SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

JULY 26, 2003 PAGES 49-64 VOL. 164, NO. 4

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THE WEEKLY NEWSMAGAZINE OF SCIENCE

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JULY 26, 2003 VOL. 164, NO. 4

Features

This Week

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Sweet treatment The compound that gives licorice its characteristic taste may help fight the SARS virus. See Janet Raloff's Food for Thought.

Of Note

Meetings

Departments

Cover Industries ranging from construction to drug manufacturing depend on thorough mixing of powders and grains. Yet such mixtures often separate for reasons that aren't understood. By blending grains or powders in rotating drums, researchers are exploring the complex interplay of influences that determine how particles mingle. Page 56

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Intestinal Fortitude

Treatment for colitis shows early success

The cells that line the gastrointestinal tract, among other responsibilities, keep the immune system from reacting to bacteria and food in the gut. In people with ulcerative colitis, however, breaches in this epithelial cell layer bring immune cells into contact with the foreign material. The result is inflammation and ulcers in the colon and rectum.

A novel approach to therapy for the disease now shifts the priority from quelling the immune reaction to rebuilding the epithelial layer. In its first test in people, the treatment has yielded dramatic improvements, British scientists report in the July 24 *New England Journal of Medicine*. To refurbish the cell layer, the researchers gave patients massive doses of the human gut peptide called epidermal growth factor (EGF). The peptide had been produced in genetically engineered yeast.

Jeremy M.D. Nightingale of the Leicester Royal Infirmary in England and his colleagues randomly assigned 12 people with ulcerative colitis of the colon and rectum to receive, over 2 weeks, daily enemas containing EGF. Twelve other patients with similar disease received saline enemas as a placebo. People in both groups also got pills containing the anti-inflammatory drug mesalamine.

Ulcerative colitis, a recurring disease, is marked by gut pain, chronic diarrhea, blood in the stool, weight loss, and weakness.

Four weeks after the start of the trial, 10 of the 12 people getting EGF were free of most symptoms, but only 3 of the 12 people getting saline enemas were. After nearly 3 months, eight people in the EGF group but only one in the other group remained largely free of symptoms. Moreover, nine people in the placebo group but only four in the EGF group had developed serious symptoms that required treatment with steroids that suppress the immune system.

"This is one of the most exciting studies to come across my desk in years," says D. Brent Polk of Vanderbilt University Medical Center in Nashville. "This is a significant advance that suggests we can treat the epithelial injury as well as the immune response."

Writing in the journal carrying the new study, Richard J. Farrell of Harvard Medical School in Boston says that while the new findings are "impressive," they need to be confirmed in tests without mesalamine to sort out more precisely the benefits of EGF.

Polk suggests that researchers will next need to compare EGF treatment head-to-head against anti-inflammatory therapies, including steroids. While anti-inflammatory drugs offer some relief and give the epithelial layer a chance to heal in some patients, they have serious side effects. Steroids can cause high blood pressure, mood swings, insomnia, indigestion, and high blood sugar concentrations.

The current study will probably also spawn laboratory research to determine how EGF rebuilds the epithelial lining, Polk says.

Nightingale's team plans to follow the 24 patients to see whether cancer develops, even though animal studies suggest the peptide is safe.

If the benefits of EGF hold up, Nightingale says, he will push for a large-scale test of EGF in hundreds of patients. —N. SEPPA

Giving Aid, Staying Alive

Elderly helpers have longevity advantage

The old saying that it's better to give than to receive may be true, at least when it comes to social support. Over a 5-year period, seniors who provided either a lot of practical assistance to friends, relatives, and neighbors or regular emotional support to their spouses displayed a higher survival rate than those who didn't provide such help, a new study finds.

In contrast, recipients of plentiful social support showed death rates similar to those of their peers who got little or no such support, say psychologist Stephanie L. Brown of the University of Michigan in Ann Arbor and her colleagues.

Nearly all previous attempts to link social contacts and physical health have focused only on whether individuals receive support from others. Results have been mixed.

"Giving support may be an important component of interpersonal relationships that has considerable value to health and well-being," Brown's group concludes in the July *Psychological Science*. It's not yet known whether programs that teach ways to provide support to others would boost long-term survival rates, the researchers add.

The scientists examined data previously collected from 423 married couples living in and around Detroit. The couples were part of a larger prospective study of coping and grief reactions in the elderly.

Each husband was 65 years of age or older at the start of the study in 1987; most wives were slightly younger. Over the next 5 years, 134 individuals died.

Statistical analyses of various subgroups revealed a lower death rate, by as much as half, for participants who reported in initial surveys that they had been providing either of two types of social support. One type involved helping people other than one's spouse with errands, housework, child care, or other daily tasks. The other centered on listening to one's spouse when he or she needed to talk and making that person feel loved and cared for.

LIFE SUPPORTS New data suggest that older people who provide social support to spouses, friends, and others live longer than other seniors do.

The survival advantage for support givers remained when the researchers statistically controlled for individual differences in age, physical health, satisfaction with health, exercise, cigarette and alcohol use, mental health, and income. The findings also held after controlling for differences in extroversion, agreeableness, feeling vulnerable to stress, and other personality measures.

Still, the scientists note, more extensive research is needed to rule out the possibilities that the physically healthiest people most often provide social support and thus live longer or that an abundance of material resources fosters longevity and makes it easier to give aid to others.

Brown's study offers a fresh way to think about social support, remarks psychologist Camille B. Wortman of the State University of New York at Stony Brook. Wortman directs the larger project on coping among the elderly from which Brown and her coworkers drew their data.

"It's worthwhile to raise the question of whether giving social support, rather than receiving it, results in health benefits among those undergoing stress," Wortman says. —B. BOWER

Long-Term Ocean Venting

Seafloor system has been active for ages

Analyses of mineral deposits in and around a unique set of hydrothermal vents beneath the Atlantic Ocean suggest that the site's tallest towers of minerals have been growing for at least 30,000 years.

The vent system, dubbed the Lost City because its lofty chimneys of carbonate rock can reach the height of an 18-story building, is situated on the side of an undersea mountain about 2,500 kilometers east of Bermuda and 15 km away from the Mid-Atlantic Ridge (*SN: 7/14/01, p. 21*). The mineral-rich fluids that spew from the ocean floor are warmed by heat-generating chemical reactions between ocean water and subsurface rocks rather than by volcanic activity, a characteristic that sets this vent site apart from all others yet discovered.

The Lost City's formations consist primarily of calcium carbonate, says Gretchen L. Früh-Green, a geochemist at the Swiss Federal Institute of Technology in Zurich. She and her colleagues used carbon-dating techniques to determine the age of material gathered from active and extinct vent structures, as well as seafloor sediments nearby.

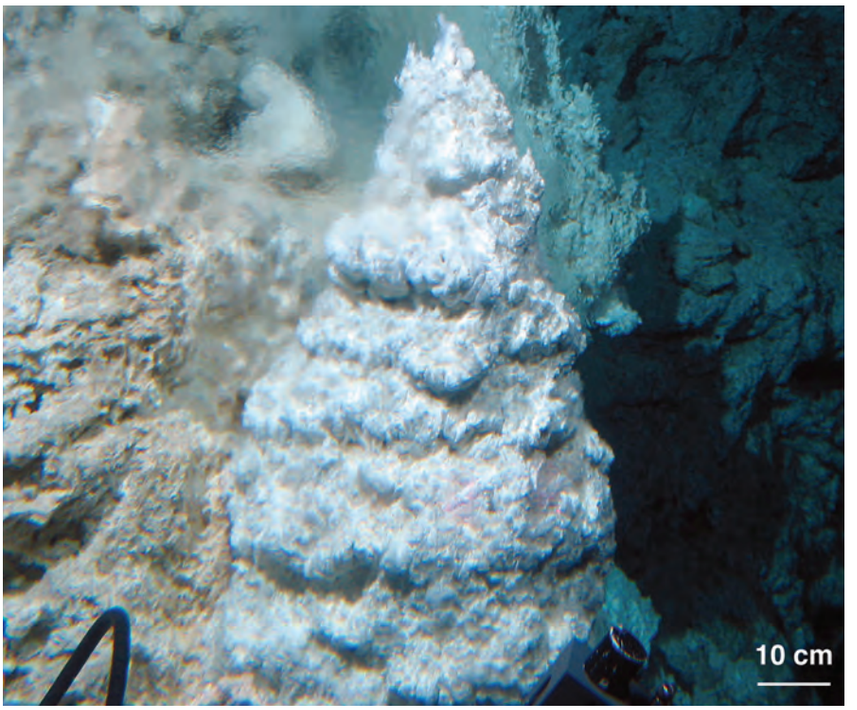
The oldest chimney material analyzed by the scientists was deposited about 25,000 years ago, well before the peak of the last ice age. Carbonate deposits in cracks near the vents are about 32,000 years old. Although the team has dated only a few mineral samples, the Lost City vents appear to have been continually active for at least 30,000 years.

White, feathery formations that surround the active vents are much younger, deposited only in the past few decades, the researchers report in the July 25 *Science*.

The hydrothermal activity at the site depends on contact of seawater with freshly exposed rock surfaces, says Früh-Green. Although tectonic activity in the region probably opened the cracks that initiated the heat-generating chemistry beneath the Lost City, the cracking may persist today because those reactions cause the rocks to swell by up to 40 percent. Früh-Green and her colleagues estimate there's enough virgin rock beneath the vent system to fuel suburban sprawl around the Lost City for hundreds of thousands of years to come.

These findings could be important for several reasons, says Susan E. Humphris of the Woods Hole (Mass.) Oceanographic Institution. Similar systems may be much more common than scientists have suspected because they've typically confined their search for hydrothermal activity to mid-ocean ridges and the boundaries of tectonic plates. Also, she notes, the analyses could illuminate the role of nonvolcanic hydrothermal systems in the ocean's geochemical cycles, many of which are poorly understood.

Perhaps most intriguing is that the Lost City vent system, which hosts a thriving microbial ecosystem, may be the closest analog available to conditions early in Earth's history. Therefore, Humphris says, it's probably the best place to study how evolution first unfolded. —S. PERKINS



UNIV WASH/WHOI

SHIMMERING WATERS **This mineral formation precipitated as warm, extremely alkaline fluids spewed from the ocean floor and hit cold, carbonate-rich seawater.**

Sky Prospecting

Surveying the universe's middle-aged galaxies

With a year's worth of data now in hand from a telescope survey of thousands of galaxies 6 to 8 billion light-years away, astronomers are filling in details about the midlife years of the nearly 14-billion-year-old universe.

"We're looking back in time," says Alison Coil of the University of California, Berkeley. "The light we're seeing traveled for [at least] 6 billion years before it reached our telescope."

The new results come from the first year of a 3-year sky survey, which is the second phase of a project known as the Deep Extragalactic Evolution Probe. In DEEP2, Coil and her colleagues are mapping galaxies within four distant, cone-shaped sec-

tions of the universe that are each about 2.5 billion light-years deep. Viewed from Earth, the base at the far end of each section is about the size of the full moon. The researchers presented their first findings last week at the annual meeting of the International Astronomical Union in Sydney, Australia.

"This survey provides the first detailed picture of what galaxies looked like and how they were clustered when the universe was about half its present age," comments Martin Rees, an astronomer at the University of Cambridge in England. In another major project, the Sloan Digital Sky Survey (*SN: 5/31/03, p. 341*), astronomers are scanning more-local neighborhoods of galaxies and the universe's outer limits—but not the vast stretches in between.

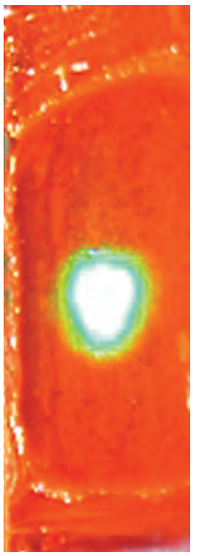
In the DEEP2 survey, Coil and her colleagues are examining how galaxies evolve by measuring their mass, motion, and chemical makeup and the ages of their stars. Clues to all these specifications can be gleaned from the different wavelengths of light that a galaxy emits. Using the telescope's Deep Imaging Multi-Object Spectrograph, or DEIMOS, the astronomers split the faint light from distant galaxies into separate wavelengths, just as a prism separates white light into distinct colored bands.

"Spectra are the Rosetta stone for understanding celestial objects," says Sandra Faber, an astrophysicist at the University of California, Santa Cruz and a member of the DEEP2 team. For example, a bluish tinge is the signature of a galaxy crowded with young stars, while galaxies with an older stellar population radiate more red light.

The DEEP2 team used red and blue light emissions to compare the clustering behavior of galaxies that are 6 to 8 billion light-years away to that of nearer galaxies. In both groups, galaxies containing mostly young stars don't clump as much as galaxies with older stars do. Overall, however, galaxies from the universe's midlife epoch show more clumping than do younger galaxies—supporting the theory that gravity increases clustering over time.

By the end of the survey, the DEEP2 scientists plan to have mapped 50,000 galaxies from the universe's middle years. Rees says that this cache of data should help refine theories about how the universe has evolved.

Also, Coil notes, knowing the masses of that many galaxies could enable astronomers to better discern the distribution of so-called dark matter—one of the driving forces behind the overall geometry and motion of galaxies. —S. MCDONAGH



BRIGHT SPOT
Under ordinary illumination, the laser imprinted on this plastic film (orange) reflects an intense spot of light that appears white.

GAAL ET AL./ADVANCED MATERIALS; A. GOLDEN/N.U.I. GALWAY

Press 'n' Peel Lasers

Coaxing light beams out of cheap plastic

Like poker chips, lasers may someday be molded out of plastic by the millions. A new laser-making method takes a major step in that direction, its Austrian developers say.

Lasers are devices that emit a coherent beam of light of a single wavelength. Their prices have been coming down over the years, but dirt cheap plastic ones could serve as the heart of mass-produced biomedical and environmental sensors and optical-telecommunications networks, the researchers say. What's more, unlike the lasers currently available, plastic ones could be flexible.

Manufacturers today rely on costly fabrication techniques for making the microchip lasers used widely in CD and DVD players and other gadgets. Those techniques require exacting procedures carried out in tightly controlled conditions and meticulously clean environments.

In the July 17 *Advanced Materials*, Martin Gaal and Emil J.W. List of the Graz University of Technology and their colleagues describe a simpler method of making lasers by imprinting patterns into plastic under ordinary conditions. The Graz scientists had teamed up with researchers from AT&S, a circuit board maker in Leoben, Austria.

The key to the new technique is a hard mold with a shallow grating on its surface. The nanometer-scale depths and spacing of the ultrafine, parallel ridges provide a fine structure that stimulates laser action.

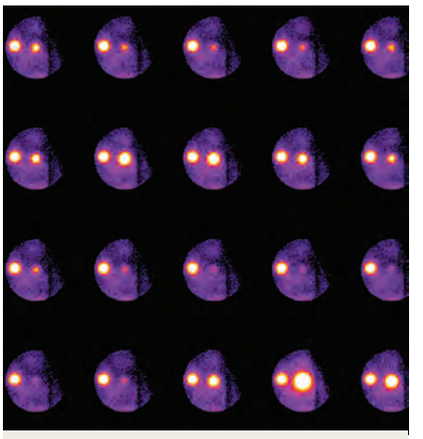
To make each laser, the researchers press their mold into a droplet of solution. It contains a semiconducting polymer, known by the acronym MEH-PPV, that has been dissolved in a fast-evaporating solvent. When the coating dries, the polymer retains a negative replica of the mold's ridges. That structure, which the researchers peel from the mold, acts as a laser.

"You can imagine the grating as if it was a fingerprint," says List, who led the team. "The real step forward is the ease of fabrication," he notes. "You have nanostructures that you just press into the material. You can do it once, twice, many times. That makes the entire process very cheap."

The tough part is producing a mold with precise nanoscale ridges only 30 nanometers high and roughly 400 nm apart. To do this, the scientists rely on the same photolithographic techniques used to make microchips.

A drawback of the new approach is that the resulting lasers produce light only when stimulated by another laser. Most lasers now in use produce light directly from an electric current. List says that researchers in his lab and many others are already racing to invent electrically driven lasers made out of polymers such as MEH-PPV.

The fabrication method of the Austrian team is not entirely new, notes John A. Rogers of the University of Illinois at Urbana–Champaign. He and his colleagues have used the same approach to create rel-



Taking the Crab's pulse

Sweeping beams of radiation from rapidly spinning stars called pulsars vary in intensity. No one knows why. Simultaneous recordings of the Crab pulsar's visible light, shown in these images to the right of another star, and its radio emissions may demystify the phenomenon. When read left to right and top to bottom, the images show the pulsar reaching peak brightness toward the end of its 33-millisecond rotation. Each image was averaged over 500,000 rotations that were captured by a telescope in the Canary Islands. Andy Shearer of the National University of Ireland in Galway and his colleagues determined, moreover, that brighter-than-normal peaks of light precede exceptionally powerful radio pulses. Whatever triggers the giant radio pulses apparently releases energy throughout the electromagnetic spectrum, the astronomers report in the July 25 *Science*. —B. HARDER

atively coarse-structured, nonlaser light sources in various shapes, such as rings. Yet List and his coworkers have attained much finer structural features and created patterns that can support laser action, Rogers says. "Those are both . . . impressive demonstrations," he adds. —P. WEISS

Beyond Clots

Platelets in blood may guide immune response

When blood spills, the human body calls on platelets. These cells quickly plug the damaged region of a blood vessel and initiate clotting.

There's more to platelets than clots, however. The bloodborne cells can also stimulate the immune system to adapt its response to a specific microbial assault, according to a report in the July *Immunity*.

"Most immunologists . . . think of platelets as these little things that induce coagulation. It will take time for them to realize the importance of platelets in modulating adaptive immunity," says study coauthor Timothy L. Ratliff of the University of Iowa in Iowa City.

Indeed, the new work adds to a growing set of data indicating that platelets may have a significant role in immunity. For example, Michael Yeaman of the University of California, Los Angeles Medical Center and his colleagues have shown that platelets can release proteins that rapidly kill bacteria and some other microbes. "It's no surprise that a cell that is adapted to navigating to wounds, where microorganisms would likely enter, also has several complementary host-defense functions," says Yeaman.

In mammals, the immune reaction to a dangerous microbe comes in two stages. An initial counterattack, the innate response depends on patrolling cells such as macrophages and neutrophils, which recognize features common to many microbes. The second defense, the adaptive response, occurs as the immune system gradually ramps up production of T and B cells that specifically target the offending microbe. For example, the response boosts the number of B cells that make antibodies that bind to unique surface features of the microbe.

Yeaman and other investigators have found that platelets may participate in the innate immune response by killing microbes directly or by releasing inflammatory chemicals that beckon macrophages and neutrophils. The new study by Ratliff and his colleagues extends the influence of platelets to subsequent immune events.

In test-tube experiments, the scientists confirmed earlier reports that platelets can make a surface protein, called CD154, that regulates the adaptive immune response. For example, CD154 induces maturation of immune system components called dendritic cells, which in turn stimulate T- and B-cell growth.

Ratliff's team showed that platelets bearing CD154 trigger dendritic-cell maturation when the two cell types are grown together. The researchers also found that a transfusion of CD154-bearing platelets into mice that can't make CD154 influenced the rodents' B cells and T cells. Among other effects, B cells began producing more of a certain class of antibodies.

Finally, Ratliff and his colleagues depleted other mice of most of their platelets and then injected the animals with a virus. These rodents produced significantly fewer antibodies to the virus than did mice with normal platelet counts.

According to John Semple of the University of Toronto, the new work could shed light on the rare cases in which the human immune system generates antibodies against its own platelets. "Platelet-derived CD154 may be the link that stimulates these pathogenic antibody responses," he says. —J. TRAVIS

Miniature Motor

Nanotubes central to new rotating device

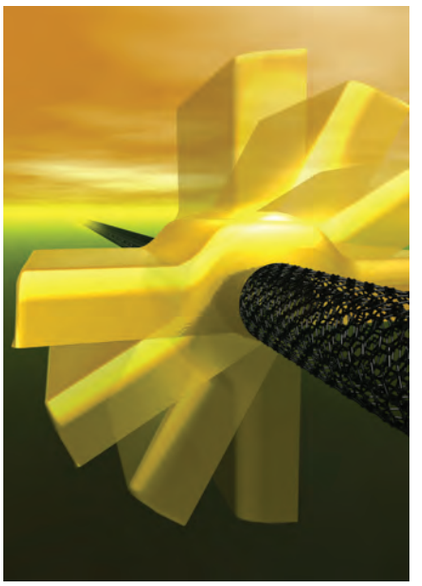
Motors, pumps, and other electromechanical devices are tinier than ever—and getting even smaller. Now, for the first time, researchers have used miniature, nested cylinders, called multiwalled carbon nanotubes, to make a motor that's only 300 nanometers long.

A variety of molecular-scale motors and other actuators are under development around the world, but many rely on biological parts, such as enzymes (*SN: 11/9/02, p. 291*). In comparison, the new system—built by Alex Zettl's research team at the University of California, Berkeley and the Lawrence Berkeley National Laboratory—is synthetic and might operate under conditions that biological components find unfriendly, such as extreme heat and harsh solvents.

Zettl's graduate students Adam Fennimore and Tom Yuzvinsky fabricated the new actuator on a silicon wafer. The rotor consists of a gold plate centered on a nanotube shaft whose ends are anchored to electrically conductive pads. The plate rotates when a voltage is applied to three stationary gold electrodes positioned on the wafer a short distance from the shaft. The nanomachinists report their results in the July 24 *Nature*.

In the team's first experiments, large voltages induced the entire shaft to twist only 20 degrees. That could prove useful, Zettl notes, but his team was aiming for a nanomotor capable of full rotations.

A route toward this goal emerged from previous studies. Three years ago, Zettl and graduate student John Cumings found that the interior tubes of a multiwalled carbon nanotube could move freely within the



ROTATIONAL MOTION In this simulation, a rotor (yellow) turns around a carbon nanotube shaft (black).

ZETTL RESEARCH GROUP, UC BERKELEY AND LAWRENCE BERKELEY NATIONAL LAB

more exterior tubes (*SN: 7/29/00, p. 71*).

To take advantage of this property, Zettl's team severed the outermost shell—or several of them—on either side of the rotor plate. This step decouples the rotor-bearing segment of the shaft from the rest of the multiwalled nanotube.

With a judicious combination of small voltages applied to the stationary electrodes, the researchers could make the rotor move any amount between 0° and 360°. They also made it flip back and forth quickly between two positions thousands of times and found that it showed no wear.

"This first demonstration of a rotational actuator using a nanotube axle and bearing is a truly exciting advance that could have important technological applications," comments Ray Baughman of the University of Texas at Dallas.

Zettl predicts that uses for nanoscale motors are "going to be huge and very diverse." Potential examples include switches in optical communication devices and pumps that move solutions though minuscule channels for mixing and analysis. —J. GORMAN

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MASTERING THE MIXER

The frustrating physics of cake mix and concrete

BY PETER WEISS

Part of the fun of experimenting with granular materials, says Stephen W. Morris, is the showmanship. In one stunt that he has demonstrated in settings ranging from high school classrooms to television studios, the University of Toronto physicist loads clear plastic tubes with white table salt and black sand and starts them rotating. What transpires in the tubes usually knocks the socks off of any unsuspecting bystander. Instead of mixing into a drab gray sameness, the sand particles slowly separate into crisp black bands cutting across a long, narrow field of salt. As the spinning continues, some bands disappear and new ones arise.

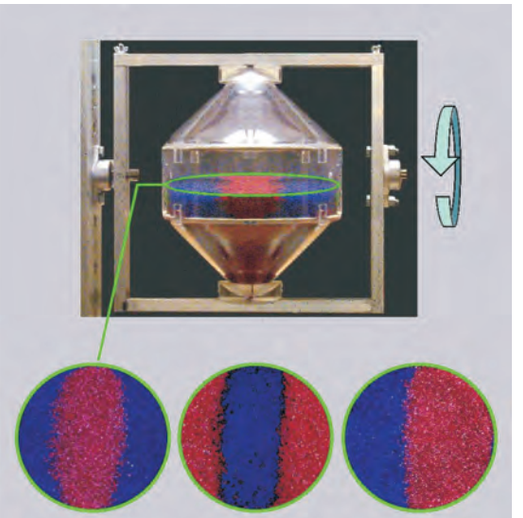
"It's a parlor trick," Morris says.

Not to deny its entertainment value, this demonstration of how strangely granular materials can behave is also an authentic experiment in a field both rich in fundamental physics and major practical consequences.

Yet granular mixing today remains more of an art than a science, says chemical engineer Fernando J. Muzzio of Rutgers University in New Brunswick, N.J. Scientists are often at a loss to explain why grains assume surprising patterns instead of simply mixing uniformly (*SN: 11/17/01, p. 309*). Most industrial-mixing processes are devised by trial and error.

In the past decade, by using laboratory mixers and mathematical models trimmed of many of the complexities of actual industrial-mixing operations, investigators have made progress toward predicting why mixing does or doesn't occur. Some scientists are now taking further steps by teasing out on a microscopic level how adhesive forces, collisions, and other interactions among particles affect the outcome of mixing. At the same time, researchers are turning up yet more unexpected phenomena.

A better understanding of mixing would benefit many industries, Muzzio says. "Without good powder mixing," he says, "you can't build a road, you can't make a cake, and you can't even kill crabgrass, let alone make high potency pharmaceuticals."



YIKES, STRIPES! — Small changes to either the fill level or rotation speed of this industrial-style double-cone blender (top) produce strikingly different segregation patterns (bottom). Bead diameters are 4 millimeters (red) and 1.4 mm (blue).

SHINBROT & MUZZIO/PHYSICS TODAY

SPILL THE BEANS There's nothing exotic about granular mixtures. They're as mundane as the flour, cocoa, and sugar in brownie mix or the sand, gravel, and cement used to make concrete. Regardless of their ingredients, such mixtures have perplexing properties. Depending on how the grain combinations are piled, poured, or shaken, they may behave collectively like solids, liquids, or even gases. Indeed, many physicists consider granular materials to be a distinct state of matter.

Studying this quixotic state of matter entails a whole lot of shaking, rolling, and agitating—and researchers in this arena have devised many ways of doing that (*SN: 8/31/96, p. 135*). One of the most common and industrially relevant techniques is to rotate loads of grains or powders in tumblers, essentially rotating drums, such as those used widely in the pharmaceutical industry.

Inside a tumbler, contact with the drum's inner wall drags the pile of compacted grains upward until the surface becomes steeply sloped. Then, a layer of grains on and near the top of that incline breaks loose and cascades down (*SN: 3/11/95, p. 159*).

Mixing takes place in the cascading surface layer as falling particles collide and are buried by later arrivals. Those particles get reincorporated into the main mass and eventually are carried back up to the leading edge, and the cycle begins again.

"Every grain comes to the surface, and every grain slides down the surface and then gets subducted again," says Troy Shinbrot of Rutgers University.

Experiments over the past decade have shown that a bewildering number of factors influence whether a given combination of particles in the tumbler will thoroughly mix or one of countless segregation patterns will appear. For instance, particles of two different sizes will tend to segregate into different regions of the drum. The weights of the particles, the rotation speed of the tumbler, and even how the particles are placed in the drum are among the other factors that make a difference.

Although the grains in a tumbler are subjected to just one type of agitation—the drum's rotations—scientists describe the subsequent patterns of mixing and segregation as the consequence of two nearly independent processes.

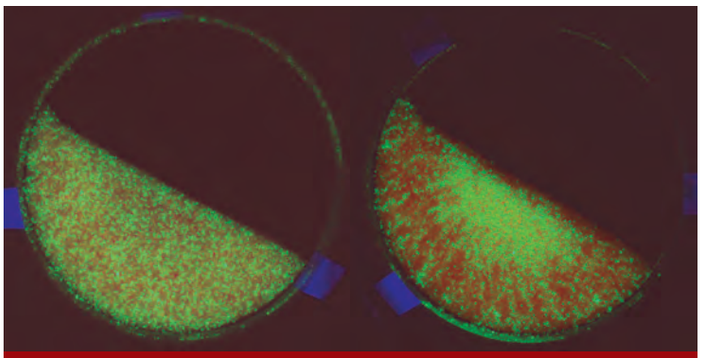
To study one of them, called radial mixing, researchers examine the effects of particle motions as seen in circular cross-sections of drums. One way they do this is by stopping the rotating tumbler and then hardening a drum's contents with glue—freezing the particles in place. Next, they cut through the drum perpendicular to its axis of rotation. The distribution of ingredients reveals how particles travel in that plane.

The other blending process acts along the drum's length. To

study this axial mixing, researchers use tools ranging from video cameras and lasers to magnetic resonance imaging (MRI).

TURN STYLES The smallest changes in radial-mixing studies can lead to wildly different and often visually striking patterns.

Some experiments begin by charging a tumbler with two side-by-side portions of sand-size grains that are identical except for color. As soon as the tumbler begins turning, a spiral pattern appears as grains of one color wrap around grains of the other color. Using a so-called continuum model that assumes that individual grains are vanishingly small, theorists have simulated the formation of spiral patterns and their quick onset.



JUST ADD WATER — In this tumbler experiment, all beads are the same size but coated with a water-attracting film (orange) or a water-repellent one (green). The beads mix well when dry (left). In an odd twist, adding moisture makes them segregate (right).

Researchers have also found, both in theory and experiment, that getting from that initial spiral arrangement to a completely mixed state requires dozens of rotations. In food processing, pharmaceutical and chemical production, and other industrial processes, a more thorough knowledge of these dynamics could tell process managers what types of blenders to use and how to fill them to rapidly achieve complete mixing.

Currently, drug makers develop mixing methods by testing many different sets of conditions, says Ajaz Hussain, deputy director of the Food and Drug Administration office that oversees pharmaceutical research and regulations. "That's not very efficient," he says. "If we can improve the scientific understanding . . . things can be much, much better."

Experiments have shown that the size of the particles matters a lot, says Julio M. Ottino of Northwestern University in Evanston, Ill. A downward shift in size transforms circulation patterns of particles in a tumbler. He and his colleagues have found that if the two types of same-size particles are each on the scale of a powder rather than of sand, a single turn of a tumbler produces a splintered and stretched pattern instead of one with clean outlines. Moreover, it takes only a few additional turns to progress from the spiral formation to a homogeneous condition of complete mixing.

Why does particle size make such a large difference? Ottino explains that poppy-seed-size grains, for instance, tend to move in orderly loops, like runners on a track. However, grains the size of powder, such as flour particles, typically move erratically, like players in a soccer game.

Size reduction leads to the famous type of irregularity known as chaos (*SN: 8/1/98, p. 70*). Chaos refers to situations in which the outcome depends strongly on the initial conditions. Slightly change the initial positions of the particles in the tumbler experiment and those particles' trajectories can be dramatically different.

"Whenever something mixes well, it is because chaos is present," Ottino says. Although commercial mixing operations have always unwittingly exploited chaos, only now are they moving toward a scientific footing in the design of blending equipment and processes.

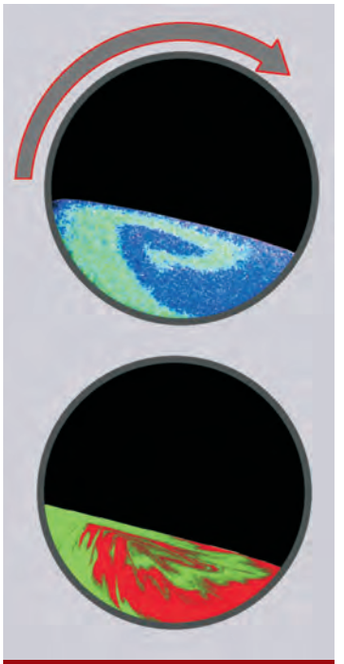
Researchers attribute the chaotic trajectories of very small, tumbled particles to the influence of weak interparticle attractions called van der Waals bonds. For particles smaller than salt grains, or less than about 300 micrometers, those bonds can affect particle flow by competing against both the downward pull of gravity and the propulsive kicks of collisions.

Another type of bonding that can arise between granular particles results from the influence of tiny bridges of water (*SN: 1/2/99, p. 6*). In production plants, mixing specialists have found that adding some moisture to a combination of dry granules lessens the likelihood of segregation. However, a new study finds that moisture's effects can have a flip side.

Hongming Li and Joseph J. McCarthy, both chemical engineers at the University of Pittsburgh, applied polymer coatings to glass beads of varying submillimeter diameters. One coating made water cling to the beads' surfaces; the other repelled water. To examine radial mixing, the researchers used a flattened tumbler, a thin, transparent disk that turns like a wheel, in which they could observe particles.

According to calculations by the team, their bead-surface treatments set the stage for a competition of forces. On one side are the natural tendencies of the beads to mix or to segregate because of size differences. On the other side is a force between beads that can be attractive, repulsive, or absent, depending on how much water is present and how the beads are coated.

In the May 9 *Physical Review Letters*, Li and McCarthy report that their mixtures of two beads behave normally under dry conditions, regardless of the coatings. That is to say, different-size beads segregate, and same-size beads mix. However, if beads of different sizes are given water-attracting coatings and a little water is added, they mix thoroughly. In an even more atypical behavior, beads of equal size but opposite coatings segregate when dampened.



ON A ROLL — After quickly forming a spiral (top), sand-grain-size particles that are identical except in color will mix fully after dozens of cycles. If powder-size grains are used instead, the spiral becomes jagged (bottom) as chaotic grain motions hasten mixing.

To look in on interparticle forces at work in such behavior, Muzzio, Shinbrot, and their colleagues have recently used an atomic-force microscope to measure the attractive tug created by films of water on glass beads. These unpublished data reveal that the strongest tugs correlate with the least segregation in tests in an industrial blender, says Muzzio.

"Learning to characterize and manage interparticle forces is the key to understanding and controlling [mixing] processes," he says.

One potential benefit of doing so would be to find ways of simultaneously using several catalysts in complex industrial-chemical processes and then, by controlling how the catalysts segregate, retrieving each one separately. Says Muzzio: "We might be able to make chemical products faster in smaller factories that are cheaper and have better yields."

SHINBROT & MUZZIO/PHYSICS TODAY; LI ET AL./PHYSICAL REVIEW LETTERS

MISSING THE BANDWAGON No less intriguing than the radial component of mixing is the axial component. This segregation of particles into bands along a tumbler's length is the basis of Morris' parlor tricks. A topic of study since the 1930s, this type of banding results primarily from interparticle collisions in the tumbler's flowing layer. But scientists don't know how those collisions generate bands and can't predict the bands' appearance and disappearance.

This impasse is "a stick in the eye of theorists," Shinbrot says. Forming the banding patterns is "the silliest little thing [the tumbler system] could possibly do, but we cannot come to grips with it and that's a frustration," he adds.

In the past decade, researchers have measured many features of axial mixing. For instance, scientists probing beneath the surface of the drum's contents with MRI have made the surprising discovery that fine particles form a roughly circular core that extends along the axis of the drum. What's more, that shaft develops bulges along its length that grow and shrink, sometimes reaching the surface to appear as bands of small particles surrounded by larger particles.

The more they look, the more researchers find. For example, some have observed that the height of the particle mass in the drum is different in the band areas than in the intervening spaces. Morris and his coworkers have detected moving, wavelike variations in the distribution of particle sizes.

In new work, Muzzio, Shinbrot, and their Rutgers colleague Albert W. Alexander have found that little particles in big drums readily form bands, whereas big particles in small drums don't. Between those extremes, bands come and go as the drum is made to rotate at a faster or slower rate.

Meanwhile, Morris and his colleagues are testing predictions of a leading theory of axial mixing that attempts to explain how differences in surface height and particle distribution underlie band behavior. The timing of the changes observed in the tests doesn't support the model. "It's really mysterious," Morris says.

Even as researchers continue scratching their heads about the dynamics of granular mixing in idealized settings such as laboratory tumblers, they're getting a dose of reality in investigations of commercial-style mixing equipment.

In experiments on one such device called a double-cone blender and used in the pharmaceutical industry, investigators put particles of two sizes into the device until it's more than a quarter full. The result is rapid and nearly total segregation: The larger particles accumulate in the middle of the blender while the finer particles crowd to the sides. However, even a 1 percent decrease in the volume of particles dumped into the blender—or an equally tiny increase in the tumbler's rotation rate—makes the pattern flip so that the smaller particles hog the center and the larger ones fill the periphery.

For a field that has barely begun to tackle real-world conditions, such findings suggest that many tough challenges remain in the mix. ■

STRIKE UP THE BAND — When different-size grains rotate in a tumbler, the smaller grains clump into mobile bands that scientists still can't explain after decades of study. Here, fine sand forms a band amid coarser salt inside a glass tube.

MORRIS

CATCH ZERO

What can be done as marine ecosystems face a deepening crisis?

BY BEN HARDER

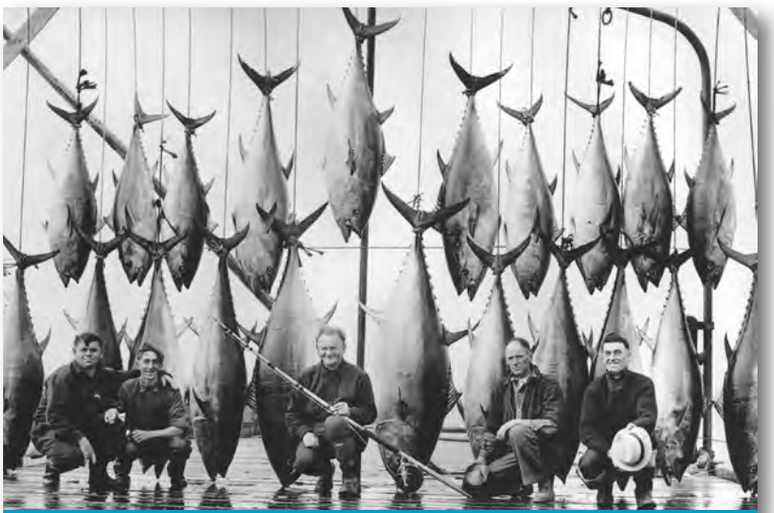
Give a man a fish, goes the Chinese proverb, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime. If he catches too many fish, however, he may leave few fish behind for his children's table. It has taken less than a generation for modern industrial-scale fishing, once it's deployed in an ocean area, to exhaust the vast majority of that area's edible bounty. These massive harvests have left behind devastated ecosystems and depleted economic opportunities.

"There's no place in the ocean left where there are undisturbed fish stocks," says ecologist Boris Worm of the Institute for Marine Science in Kiel, Germany. "The whole ocean has been transformed."

For species after species, in sea after sea, the 20th-century juggernaut of commercial fishing swiftly thinned marine life to a fraction of what it otherwise would be, Worm and Ransom A. Myers of Dalhousie University in Halifax, Nova Scotia, report in the May 15 *Nature*.

More than just documenting what the seas have lost, their analysis and other recent studies hint at the enduring economic costs of mismanaging marine resources. Unless governments take immediate, dramatic steps to curtail overfishing and undo the damage that's been done, swathes of ocean may be rendered practically barren, scientists warn with increasing urgency. Although corrective measures would mean lost revenue and fewer jobs in the near term, the long-term payoffs would be substantial, researchers predict.

For fisheries—the commercial operations that harvest wild fish—to reach those promised waters, however, they'll need to first navigate a maze of political and economic straits. Fisheries scientist Daniel Pauly of the University of British Columbia in Vancouver contends that governments need to overhaul the way they manage activities in the deep seas, as well as along coasts and watersheds that can affect marine ecosystems. The creation of marine areas, in which fishing is banned, and the reduction of fishing elsewhere are among the most essential steps, Pauly says.



GONE FISHING — Fish such as these bluefin tuna, caught off Nova Scotia in 1935, were several times more abundant then than they are now.

ED PRITCHARD, ANTIQUEFISHINGREELS.COM

When fisheries extract seafood from a region of the sea, they necessarily reduce marine biomass. To a point, that can actually help a fishery, Myers says. That's because the remaining fish enjoy more resources and thus grow and reproduce more rapidly than they would in a crowded natural ecosystem.

For most species, Myers says, sustainable yield is greatest when a stock is at about half its natural size—that is, the size it would be in the absence of industrial fishing. At lesser densities, populations replenish themselves more gradually, and the quantities of fish that can be harvested each year without further diminishing stocks shrink accordingly.

Archived fishing records indicate that most fish stocks now lie well below the size that would produce maximum sustainable yield. Myers and Worm collected raw data from historical sources that chronicled catches from many fisheries dating back to the 1950s. To obtain comparable measurements for fisheries operating at different times and places, the researchers calculated the average number of fish caught per 100 hooks set by boats that spool out and then reel in miles of baited lines.

At the advent of intensive commercial fishing, Myers and Worm found, most fleets caught 6 to 12 fish per 100 hooks. But in every fishery the researchers studied, the number of catches declined by about 16 percent per year. Within a decade, most fleets caught only about 1 fish per 100 hooks.

"Industrialized fisheries typically reduced community biomass by 80 percent within less than 15 years of exploitation," Myers and Worm assert. Moreover, they say, "the global ocean has lost more than 90 percent of large predatory fishes." Those species include tuna, swordfish, and others traditionally favored by chefs and gourmets.

In a separate study in the Jan. 17 *Science*, Worm, Myers, and their colleagues reported that northwest Atlantic populations of three predatory shark species have declined, because of fishing, by more than 75 percent over the past 15 years. Numerous other shark stocks have also suffered substantial losses, the researchers report.

EMPTYING THE TANK Long after some fish stocks sank below their maximally productive sizes, fisheries' hauls continued to rise, says Pauly. As certain fishes became rare and individual fisheries—such as those that harvest California's sardines

Sea-Friendly Eating

Consumers can make a difference

Lest individuals feel helpless to reverse the downward slide of fisheries, those who consume seafood at home or in restaurants can dine selectively to ease catches' toll on the sea—and support fisheries that sustain fish stocks. The Monterey Bay Aquarium (www.mbayaq.org) and the National Audubon Society (www.audubon.org) publish wallet-size lists that rate various types of seafood according to how ecologically sound their fisheries or fish farms are.

The lists discourage consumers from purchasing bluefin tuna, cod, farm-raised (Atlantic) salmon, orange roughy, swordfish, toothfish (Chilean sea bass), wild caviar, King crab, and imported shrimp. Alaskan halibut, Alaskan salmon, sardines, white sea bass, and many farm-raised species, including tilapia, are better choices, according to the lists.

On another front, certain seafood marketers are trawling for conscientious consumers. Whole Foods Market tells visitors to its Web site, "We work closely with small, independent fishermen to find the best quality, environmentally responsible seafood choices for our customers." In the United States, Whole Foods and Wild Oats Natural Marketplace Market label fish varieties that the nonprofit Marine Stewardship Council (www.msc.org) in Seattle has certified as responsibly managed species. —B.H.

and New England's cod—collapsed, commercial fishers turned their attentions elsewhere. The discovery of more abundant fish stocks in less exploited waters masked for decades the falling yields of populations and species.

"For a long time, the rate of discovery offset the rate of depletion." Pauly says.

Growing fleets, government subsidies, larger investments in fuel, and improvements in the gear and techniques used to find and catch fish also helped maintain high global catches. Between 1950 and 1988, total annual fish catches reported to the United Nations Food and Agriculture Organization (FAO) grew from 19.2 million metric tons to a peak of 88.6 million metric tons.

The late 1980s marked the turning point. By then, the fisheries mounting efforts to find and catch new fish could no longer compensate for the oceans' waning productivity. The global fish catch has been falling ever since, Pauly has estimated (*SN: 12/1/01, p. 343*).

Along with causing the decline in fish populations, modern fishing techniques have also been altering the seas' ecosystems. Skimming large and medium-size fish off the top of oceanic food webs has left a disproportionate fraction of marine biomass at the lower end of the "pyramid of life," says Pauly. This end of the food web includes crustaceans and small fish, as well as phytoplankton and other microorganisms.

"Fishing down the food web is an ecological disaster," Pauly maintains. As ecosystems become bottom-heavy, those larger fish still in the game depend increasingly on smaller and smaller organisms. Since the seasonal abundance of small fish and tiny organisms fluctuates more than that of organisms higher in the food web, the "flattening" of food webs exposes large fish to unusually extreme variations in their food supply, Pauly says. That, in turn, makes their populations less stable and more susceptible to environmental or climatic changes.

Fishing down marine food webs elicits market effects that disguise the consequences of overfishing, Pauly says. Scarcity makes rare species expensive and economically props up fisheries even as their resources erode. For example, he says, stocks of bluefin tuna are "abysmally low," but a single fish can fetch $40,000 in Japan. "[The bluefin's] enormous price essentially dooms it," says Pauly. "The fishery . . . will be profitable to the last fish," he adds.

Fisheries affect more marine animals than just those they aim to catch. Tuna boats, for example, often kill sharks, turtles, and dolphins that get trapped in their nets. Such casualties of fishing, called bycatch, may pare down populations of vulnerable species even if targeted species in the same waters are managed for sustainable yield, says Worm. If fisheries managers consider only the abundance of targeted fishes, he says, they'll "lose the sensitive species in the long run." And that could lead to ecological changes that end up affecting the targeted species.

Even as fish stocks dwindle, demand is growing. Health researchers have produced countless studies on the benefits of eating fish—especially those rich in omega-3 fatty acids, such as tuna and swordfish. Consequently, many health-conscious people have increased their fish consumption.

At the same time, coastal populations of people who rely on fish for their protein are burgeoning around the globe, says Lester R. Brown of the Earth Policy Institute in Washington, D.C. Yet the capacity of the oceans to meet the world's demand for protein has "hit the wall," says Brown.

There are plenty of insults that can add to this injury. For example, Brown predicts that recent shortfalls in global grain production will soon force buyers to bid up prices for that basic commodity and substantially raise prices for many farm-derived foods. Those higher prices could increase demand for oceanic fish and put added pressure on fisheries.

CATCHING ON The problems with fisheries may run deep, but the remedy is practically jumping into the boat. Regardless of how it's achieved, says Worm, the overriding requirement is to reduce fishing.

"The solution is simple," he says. "The question is how do you get there."

Pauly and Jay Maclean, an independent marine biologist in the Philippines, suggest several approaches to transforming the management of fisheries in their book, *In a Perfect Ocean* (2002, Island Press).

The book describes one crucial tactic available to fisheries managers—one that Worm and others also advocate: Limit the number and type of fish that fisheries may remove from a region. For example, seasonal quotas on halibut in Alaskan waters helped those fish recover in the 1990s. Since harvesting these bottom dwellers damages seafloor habitat, the quotas also helped other fish stocks in the region recover, Worm says.

Another essential step, say Pauly and Maclean, is to prohibit fishing in large areas of the ocean, especially those rich in fish nurseries. Such no-take zones can serve as refuges for breeding and immature fish, they say.

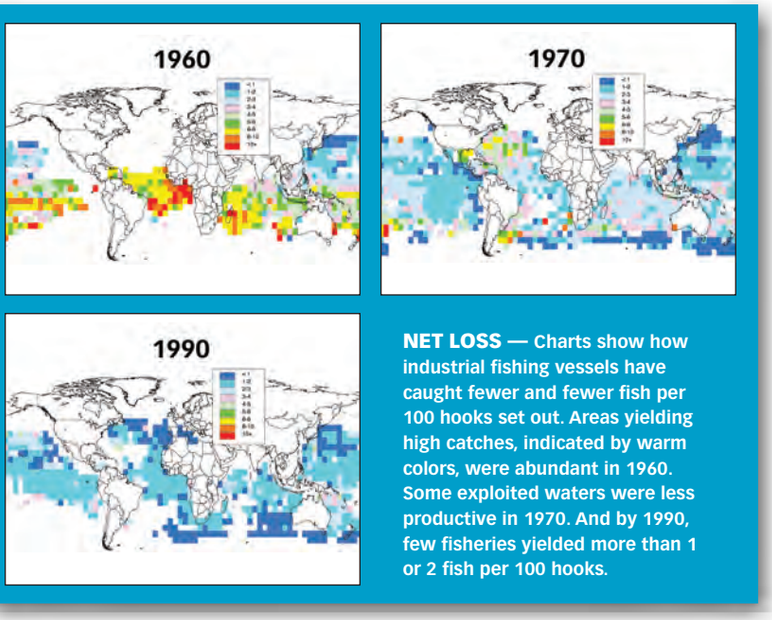
Experience supports the value of no-take zones, says Worm. Following years of unrelenting declines in cod, haddock, halibut, and other species on George's Bank in the northwest Atlantic, fleets agreed in 1993 to cease harvesting fish in a portion of those waters. "All the stocks . . . rebounded much more quickly than people anticipated," Worm says.

Most of the marine sanctuaries in the United States, however, are not true no-take areas. Some allow fishing on a limited scale, as well as recreational boating, diving, mining, and other activities that could disturb sea life (*SN: 4/28/01, p. 264*).

Pauly and Maclean also recommend that governments transform the management of fisheries. Steps would include cracking down on illegal fishing, reeling in those operations that overfish waters far from their home bases, and reducing the scale of fishing fleets, perhaps by buying and destroying vessels or providing fishers with tax breaks or other incentives to take boats out of the water.

A consensus is building. An alliance of professional fishers, marine scientists, and former elected officials working for the Pew Oceans Commission released a report on June 4 that calls for national political action to protect and restore marine productivity. The commission called for a network of no-take zones in U.S. waters, steps to monitor and limit bycatch and marine habitat destruction, and new national and regional agencies to manage marine resources and regulate fishing activity.

The Pew report's ultimate impact may depend on the degree to which a report commissioned by the U.S. government and due later this year seconds its proposals, says Worm.



NET LOSS — Charts show how industrial fishing vessels have caught fewer and fewer fish per 100 hooks set out. Areas yielding high catches, indicated by warm colors, were abundant in 1960. Some exploited waters were less productive in 1970. And by 1990, few fisheries yielded more than 1 or 2 fish per 100 hooks.

MYERS AND WORM

On May 6, the fisheries department of the European Community proposed to its member nations a series of new and stricter rules for managing cod in and around the North Sea. The proposed rules fell short of European scientists' pitch for a regional moratorium on cod fishing until evidence of recovery appears.

While the United States and European Community are deciding what to do, individual nations and neighbors are taking action. Denmark, Finland, Germany, and Sweden agreed this April to a summertime ban on cod fishing throughout the Baltic Sea. The seasonal moratorium will buy time for young codfish to mature and for scientists to better understand why shorter stoppages of fishing in recent years failed to halt the species' decline.

This move matches another one on the other side of the Atlantic: Canada closed its cod fisheries in April after years of half measures failed to halt the decline of stocks (*SN: 5/17/03, p. 318*).

Such steps establish important and encouraging momentum toward the goal of more-sustainable fishing practices, says Myers.

"If we fish less", says Myers, "after a delay, there'd be a lot more fish." As a result, he says, seafood would become cheaper and easier to catch, and desirable varieties would be more readily available.

By putting this lesson into practice, fishers and fisheries managers might justify adding a line to the ancient couplet: Teach humankind sustainable fishing, and you feed it forever. ■

OF NOTE

ASTRONOMY

Dusty times on Mars

On July 1, a dust cloud emerged from Mars' Hellas Basin, a crater that ranks as one of the biggest in the solar system. Just 3 days later, the cloud had become 1,800 kilometers wide, roughly one-fourth the Red Planet's diameter.

Two years ago, a similar cloud from Hellas Basin grew until it circled the entire planet, blurring Mars into a featureless orange ball (*SN: 11/10/01, p. 299*). Such planetwide dust storms are rare.

Martian dust storms are powered by solar heating, which whips up the winds that lift dust off the ground. On Aug. 27, Earth and Mars will be closer than they've been in nearly 60,000 years, enabling astronomers to make higher-quality observations of the Red Planet than usual. A few days later, on Aug. 30, Mars will reach its closest approach to the sun. For several weeks before and after that time, the amount of sunlight striking the planet will be about 20 percent more than average.

"This means the season for dust storms is just beginning," says James Bell of Cornell University. But he adds that the two spacecraft now orbiting the Red Planet—the Mars Global Surveyor and Mars Odyssey—have demonstrated that localized dust storms happen "all through the Martian year." —R.C.

BIOMEDICINE

Keeping breathing steady and safe

Opiates, including morphine and fentanyl, are powerful painkillers and anesthetics, but they also can slow a person's breathing to a dangerous rate. Scientists studying the kernel of brain cells that controls a body's breathing rhythm may have discovered a way to prevent this sometimes-fatal side effect.

Over the past decade, biologists have pinpointed a region in the brain stem called the pre-Bötzinger complex and learned that it generates the electrical impulses that drive breathing (*SN: 1/4/03, p. 8*). Nerve cells in this region have proteins on their surfaces that respond to opiates, which is how drugs that bind to the proteins suppress breathing.

Diethelm W. Richter of the University of Göttingen in Germany and his colleagues now have shown that about half the cells in the pre-Bötzinger complex sport proteins that respond to serotonin, a major neurotransmitter. If rats are treated with an experimental drug, dubbed BIMU8, that stimulates one of these serotonin receptors, their breathing rate increases, the scientists report in the July 11 *Science*.

Moreover, fentanyl-treated rats resumed normal breathing when given BIMU8. Equally important, say the researchers, fentanyl's painkilling properties remained potent after the animals received the experimental drug. —J.T.

ALTERNATIVE MEDICINE

Herbal therapy may carry cancer danger

An herbal extract that some women use to relieve symptoms of menopause increases the likelihood in mice with breast cancer that the disease will spread, researchers have found.

The extract, called black cohosh, is especially popular among women who have developed breast cancer, because hormone-replacement therapy for menopausal symptoms isn't recommended for such women.

Some studies have suggested that black cohosh acts as a sex hormone, a trait that could affect breast cancers in women who take it. To investigate that possibility, Vicki L. Davis of Duquesne University in Pittsburgh and her colleagues fed black cohosh to mice that were genetically predisposed to develop breast cancer. The researchers gave other mice of that breed a diet free of hormone-mimicking plant compounds.

Black cohosh didn't affect the animals' likelihood of developing breast cancer or how quickly tumors arose, but after 14 months, animals that had received the extract were 2.5 times as likely as the other mice were to have visible tumors in their lungs, Davis reports.

In other experiments, Sara Rockwell of Yale University found that breast cancer cells exposed to either of two antitumor drugs were more likely to die if they were also exposed to black cohosh extract. That could make the extract useful in fighting breast cancer. However, Rockwell says, if black cohosh also intensifies the drug's cell-killing powers in the bone marrow and heart, it could substantially increase toxic side effects in those parts of the body. —B.H.

GENETICS

Genes linked to colon cancer take sides

Cancers on opposite ends of the colon are genetically distinct, researchers from Denmark and Finland have found. The standard practice of treating them as the same disease could explain why some people with colon cancer respond better to certain treatments than others do, says Sanne H. Olesen of Århus University Hospital in Denmark.

The colon forms an inverted U between the small intestine and the rectum. Some studies have suggested that colon cancers develop differently, depending on whether they originate in the organ's right or left side. In general, right-side colon cancers are less aggressive and less deadly.

To explore these differences, Olesen and her colleagues compiled profiles of gene activity in both portions of cancer patients' colons.

Using samples of healthy and cancerous tissue from both sides of the colon, the researchers established the pattern of activity for 6,800 genes. Compared with healthy tissue, cancerous tissue from the left colon exhibited telltale differences in the activity of 186 of the genes, the researchers found. The number of gene-activity differences for the right-colon cancer was 118.

Only 30 of the differences in gene expression that distinguished cancer cells from healthy ones were common to cancers from both sides of the organ, Olesen reports. Therefore, she and her colleagues suggest, gene-based therapies and diagnostic tests for colon cancer should focus on those 30 genes. —B.H.

RADIATION THERAPY

Immune test predicts tolerance for radiation

A new blood test can foretell which cancer patients are likely to suffer serious delayed side effects from radiation therapy. Physicians could use the technique to decide whom not to treat with radiation, says Nigel Crompton of Cornerstone University in Grand Rapids, Mich.

Radiation therapy is an important treatment for many cancers, but in some people it causes serious delayed side effects, after it's too late to adjust the amount of radiation used. To see whether it's possible to predict the likelihood of side effects for an individual, Crompton and his colleagues drew blood from nearly 400 people who had been diagnosed with various forms of cancer and who were about to begin long-term radiation therapy.

The researchers irradiated the blood samples with X rays and over the next 48 hours measured the proportion of certain types of immune cells that died. Such cell death is part of a healthy response to radiation damage, says Crompton. The scientists then followed the volunteers' health for an average of 29 months and gathered data on which patients developed late reactions to radiation therapy.

Six percent of the volunteers had severe delayed reactions, including problems of the skin, bladder, and intestine. Those volunteers were much more likely than the others to have had a relatively small proportion of immune cells die in the original blood test, Crompton reports. —B.H.

DRUG RESEARCH

Promising drug cuts tumor metabolism

Early safety trials of an experimental medicine suggest that it could be used for treating several serious cancers.

Gastrointestinal stromal tumor, or GIST, is an unusual but highly lethal form of cancer. Two years ago, George Demetri of the Dana-Farber Cancer Institute in Boston and his colleagues demonstrated that the drug imatinib, also called Gleevec, can dramatically shrink tumors in people with GIST (*SN: 5/26/01, p. 328*). That drug has since become standard therapy for people with the disease. After treatment for an average of about 18 months, however, GIST becomes resistant to imatinib and tumor growth accelerates.

Lately, Demetri has been testing a new experimental drug, called SU11248, against imatinib-resistant GIST. SU11248 has been tested in mice, but its safety and effectiveness in people haven't been established.

Demetri's team gave varying doses of SU11248 to 45 GIST patients whose cancers either never responded to imatinib or had become resistant to the drug.

Aberrant metabolic activity that supports tumor growth dropped off in nearly three-quarters of the people taking the experimental drug, Demetri and his colleagues found. Positron-emission tomography images taken after patients began receiving SU11248 showed reduced tumor metabolism, compared with images taken prior to treatment.

In other recent experiments with SU11248, Jean-Pierre Armand of the Institut Gustave Roussy in Villejuif, France, and his colleagues report preliminary data suggesting that the drug might also work against kidney cancers and neuroendocrine tumors, which can arise in various parts of the body.

Both Armand and Demetri found fatigue to be the most common side effect that caused patients to discontinue treatment with SU11248. Other side effects, which will have to be monitored as trials continue, include damage to bone marrow and gastrointestinal bleeding. —B.H.

Books

A selection of new and notable books of scientific interest

FOUR COLORS SUFFICE: How the Map Problem Was Solved

ROBIN WILSON

In 1852, in a letter to a colleague, Augustus De Morgan of London unwittingly presented a mathematical conundrum that perplexed professional and recreational mathematicians for 125 years. Today, some are still not satisfied with the solution. The four-color problem poses this hypothesis: Every map can be colored with at most four colors in such a way that all neighboring countries are colored differently. Wilson charts the history of this problem and details its proof, as posited by Wolfgang Haken and Kenneth Appel in 1976. Before this team's success, the efforts of many people, including the author of *Alice's Adventures in Wonderland*, known as Lewis Carroll, elucidated the problem and contributed to the mathematics of computing and graph theory. Originally published in the United Kingdom in 2002. ***Princeton U Pr, 2003, 262 p., b&w photos/illus., hardcover, $24.95.***

GOLDEN WINGS: And Other Stories about Birders and Birding

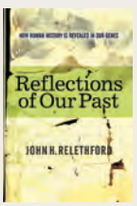
PETE DUNNE

Dunne is perhaps the world's best-known living birdwatcher. This book pulls together 41 articles he has published in recent years on the subjects of his affection. Among them is a wandering albatross with which he had a remarkable encounter. In another essay, Dunne imagines the "perfect bird": with the size of a turkey, the wingspan of an eagle, the legs of a crane, the feet of a moorhen, and the talons of a great horned owl. He opens his book with a tribute to the late birding legend Robert Tory Peterson. ***U TX Pr, 2003, 122 p., paperback, $15.95.***

REFLECTIONS OF OUR PAST: How Human History Is Revealed in Our Genes

JOHN H. RELETHFORD

Advances in the field of genetics aren't only helping us understand how we are the way we are; they're also helping define where we came from. Relethford summarizes some of the methods and findings of geneticists and anthropologists who have collected genetic data and identified our ancestors dating to 7 million years ago. He examines who our closest living relatives are and when we diverged from them along our evolutionary path. Then the author explores when and where modern humans first appeared, what happened to the Neandertals, the genetic history of the Jews, and how farming spread across Europe, among other provocative topics. ***Westview, 2003, 257 p., b&w illus., hardcover, $26.00.***



SNOWBALL EARTH: The Story of the Great Global Catastrophe That Spawned Life as We Know It

GABRIELLE WALKER

For years, geologists have struggled with why life flourished so dramatically during the Cambrian era. Walker tells the story of how Harvard geologist Paul Hoffman has roiled his field with a new answer. Hoffman asserts that the worst ice age ever, about 700 million years ago, jumpstarted life on Earth rather than threatened it. This period of intense cold was followed by intense heat that made Earth's climate ripe for life, Hoffman says. The key to this theory is in ancient carbonate rocks, apparently formed by glaciers, that Hoffman found in Namibia. Not everyone is convinced by this evidence, and as Walker shows, Hoffman is contentious, as well as persuasive. In *Snowball Earth,* Walker, a feature writer at *New Scientist*, does a superb job of clearly explaining both the science and academic politics involved in this debate. She relates the adventure of Hoffman's fieldwork, which takes him and his team to many exotic locales around the globe. ***Crown, 2003, 269 p., hardcover, $24.95.***

STIKKY NIGHT SKIES: Learn 6 Constellations, 4 Stars, a Planet, a Galaxy, and How to Navigate at Night—in One Hour, Guaranteed

Geared to the novice, this guide presents a purely visual tour of the night sky. Each image builds on what came before it and reinforces what the reader just learned. The book begins with an introduction to the constellation Orion and guides any would-be astronomer to finding it. After pointing out the parts of Orion, such as the star Betelgeuse, the text challenges readers to find similar elements among other constellations of stars and planets in the night sky. The tour includes the Big Dipper; constellations Cygnus, Taurus, and Pleiades; the stars Sirius and Vega; and the Milky Way. A concluding section reviews all that has been learned. ***Laurence Holt Bks, 2003, 234 p., b&w photos, paperback, $12.00.***

THE WEATHER IDENTIFICATION HANDBOOK

STORM DUNLOP

How do you tell the difference between stratocumulus and nimbostratus clouds? How wide is the base of a tornado? How cold must cloud temperatures be for a thunderstorm to occur? What is a fogbow? Dunlop answers these questions as he clearly and succinctly profiles all types of weather phenomena. With an emphasis on the 10 types of clouds, the book includes chapters on precipitation, winds, severe weather, and optical phenomena. This guide is enhanced by a multitude of color photographs and easy-to-use cross-references. ***Lyons, 2003, 192 p., b&w and color photos, paperback, $16.95.***

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

LETTERS

For art's sake

For those of us who know how to draw and understand the varieties of linear perspective, David Hockney's proposal that the old masters used optical aids rings true ("Reflections on Art," *SN: 5/31/03, p. 346*). One of his examples will suffice: The uncanny accuracy of difficult-to-depict patterns in folding cloth in works of the early 1400s is an indication that optical aids were used.

EDWARD HARVEY, ALLAN HANCOCK COLLEGE, SANTA MARIA, CALIF.

Concerning the question of optical aids, there is a possible answer well short of the use of lenses, mirrors, or a pinhole camera obscura. A simple grid of strings and a fixed eye point will allow the artist to create a correct perspective with the use of a corresponding grid on paper. There is evidence that Albrecht Dürer used this technique.

PETER JONES, BOSTON, MASS.

The Impressionists insisted they wanted to paint directly what they saw in nature. The true revolt of these artists was against the use of mirror images to create art.

MARY BELLE O'BRIEN, NEW YORK, N.Y.

Stork's analysis of the chandelier in "Portrait of Giovanni Arnolfini and His Wife" by Jan van Eyck rests on the axiom that its arms are precisely identical. It seems anachronistic to expect the 15th-century artisan who fabricated the chandelier to have bothered with this detail. And the argument neglects the possibilities of imprecise assembly, as well as wear and tear. In short, the chandelier itself might have given these results, even if photographically rendered.

LEANDRA VICCI, SILK HOPE, N.C.

David Stork says that he has superimposed lines on a photograph of a casting of a 15th-century chandelier from the town where van Eyck painted. The photo passes tests of symmetry that the painted chandelier fails, Stork says. —P. WEISS

Corrections *"Gorgeous Gas"* (SN: 5/24/03, p. 328) *states that star BAT99-2 "is the hottest Wolf-Rayet star known, with a surface temperature of 120,000 kelvins. . . ." BAT99-2's temperature is actually less than 100,000 kelvins, and the star is the hottest Wolf-Rayet star known in the Large Magellanic Cloud galaxy.*

The credit for part of the composite image on the SN: 6/21/03 *cover (for "Mystery in the Middle") should have read M. Christopher/OVRO, rather than C. Howard/OVRO.*

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