like, its flower, and finally its virtues. For instance, the cockleburs that often turn up in the fur of pets were the inspiration for Velcro. Ground ivy has been used as an herbal remedy for treating coughs. Heiser also explains how weeds spread and how to control them. ***Timber Pr, 2003, 247 p., color plates/b&w photos/illus., hardcover, $22.95.***

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LETTERS

Beyond ballistic

While the report of ballistic testing of bacteria is a fascinating study of bacterial survival ("Bulletproof bacteria," *SN: 6/7/03, p. 366*), I'd be more concerned about the effects of severe extremes of heat, cold, and vacuum on the survival of bacterial spores. As the study stands, we're still left wondering about these other important factors.

JON ONG, WOODLAND HILLS, CALIF.

A couple of things seemed somewhat incongruous. The article indicates that it would take an acceleration of 3.4 million meters per second per second to escape Mars' gravitational pull but equates this to about 35,000 times Earth's gravity. Also, does the 3.4 million m/s/s mean an instantaneous acceleration, as in an explosion or volcanic expulsion?

JAMES ZUKOWSKI, YELM, WASH.

Bacteria can indeed survive such extremes. Also, the article should have said that material escaping Mars' gravity would have to accelerate about 350,000 times the force of Earth's gravity. And yes, the acceleration would be nearly instantaneous. —J. TRAVIS

Gripping question

"Caught on Tape: Gecko-inspired adhesive is superstrong" (*SN: 6/7/03, p. 356*) reports that, wearing a gecko-inspired glove, "a person could dangle from the ceiling." How would that person let go?

DAVID D. JONES, ST. PAUL, MINN.

The microscopic hairs on a gecko's feet stick only when the angle at which they meet the surface is just right. To unstick its feet, a gecko peels them off the surface, changing the angle at which the hairs meet the surface. The same would go for gecko tape and thus for gecko gloves. A person wearing gecko gloves would have to learn to peel his or her hand from the surface. —S. MCDONAGH

Aswirl where?

"Oceans Aswirl" (*SN: 6/14/03, p. 375*) says that Robert R. Leben of the University of Colorado operates a Web site that monitors the positions of Gulf of Mexico eddies, but it doesn't give the Web site. It would be most valuable to the millions of us who live along the gulf.

ROY P. FINNEY, WEEKI WACHEE, FLA.

Two sites you might try are ftp://ccar.colorado.edu/pub/gom/nrt/gif.mean/latest.gif *and* http://www-ccar.colorado.edu/~realtime/welcome. —S. PERKINS