SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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scopefree colonoscopy

exploring exosomes

sun's magnetic flip-flop

doppler effect reversed

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to morph!

TRANSFORMATION IN AVIATION

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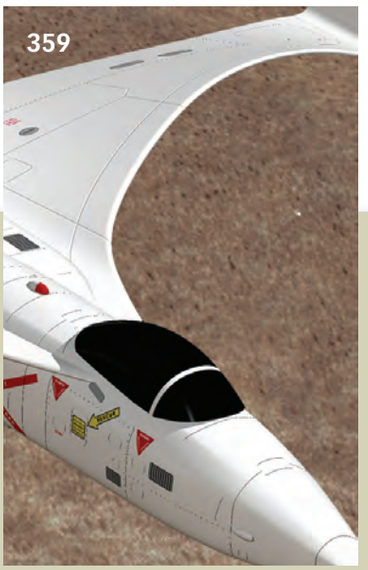

Features

This Week

Of Note

Departments

Cover Future aircraft may undergo fluid reshaping of components during flight, such as the transformation of the wings illustrated here. A long-neglected legacy of the Wright brothers, such morphing is expected to improve range and aerodynamic performance, as well as broaden the types of missions that a single aircraft can perform.
(Chuck Henderson, www.henderson3d.com)
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No Scope

CT scan works as well as colonoscopy

For anyone seeking to avoid the unpleas-antness and discomfort of a colonoscopy, here's good news: A computed tomography (CT) scan that provides a "virtual colonoscopy" of the large intestine is just as adept at detecting signs of cancer as is a viewing device moved through the colon, a new study finds.

A team led by researchers at the National Naval Medical Center in Bethesda, Md., used a CT scanner to generate three-dimensional images of the colon, an emerging technique that seems to be more accurate than typical two-dimensional CT scanning. The 3-D images consistently revealed polyps growing inside the colon. Such growths aren't necessarily cancerous, but some can develop into tumors.

The scientists performed CT scans on 1,233 people, average age 58, who were free of signs of cancer. Next, without knowing the CT results, other doctors conducted a colonoscopy on each volunteer. In this procedure, a physician inserts a flexible, camera-tipped tube into a sedated patient's colon via the rectum and withdraws it gradually while watching a video screen for polyps.

In this generally healthy group of volunteers, only two cancerous polyps showed up. CT scanning spotted both, but colonoscopy found only one. Of 48 worrisome polyps at least 1 centimeter in diameter, 45 turned up in the CT scans and 42 were detected by the colonoscopy. Between them, the tests turned up 554 polyps deemed to have malignant potential.

"The results were quite comparable," says study coauthor Pauline A. Mysliwiec, a gastroenterologist now at the University of California, Davis, Medical Center in Sacramento. The report appears in the Dec. 4 *New England Journal of Medicine*.

Patients spent an average of 14 minutes in the CT scanning room, where they received a sometimes-uncomfortable infusion of air into the colon. A colonoscopy took 32 minutes during which patients were sedated to a dreamlike state.

Colon cancer kills nearly 60,000 people annually in the United States, even though it is largely preventable through polyp detection and removal. The Centers for Disease Control and Prevention in Atlanta reported earlier this year that fewer than half of U.S. residents over age 50 have had a colonoscopy or a sigmoidoscopy, a similar but less-thorough exam.

A physician who detects polyps during a colonoscopy routinely removes them using equipment built into the scope. A CT scan revealing a large polyp triggers a colonoscopy for the growth's removal.

However, colonoscopy has drawbacks as a screening tool. It risks perforating the colon, and the sedated patient requires up to an hour of recovery time and a ride home, say Martina M. Morrin and J. Thomas LaMont of Harvard Medical School in Boston in an article accompanying the new study. If the new findings are replicated and doctors can agree on how big a CT-detected polyp needs to be to warrant immediate removal, then "virtual colonoscopy is ready for prime time," Morrin and LaMont say.

The price tag for such a CT scan is "still being worked out," says John H. Bond, a gastroenterologist at the University of Minnesota and the Veterans Affairs Medical Center in Minneapolis. Once medical authorities agree that a CT scan is as good as colonoscopy, he predicts that Medicare and insurance companies will pay for CT—probably within the next 2 years.

"A lot of people are going to opt for this procedure," Bond says. —N. SEPPA

Solar Flip-Flops

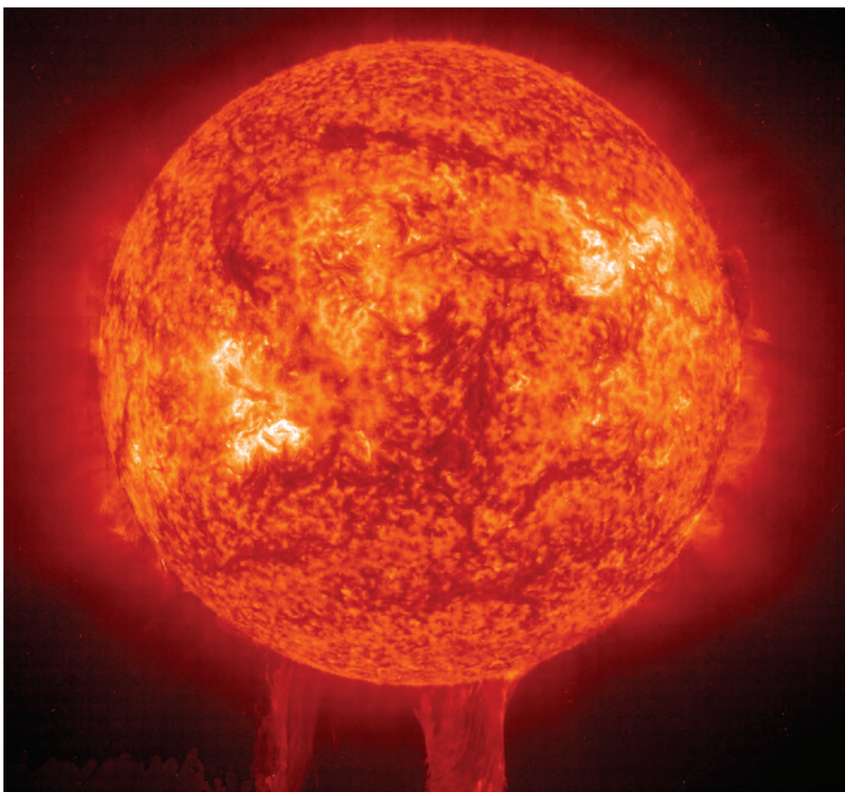
Sun storms spawn magnetic reversal

Every 11 years, the sun reaches a peak in its turbulent activity, sporting huge numbers of sunspots and hurling many billion-ton clouds of charged particles into space. At about the same time, the sun's magnetic poles flip: North becomes south, and south becomes north (*SN: 3/3/01, p. 139*).

Solar physicists have had scant clues about why this switch happens, but a new study suggests that the clouds, known as coronal mass ejections (CMEs), play a central role. By prying loose magnetic-field loops anchored to the visible solar surface, coronal mass ejections may sweep the surface clean of old magnetic fields and prepare the sun for its magnetic reversal.

The gradual process requires more than 1,000 CMEs erupting from the polar regions over several years, notes study coauthor Nat Gopalswamy of NASA's Goddard Space Flight Center in Greenbelt, Md. "When it's all over, the sun's magnetic stripes run in the opposite direction," Gopalswamy says.

In the Nov. 20 *Astrophysical Journal Let-*



NASA, EUROPEAN SPACE AGENCY

MAGNETIC SUN This false-color ultraviolet image, which was taken last year, shows part of a magnetic loop of hot gas (bottom) protruding from the sun's south pole.

ters, Gopalswamy and his colleagues consider the rate and timing of polar CMEs and the direction of the polar magnetic field. For the current cycle, the team analyzed CME data collected by the orbiting Solar and Heliospheric Observatory from 1996 to 2002. For the previous cycle, they examined data recorded by a U.S. Air Force satellite, P78-1, from 1979 to 1985. Ground-based telescopes provided data on the sun's polar magnetic field during these years.

The analysis reveals "an important connection" between the reversal of the sun's magnetic poles and polar CMEs, the researchers note. Although polar CMEs make up only 16 percent of all CMEs on the sun, they are the ones most important for the magnetic reversals.

At each pole and for both solar cycles the team examined, the number of polar CMEs and their speeds peaked just before the magnetic reversals occurred. Remnants of the sun's polar magnetic field were often found within these CMEs. The findings indicate that high-latitude CMEs rid the polar regions of their old magnetic field by literally lifting them off the sun's surface.

Solar physicist David H. Hathaway of NASA's Marshall Space Flight Center in Huntsville, Ala, notes that getting rid of the sun's old polar magnetic field is only part of the story in reversing polarity.

The sun's surface layer is divided into alternating bands of electric charge, either positive or negative, and each band has a different magnetic polarity. When the magnetic field at the north pole is removed by CMEs, a band with opposite polarity moves up, as if on a conveyor belt, to replace it. This flow of material from the equator is also crucial to flipping the magnetic field, says Hathaway.

Scientists don't yet know what drives the 11-year solar cycle. The answer to that question, Gopalswamy says, lies deep within the sun's churning interior. —R. COWEN

Cloud Chemistry

Atmospheric scientists dissect cirrus clouds

The formation of wispy cirrus clouds is not a simple matter. New research is revealing more about the conditions needed to generate these high-altitude ice clouds and illustrates new ways that pollutants can have consequences many kilometers up in the atmosphere.

Atmospheric scientists have known that when compounds such as sulfates dissolve in water droplets, those tiny airborne solutions can freeze and create cirrus clouds. Also, scientists have known that dust particles can serve as airborne platforms on which vapor freezes. Now, using vapor and particles harvested from the atmosphere, researchers have teased out more details about how cirrus clouds form.

A group led by Paul J. DeMott of Colorado State University in Fort Collins collected air samples at a lab atop a 3-kilometer-high ski mountain at Steamboat Springs, Colo. The team was about as close as it could be without a plane to the 5-kilometer altitude above which cirrus clouds form naturally.

The researchers then streamed their samples through a chamber with adjustable temperature and humidity. When the conditions were right for the formation of ice, the scientists collected crystals, melted them, and identified their chemical and solid components.

DeMott and his colleagues found that dustfree ice formed under conditions predicted by existing models of cirrus clouds, for example, at –42 °C at a relative humidity of 99.5 percent.

However, the researchers also found that

CLOUD COVER Cirrus clouds, at heights up to 16 kilometers, can cover 30 percent of Earth.

insoluble metal particles and dust in their samples could start the freezing process at a much higher temperature. When this happens, the humidity in the vicinity decreases, preventing the formation of dustfree ice crystals, says DeMott. The scientists report their findings in an upcoming *Proceedings of the National Academy of Sciences*.

"It's a competition," says DeMott. "If there are enough of these insoluble particles, they can control the formation of a cloud."

This research "shows that cirrus clouds are forming on the same types of particles that people are producing" by such activities as industrial manufacturing, says Brian Toon of the University of Colorado at Boulder. He notes that previous studies showed that cirrus clouds have become more prevalent worldwide over the past 20 years.

The new data could be used to improve models of cirrus cloud formation, the researchers say. Meanwhile, atmospheric scientists are still debating what effect cirrus clouds have on the global climate. Toon and others assert that high-altitude clouds have an Earth-warming effect by trapping incoming solar radiation that otherwise might reflect back out to space. However, increased cirrus-cloud cover could also have a cooling effect by reflecting the sun's light before it can penetrate to lower altitudes. —K. RAMSAYER

Seek and Destroy

Virus attacks cancer, spares normal cells

A mosquito-borne virus isolated 5 decades ago in the Egyptian town of Sindbis could become the latest weapon in the battle against cancer. A seemingly harmless strain of the virus homes in on cancer cells and destroys them, according to a report in the December *Nature Biotechnology*.

Daniel Meruelo of New York University School of Medicine and his colleagues stumbled upon this unusual medicinal property of the Sindbis virus while seeking to exploit the virus for gene therapy. The original plan was to alter surface proteins of the virus so that it would bind to specific types of cells and shuttle therapeutic genes into them.

In studying a strain of the Sindbis virus stripped of its capability to reproduce, however, the researchers noticed that the strain itself could invade and kill many types of cancer cells growing in lab dishes. No additional gene or alteration was required. What's more, the virus didn't seem to infect most normal cells.

"The virus, on its own, targets tumor cells without us doing anything to it," says Meruelo. "If you inject this into an animal with a tumor, the [virus] will find the tumor cells and kill them, in many cases eradicating the tumor completely."

One year ago, the researchers reported that the Sindbis virus could target cancerous hamster-kidney cells that had been implanted under the skin of mice. In the new study, the virus successfully homed in on and killed the same kind of cancer cells growing in the lungs or pancreas of mice. The virus also rid mice of

C. WOZNIAK

tumors generated from ovarian cancer cells or pancreatic cancer cells. It even infected cancer cells that had spread, or metastasized, from the initial tumors in the mice.

Sindbis virus can cause fever, headache, and other symptoms in infected people, but any illness usually passes within a week. The weakened strain used by Meruelo's group doesn't cause obvious side effects in treated animals, and there's no evidence that it would cause illness in people.

Meruelo suspects that the virus favors cancer cells because they carry a surface protein called the laminin receptor. Normal cells harbor this receptor, too, but it's usually occupied by the protein laminin. In contrast, many types of cancer cells overproduce the receptor, apparently leaving copies of it free to receive the virus.

It's not yet clear how the virus kills cancer cells, says Meruelo. Biomedical investigators have long sought to slay cancer cells by using viruses that reproduce more readily in cancer cells than in normal ones (*SN: 8/19/00, p. 126*). Since the viral strain used by Meruelo's team doesn't replicate, it must kill the cells in another manner. Meruelo speculates that the strain could be tested on people with cancer within 2 years.

"What works in a mouse model [of cancer] doesn't necessarily translate into humans," cautions Frank McCormick of the University of California, San Francisco, who has engineered cold viruses that destroy tumors. He notes that a person's immune response may thwart repeated administrations of the Sindbis virus. —J. TRAVIS

Allies in Therapy

Depression fix feeds off patient-therapist bond

In an era of intense competition for health-care dollars, psychotherapists often characterize their techniques as scientifically grounded and capable of alleviating specific mental ailments. These professionals increasingly consult manuals that describe specific procedures for treating depression and other conditions.

However, much of psychotherapy's power in quelling chronic depression comes from a less-formal aspect of therapy, according to a new study. A 3-month course of cognitive-behavioral psychotherapy proves most beneficial if the therapist and patient establish an emotional bond early on and work toward common goals, say psychologist Daniel N. Klein of the State University of New York at Stony Brook and his colleagues.

Some researchers argue that there's no solid evidence that this facet of psychotherapy, known as the therapeutic alliance (*SN: 1/11/97, p. 21*), alleviates any mental disorders. These scientists contend that a therapeutic alliance may develop only after patients have started to improve.

The new investigation counters much of that skepticism, in Klein's view. "The therapeutic alliance is probably more important to psychotherapy's effectiveness than specific techniques are," he says. Klein and his coworkers present their findings in the December *Journal of Consulting and Clinical Psychology*.

The researchers studied 367 people who had suffered from major depression for at least 2 years. Participants received 16 sessions of cognitive-behavioral therapy over 3 months. In such sessions, psychotherapists help a patient identify his or her harmful thinking patterns so as to develop better coping strategies and social skills. More than half the patients were also prescribed an antidepressant.

At weeks 2, 6, and 12, patients completed surveys that asked whether a mutually agreed-upon plan existed for achieving goals in the therapy and that gauged the perceived quality of the patient-therapist relationship.

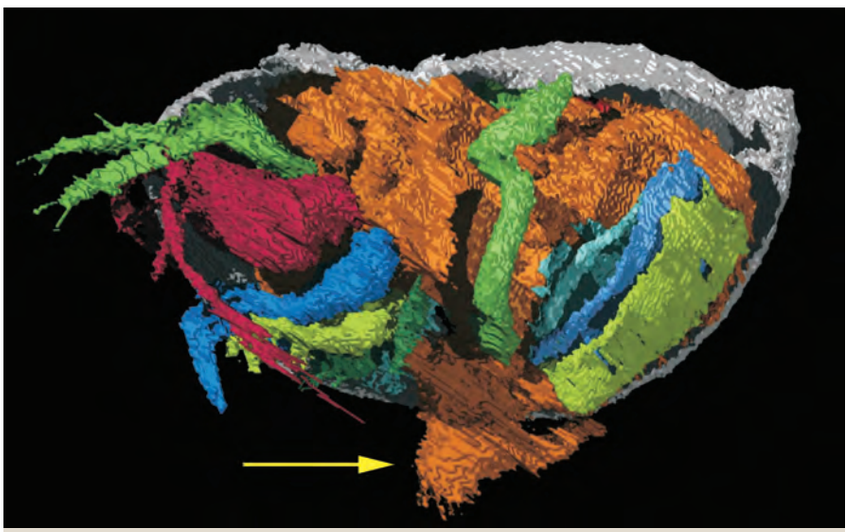
Depressed participants who, on the survey, reported a strong therapeutic alliance by week 2 exhibited the most improvement by the end of treatment. This pattern held after the team accounted for factors that could have influenced whether a patient formed a therapeutic alliance, such as sex, the severity and length of the depression, childhood abuse, and anxiety symptoms.

Patients receiving medication and psychotherapy reported slightly stronger therapeutic alliances than the others did. Added attention from a pharmacologist for people taking medication may have contributed to this effect, the scientists suggest.

"This is an important study," remarks psychologist Bruce E. Wampold of the University of Wisconsin–Madison. He supports the view that psychotherapy works primarily through general influences, such as the therapeutic alliance.

In the same journal, he and his coworkers report that in well-controlled studies of depression and other conditions, placebo therapies such as supportive counseling have achieved results comparable to those of specific psychotherapies. The therapeutic alliance influences this placebo effect, Wampold says.

Psychologist Scott O. Lilienfeld of Emory University in Atlanta advises caution in interpreting Klein's findings. "It's still difficult to know whether the therapeutic alliance directly causes improvement in depression symptoms," says Lilienfeld. Patients who possessed positive characteristics that the researchers didn't measure, such as emotional resilience and optimism,



SIVETER

Proud paleontologists proclaim: It's a boy!

Ancient marine sediments have yielded what scientists contend is the world's oldest fossil of malehood. Fossils of ostracods, a type of aquatic bivalve crustacean, typically include only shells, says David J. Siveter of England's University of Leicester. Now, he and his colleagues have constructed a virtual model of an unusually well-preserved, 5-millimeter-long specimen by grinding away hair-thin layers of rock, photographing the exposed surfaces, and digitally reassembling the slices. The 425-million-year-old fossil, described in the Dec. 5 *Science*, includes impressions of soft tissues such as the digestive tract, gills, and sex organ (arrow). Although some ostracod species don't reproduce sexually (*SN: 6/28/03, p. 406*), this creature obviously does, says Siveter. The researchers dubbed the new species *Colymbosathon ecplecticos*, which, in Greek, means "astounding swimmer with a large penis." —S. PERKINS

may have most readily formed therapeutic alliances and also most successfully fought the depression, he asserts. —B. BOWER

Doppler Toppler

Experiment upends normal frequency shift

The pitch of a blaring car horn rises as the vehicle approaches and falls as it moves away. That's the Doppler effect, and it also occurs for electromagnetic radiation, enabling police to catch speeders with radar guns and astronomers to determine distances to stars.

Now, physicists in England have demonstrated a topsy-turvy Doppler shift in which a radio wave's frequency rises as the source recedes. This inverse Doppler effect, first predicted in the 1940s, produces a frequency boost some 100,000 times greater than the drops of ordinary Doppler shifts, the researchers report in the Nov. 28 *Science*.

The large shift may make inverse Doppler useful for pushing radiation sources to yield frequencies that are now difficult to attain. One such hard-to-reach frequency range is terahertz radiation, which oscillates at trillions of cycles per second. It shows promise for medical imaging, security scanning, and many other applications (*SN: 8/26/95, p. 136*).

In the newly reported experiment, Nigel Seddon and Trevor Bearpark of BAE Systems, an aerospace and defense firm in Bristol, generated the Doppler reversal by following a strategy devised recently by Russian theorists.

At the heart of the scheme is a half-meter-long assembly of capacitors and electrical inductors into which the BAE team drives a brief, potent pulse of some 100 amperes of current. Whizzing along this transmission pathway at up to a tenth the speed of light, the powerful pulse creates all the needed inversion conditions, says Seddon.

To start with, the pulse alters the properties of each section of the pathway so that it exhibits what's known as anomalous dispersion. Normally, the directions of waves and their energy match. However, in the altered sections of the new transmission pathway, the energy carried by electrical waves travels in the opposite direction of the waves themselves. Electromagnetic radiation can reflect from the sharp, moving boundary between anomalous regions and normal ones.

Besides creating anomalous dispersion, the pulse, like a boat churning up a wave with its bow, sheds an even-faster-moving radio wave that heads off in the direction opposite to that of the pulse. When that bow wave hits the start of the transmission line, it bounces back, catches up to the mobile boundary, and gets reflected again there.

That's when the inverse Doppler effect kicks in. Reflecting off a receding boundary, an ordinary electromagnetic wave would Doppler-shift downward by a minute fraction of its frequency. However, with anomalous dispersion, the bow wave's frequency jumps a whopping 20 percent of the original frequency. That's because of the boundary's tremendous speed, Seddon says.

"Within the context of everyday experience, [this inverted effect] is certainly very unnatural," comments theorist Evan J. Reed of the Massachusetts Institute of Technology. However, inverted Doppler may soon be seen beyond electrical systems. Last September, Reed and his colleagues unveiled a theoretical analysis showing that the reversal should be possible in light-manipulating materials, including photonic crystals (*SN: 5/3/03, p. 276*). —P. WEISS

New Farmers

Salt marsh snails plow leaves, fertilize fungus

People and insects aren't the only creatures on the planet that can grow a fungus for dinner. A salt marsh snail works the leaves of a plant in what researchers say looks like a simple form of farming.

The snail *Littoraria irrorata* saws long gashes down the narrow leaves of the dominant plants in East Coast salt marshes. It doesn't eat the fresh tissue but instead waits until fungus riddles the leaf wound, explains Brian Silliman of Brown University in Providence, R.I. Snail droppings boost the amount of fungus that grows in the cut, say Silliman and Steven Y. Newell of the University of Georgia Marine Institute on Sapelo Island. They report in an upcoming *Proceedings of the National Academy of Sciences* that the snails need to eat fungus to thrive.

Previously, biologists had observed cultivation of edible fungus only in some beetles, termites, and ants (*SN: 4/24/99, p. 261*). The snail behavior "seems to be the first time fungal farming has been found outside of insects—and the first time in a marine system," says Silliman. "Fungal farming may be more widespread than we thought."

Snails graze in abundance on sick and dying cordgrass (*Spartina alterniflora*). When Silliman removed the snails, the marsh produced a burst of growth, or "a chia pet of cordgrass," as he puts it. He concluded that the snails had been somehow depleting the plants.

Piece by piece, Silliman and Newell tested the idea that the snails use the plants as real estate for fungus farming. In salt marshes on Sapelo Island, when the researchers removed snails from cordgrass leaves, the fungal infections were less extensive than when snails were present. After the researchers themselves cut leaves and applied snail droppings, the fungal biomass was almost double that on leaves protected from snail droppings.

SLASH AGRICULTURE Leaf from a salt marsh shows snail farm: a fungus-infected cut adorned with droppings.

SILLIMAN

Snails permitted to feed only on undamaged leaves barely grew, and 48 percent of their young died. However, snails thrived on fungus-only diets, and only 3 percent of their offspring perished. "It's about the fungus," Silliman concludes.

A specialist in ant farming, Ulrich Mueller of the University of Texas at Austin says, "What I find most remarkable is that [the snail] is a nonsocial species." Farming therefore may not require social interactions. Mueller also welcomes the snail findings as perhaps a rare example of early stages of farm evolution.

The work also has much to say about salt marsh ecology, says Don Strong of the University of California, Davis. According to "decades of received wisdom," he says, "salt marshes were seen as completely bottom-up phenomena." In that view, how much plant life arises at the bottom of the food chain ultimately determines how well the top animals flourish. Strong says that Silliman and his colleagues, in this and previous work, have upended that view. —S. MILIUS

WINGS OF CHANGE

Shape-shifting aircraft may ply future skyways

BY PETER WEISS

Like a bird, the world's very first airplane had flexible wings. The lightweight wood, cloth, and wire flyer, built by Wilbur Wright and Orville Wright and first flown on Dec. 17, 1903, was steered and stabilized by pulleys and cables that twist the wingtips. Some aviation historians say that this bird-inspired control mechanism was the pivotal innovation that enabled the Wright brothers to achieve heavier-than-air flight whereas others pursuing that same goal had failed.

Although the Wright brothers' control strategy worked, it vanished quickly from aviation. Stiff wings became the standard because they could withstand greater forces associated with increased flying speeds and vehicle weights. To control the sturdier aircraft, designers added movable panels to the ends of those stiff wings. Those panels manipulate the airflow and thus the aerodynamic forces that pilots use to make an airplane take off, turn, or change altitude.

Now, at the centennial of powered human flight, the original technique for controlling aircraft is in the midst of a revival. Indeed, aeronautical engineers have recently completed the first test flights of an experimental, supersonic fighter jet in which subtle twisting of the wings may steer the aircraft.

Going beyond wings that merely flex, scientists and engineers have also been developing aircraft surfaces capable of molding themselves from one shape into another, much as arm muscles bulge and flatten. These possibilities arise largely from the use of so-called smart materials, a broad range of substances that can shorten, elongate, flex, and otherwise respond mechanically to electricity, heat, light, or magnetic fields (*SN: 11/22/97, p. 328*). Even on a modest scale, such reshaping of aircraft contours could greatly enhance vehicle control and performance.

Looking yet further down the air lanes, far more drastic and complicated transformations—for instance, wings that can telescope, curl, or fold—may be on the way, yielding extraordinarily versatile airplanes and missiles that change their shapes according to the missions they are expected to perform. If research programs that are just starting eventually reveal that such large-scale morphing is feasible, the first of those aircraft may streak across the skies 20 to 30 years from now.

MORPHER'S HELPERS Many aircraft already change their shapes in striking ways. Both the B1B bomber and F-14 fighter plane pivot their wings from outstretched to swept-back positions. The recently retired supersonic commercial transport, the Concorde, tilted its nose downward for subsonic flight. Even when an ordinary commercial jet deploys its wing flaps, it could be said to be changing shape, or morphing.

However, all those familiar changes follow the same paradigm: Chunks of aircraft get pushed or pulled by an actuator, be it a motor, a piston, or other device. Bit players taking part in the action include linkages, structural reinforcements, and hydraulic lines. All told, the capability to change shape in even limited ways is expensive in terms of added aircraft weight and complexity.

New morphing strategies strive for more dramatic and versatile shape changes by means of simpler mechanisms and with little or no added weight. Taking advantage of today's high-tech materials, some rely on substances that can be bent or stretched into a new shape until reheating snaps them back into the old one. Other strategies employ fluids that thicken when subjected to a magnetic field or materials that expand or contract in response to electricity or light.

Another approach uses so-called compliant structures. Typically injection molded or machined from a single piece of material, these frameworks of metal or plastic can serve as the interior structures of, say, wing edges or other malleable components. These frameworks distribute forces in such a way that they can simultaneously flex like woven basketry in some places while resisting deformation elsewhere.

Wings that can telescope, curl, or fold may be on the way.

TWIST AND SOAR Whether or not an aircraft changes its shape, the same aerodynamic conditions govern its flight. The contours of a wing are designed to make air pressure over the wing lower than the pressure beneath it, creating the net lifting force that enables the aircraft to take off and fly.

The airflow across wings and fuselage also exerts a force, known as drag, that resists the forward motion of the aircraft. Drag results mostly from friction between the moving wing surface and the air.

To enhance lift and minimize drag, aeronautical engineers design airplanes to have smooth, continuous contours, free of drag-inducing irregularities. But the movable panels typically deployed for steering and control create drag-inducing obstacles.

To avoid that drawback, aircraft builders are now reconsidering what the Wright brothers called wing warping.

Next summer, researchers expect to demonstrate wing warping on an aircraft that's otherwise about as different from the Wright Flyer as modern technology allows. It's a modified F/A-18A fighter capable of supersonic flight. The jet has been retrofitted with exceptionally thin wings that were part of the original design for the 1980s-era aircraft but were rejected as a safety hazard because they twisted too much.

Last spring, researchers from NASA, the Air Force Research Laboratory (AFRL), and Boeing Phantom Works, the advanced research arm of the aircraft manufacturer, conducted preliminary flight tests to measure forces and other wing parameters under various flight conditions.

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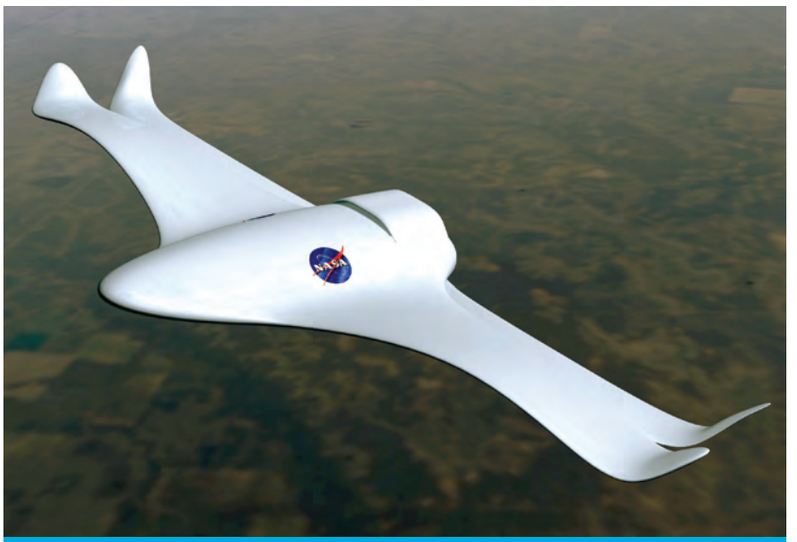
The plane still has conventional control panels, such as ailerons that are typically raised or lowered to turn, or roll, the aircraft, and flaps, which are extended or retracted to vary the amount of lift. But these structures have been relegated to a supporting role, serving as the levers used to initiate specific wing reshapings that are wrought by onrushing air currents.

The so-called active aeroelastic wing has a major advantage: It can be up to 15 percent lighter than a conventional wing because it's thinner and more flexible.

What's more, using the entire wing as a control surface generates much more torque than using conventional flaps does. "We believe we could roll the aircraft better than a conventional F/A-18, under high-speed conditions," says Peter M. Flick, AFRL's program manager on the project.

At a lab in Germany, researchers have begun a related project in the realm of civilian aviation. The goal is to exploit in-flight twisting of the wings of Airbus transports to distribute aerodynamic forces more evenly along those wings. Shifting force from the wingtips toward the fuselage might reduce an aircraft's weight by eliminating some of the heavy structural reinforcement from the wings' outer reaches, says Hans Peter Monner of the German Aerospace Center (DLR) in Braunschweig. The challenge, he adds, is to make the twistable configuration lighter than the structural weight that would be avoided.



ON A BENDER — With a bone-and-muscle-like wing structure beneath flexible skin, this concept for a morphing aircraft mimics bird flight behaviors—though not flapping. NASA predicts an aircraft like this may fly by 2030.

AVIATION UNHINGED Not everyone is taking a full-wing approach to wing warping. Wing edges that can mold themselves into a variety of graceful curves and other deformations can also provide flight control while reducing drag.

In a recent joint effort by the Defense Advanced Research Projects Agency (DARPA), AFRL, and NASA, engineers devised a spine- like structure that snakes along a wing's trailing edge. For the vertebra of that spine, researchers in the so-called Smart Wing Program used lightweight aluminum wedges. Each wedge could be independently extended or tilted using actuators. A stretchy silicone skin covered the spinal assembly.

In wind tunnel tests, the wedges on a model of the wing adjusted to form more than 70 different wing contours. What's more, for the same amount of deflection that a conventional aileron provides, the deformable wing edge produced greater torque for turning the aircraft, the researchers report in an upcoming special issue of the *Journal of Intelligent Materials Systems and Structures*.

While such wing transformations look promising for high-speed, highly maneuverable combat jets, their value in large civil transports is doubtful, a recent study shows.

The DLR's Monner and his colleagues have tested morphing structures, including a deformable trailing edge, intended to optimize wing lift-to-drag ratios and therefore fuel efficiencies for certain Airbus vehicles, such as the 300-to-400-passenger Airbus A340.

The performance of the flexible trailing edge was similar to that of a conventional set of flaps with an extra segment, the team reports. That's because a layer of turbulent air some 2 centimeters thick hugs the wing surfaces of big, subsonic jets, making airflows less sensitive to underlying shapes, such as the sharp edges of conventional control surfaces, Monner explains.

Although wings have received the most attention from shape-change researchers, "there are advantages to making changes in the propulsion system as well," says St. Louis–based Edward V. White of Boeing Phantom Works. What's more, the advantages seem to apply to both military and civil aviation.

In a recently completed DARPA-funded study, White's team demonstrated dynamic reconfiguring of engine-inlet nozzles of F-15 Eagle fighter aircraft that could boost the aircraft's range by up to 20 percent.

Now, the Boeing engineers are looking into subtle shape shifting of teeth, called chevrons, which intrude slightly into the exhaust nozzles of passenger jets to reduce engine noise on take-off. Unfortunately, the chevrons also reduce fuel efficiency. By making chevrons that would reshape themselves to withdraw from the flow after take off, aircraft makers could recoup a small but significant amount of fuel.

"It's something that would benefit just about all commercial aircraft," White says.

BREAK THE MOLD Much more radical morphing is just beginning to come off some aeronautical engineers' drawing boards. As a starting point, several companies are exploring major wing transformations.

Consider Skunk Works in Palmdale, Calif., the aeronautics research and development arm of Lockheed Martin. Engineers there have recently proposed an aircraft that would perform wing calisthenics. To transition between a large, fully extended wing suitable for cruising to a smaller, more combat-tailored wing positioned above the fuselage, the aircraft would lift and fold its wings while simultaneously drawing them together.

NextGen Aeronautics, a small company in Torrance, Calif., is investigating a morphing wing that would convert between the extremes of a swept-back "bat wing" for combat and a narrow, planklike wing for cruising.

Raytheon Missile Systems in Tucson, is exploring a telescoping wing for a cruise missile.

These participants in a year-old DARPA program called Morphing Aircraft Structures have pledged to create, by 2005, functional, scale-model wings that can vary in area or length by 50 percent. That's a huge change, considering that the control surfaces of a conventional, fixed-wing aircraft modify wing areas by no more than about 5 percent, says DARPA's Terry A. Weisshaar, who heads the program.

Each approach presents its own challenges. When an aircraft folds its wings on the fly, rapid, large shifts occur in its center of gravity and another balance point known as the aerodynamic

Continued on page 365

NASA

TINY BUBBLES

Vesicles that cells spit out are implicated in cancer and AIDS

BY JOHN TRAVIS

When Gustavio Romanio looked through his microscope last year, the University of Michigan cancer researcher was perplexed. Tumor cells that had been treated with chemotherapy agents had bubblelike objects at their edges. These microscopic vesicles were apparently being shed by the cells. What's more, the bubbles contained some of the chemotherapy drugs.

Romanio and his colleagues quickly scanned the research literature and discovered that other scientists had seen similar vesicles, dubbed exosomes, coming off many kinds of cells, including cancer cells.

"Although I was trained as a cell biologist, I had not heard of exosomes or vesicle shedding before," recalls Romanio.

Many biologists still haven't. This spring, James Hildreth of Johns Hopkins Medical Institutions in Baltimore spoke at a meeting of AIDS researchers and proposed that HIV travels between cells as cargo in exosomes. "Many of the [people at this meeting] didn't even know what an exosome was," Hildreth recalls.

That may be changing. In the Sept. 16 *Proceedings of the National Academy of Sciences*, Hildreth and his colleagues detail the provocative connections between exosomes and HIV and call for a new vaccine strategy based on those links. And Romanio's group has just published data suggesting that tumors use exosomes to foil cancer drugs. And other scientists are now using exosomes given off by immune cells to battle cancer and infectious microbes.

"Exosomes are a device for transporting material from cell to cell. It's kind of a biological FedEx," says Jean-Bernard Le Pecq, cofounder of a company that's testing whether exosomes can stimulate immune responses against tumors.

IN THE BLOOD Unless one knows what to look for, it's easy to miss exosomes. Until 20 years ago, the flattened spheres of lipid molecules, ranging from 50 to 200 nanometers in diameter, were dismissed as merely free-floating fragments of a cell's membrane.

In 1983, however, a research group studying immature red blood cells concluded that exosomes have a function. As red blood cells mature, they expel most proteins other than the oxygen-carrying molecule hemoglobin. The investigators determined that exosomes served as cellular garbage bags for the unneeded proteins. "It was interesting, but people were not that excited about [exosomes] at the time," recalls Clotilde Théry of the Curie Institute in Paris.

In 1996, a Dutch group led by Graça Raposo of Utrecht University in the Netherlands reignited the exosome field by reporting that the vesicles are also made by immune cells called B lymphocytes. The researchers showed that exosomes form within larger sacs inside the cell before traveling to the cell surface for release.

Something else very interesting occurs within these sacs: Immune system proteins of the major histocompatibility complex (MHC) join to molecular fragments, called antigens, such as bits of an invading bacterium. In fact, Raposo's team found that exosomes carry these MHC-antigen complexes, which typically stimulate immune action against microbes bearing the antigens.

"At that point, people started to think that exosomes could play a role in immune responses," Théry says.

MHC-antigen complexes are crucial to how a person's immune system defends against infectious microbes. Macrophages, dendritic cells, B lymphocytes, and other immune cells chop up bacterial and viral proteins into fragments. Those cells package the resulting antigens with MHC proteins and present them to T cells, natural killer cells, and other members of the immune system. That way, these mercenaries of the immune system know what they should be hunting down.

In 1998, Raposo, who had moved to the Curie Institute, joined with colleagues in France and Italy to report that dendritic cells also secrete exosomes containing MHC-antigen complexes. More important, the scientists reported that these exosomes could serve as the basis of a new anticancer strategy.

> "We are exploring strategies to constipate the cancer cell to death."
>
> — GUSTAVE ROMANIO
> UNIVERSITY OF MICHIGAN

Scientists consider dendritic cells to be the most potent antigen-presenting cells in the body. Some investigators have primed these immune sentinels by loading the cells with antigens in the form of proteins or protein fragments from cancer cells. The dendritic cells are then injected into a patient as a cancer vaccine.

In a twist on that strategy, Raposo and her colleagues loaded laboratory-grown dendritic cells with potential tumor antigens. Instead of injecting the dendritic cells into test mice, the researchers isolated exosomes released by the immune cells and injected the exosomes. The new strategy prompted the animals to mount immune attacks on their tumors that ultimately eradicated the cancer. In mice, the exosome approach has worked against lymphomas, melanomas, and breast cancer, says Théry.

She and her colleagues are now trying to determine how exosomes excite an immune response. In the December 2002 *Nature Immunology*, they reported that exosomes originally isolated from dendritic cells, when injected into mice, are captured by other dendritic cells. These cells then apparently use the antigens and other molecules within the exosomes to stimulate the activity of T cells, the true warriors of the immune system.

Théry speculates that the first dendritic cells to encounter an infectious microbe produce exosomes bearing microbial antigens as messages to other dendritic cells, sparking a chain reaction that amplifies and perhaps speeds the overall immune response.

CANCER FIGHTER OR HELPER? Whatever their mechanism of immune stimulation, exosomes have already been drafted by researchers for the fight against human cancer. A company called Anosys, based in Menlo Park, Calif., and cofounded by Le Pecq, has sponsored safety trials of exosomes derived from dendritic

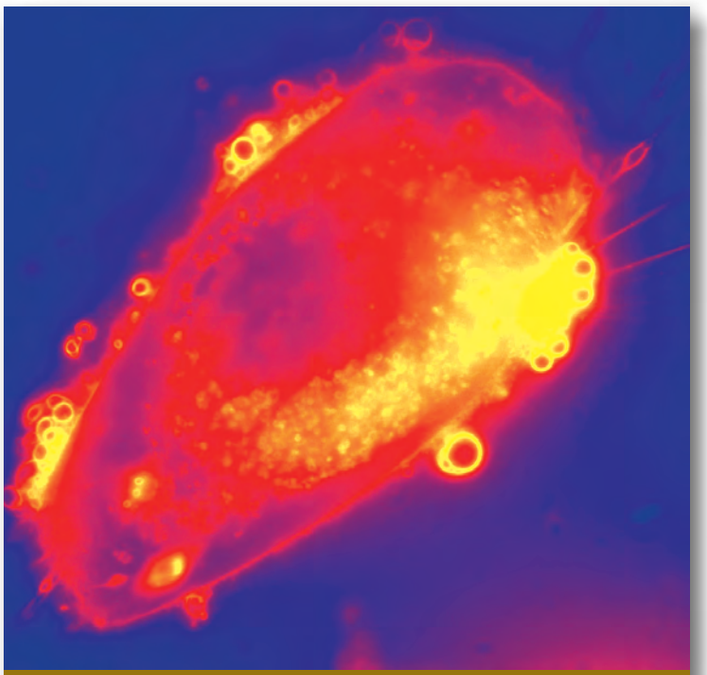
cells. So far, a few patients with either small-cell lung cancer or melanoma have received them intravenously.

"We don't see any toxic side effects," says Le Pecq. "We have seen slight tumor regressions, but nothing spectacular."

Still, the results from these preliminary studies are encouraging enough that Anosys-funded researchers in France and the United States will next year launch a larger trial of exosome treatment for people with severe lung cancer. The firm is also exploring whether exosomes loaded with microbial protein fragments might offer a new way of vaccinating people against infectious diseases.

As researchers try to determine whether exosomes can be used as weapons against tumors, that effort begs the question of why tumor cells themselves typically secrete the vesicles. Théry's colleagues, led by Laurence Zitvogel of the Gustave Roussy Institute in Villejuif, France, first documented that phenomenon in 2001, and Romanio's observations last year seemed to confirm it. Zitvogel's team has speculated that the tumor makes exosomes to somehow blind the immune system to the growth of the cancer cells.

Romanio's research offers another potential dark side to exosomes. His group has been studying how tumor cells respond to anticancer drugs. Many tumors can withstand the actions of such medications, and investigators have identified several molecules that pump drugs out of resistant cells or transport them to regions of the cell that corral and disarm the chemicals.



BUBBLING OUT — Vesicles at the surface of this cancer cell contain a fluorescent chemotherapy drug. Cancer cells may use such vesicles to expel the medication, thereby thwarting its therapeutic effect.

In the Aug. 1 *Cancer Research*, Romanio and his colleague report that the chemotherapy agent doxorubicin and similar compounds accumulate in vesicles shed by cancer cells. Immediately after doxorubicin is added to cells, it travels to a cell's nucleus, but within 3 hours, it's seen in exosomelike vesicles at the cell's edges. "We don't really know if they are exosomes," cautions Romanio.

Supporting the hypothesis that these vesicles offer a way for tumors to rid themselves of toxic drugs, the researchers also document that genes involved in vesicle formation are more active than normal in tumor cells with increased drug resistance. Indeed, the amount of vesicle shedding by various cancer cells correlates with each type's degree of drug resistance.

Romanio speculates that certain anticancer drugs, such as those attracted to the lipids that make up exosome membranes, are most susceptible to removal by the vesicles. Conceivably, interfering with the expulsion of the drugs by the vesicles could make chemotherapies more potent. "We are exploring strategies to constipate the cancer cell to death," says Romanio.

THE TROJAN EXOSOME Beyond their potential connection to cancer, what has thrown the spotlight on exosomes is a recent paper authored by Hildreth, his Johns Hopkins Medical Institutions colleague Stephen J. Gould, and Gould's student Amy M. Booth. Part of the attention stems from the paper's snazzy title—"The Trojan exosome hypothesis"—and its implication that the AIDS virus can sneak into cells via exosomes, much as Greek soldiers invaded Troy by hiding in a wooden horse.

The hypothesis came about after Gould, a cell biologist, and Hildreth, who studies HIV, began discussing the fact that each HIV is adorned with a variety of human-cell proteins. "It's now very clear that the preponderance of proteins in the membrane of the virus is host proteins," says Hildreth.

Most biologists simply attributed that phenomenon to the virus particle budding out of an infected person's cell and becoming coated with part of that cell's protein-studded membrane. But if that's the case, it's hard to explain why some abundant cell-surface proteins are all but absent on HIV, while relatively rare cell-surface proteins are present at high concentrations. Moreover, an array of proteins from inside human cells is also present in the HIV.

Over the past few years, several research groups have shown that HIV can assemble itself inside cells in the same sacs where exosomes form. "It became obvious to us that retroviruses generally, and HIV in particular, evolved to become cargo of this pathway," says Hildreth.

HIV usually infects cells when proteins in its envelope attach to specific proteins on an immune cell and initiate fusion between the virus and cell. Yet there have been controversial reports that the AIDS virus doesn't need its envelope proteins to infect cells and that the virus can infect nonimmune cells lacking the molecular handholds that the envelope proteins grip.

The Trojan-exosome hypothesis could offer an explanation for these phenomena, since the vesicles have their own methods of attaching to cells and dumping their cargo inside. "If we model HIV as an exosome, it means that this virus possesses an ancient, preexisting method to fuse to [cell] membranes," says Hildreth.

The Trojan-exosome hypothesis has drawn a mixed reaction from AIDS researchers. If exosomes were significant players in HIV infection, then cells everywhere in the human body would be infected, and that's not the case, says Robert Gallo of the Institute of Human Virology in Baltimore. Also, newly developed drugs that block HIV's envelope proteins from binding or fusing with cells wouldn't slow infections as dramatically as they seem to, he adds.

"I can't accept [exosomes] as being of real significance," concludes Gallo.

Gould counters that he and Hildreth don't claim that exosomes account for most of HIV's virulence in patients with AIDS, but they do believe the vesicles provide a way for the virus to hide out in the body.

"If your definition of clinical relevance is whether this alternative, backdoor pathway has any relevance to the virus' ability to persist in the face of potent antibody and [immune cell] responses, then it is relevant," Gould argues.

A RETROVIRUS IS BORN Wesley I. Sundquist and his group at the University of Utah in Salt Lake City have provided much of the evidence showing that the release of HIV from infected cells depends on the same intracellular pathway used to assemble exosomes. Although he remains skeptical about the importance of

ROMANIO

vesicles in the spread of the AIDS virus, Sundquist says he's intrigued by another proposition that Gould and Hildreth have floated: Exosomes may have spawned retroviruses, such as HIV.

Scientists have previously suggested that these viruses evolved from genetic sequences known as retrotransposons, which show up in most animals' cells. Indeed, the sequences make up about 10 percent of the human genome. The only apparent function of retrotransposons, which are known as selfish DNA, is to make copies of themselves. They do this by compelling the cell to make an RNA template of their DNA and then using that RNA to make another strand of DNA that is stitched back into the cell's DNA.

Similarly, HIV and other retroviruses have genes made of RNA. The retroviruses infiltrate cells by making a DNA copy of their viral RNA, and the DNA copy gets integrated into a host cell's DNA. Consequently, scientists have proposed that retroviruses evolved from retrotransposons. Hildreth says that a mutation that redirected a retrotransposon's RNA into the exosome-assembly pathway could have offered a ready-made way to package that RNA, get it out of a cell, and deliver it into another cell. Voilà, a retrovirus.

"By this one simple [mutation], we've solved the problem of how retrotransposons became retroviruses," says Hildreth. Over time, retroviruses could have evolved envelope proteins that would have enabled them to more efficiently infect cells and target specific cell types, the researchers add.

"I could kick myself for not thinking of the idea that viruses likely evolved from exosomes," says Sundquist. "It is a clever and attractive idea."

The most dramatic conclusion reached by Gould, Booth, and Hildreth concerns HIV vaccines. The researchers argue that if HIV spreads, in part, via exosomes, then current experimental vaccines may not offer enough protection because they raise an immune response only against viral-envelope protein. These scientists call for vaccine developers to look into immunizations based on a phenomenon called alloimmunity.

The quick-acting alloimmune response occurs when a person rejects a transplanted organ. It happens because the donated organ's surface molecules, particularly the MHC proteins, don't match the recipient's MHC proteins closely enough.

Hildreth and his colleagues at Johns Hopkins argue that this alloimmune response actually represents the body's original way of defending against retroviruses. The researchers theorize that because HIV uses the exosome pathway to break out of a host cell, newly formed viruses should bear MHC proteins from the people they're infecting at the time. If the viruses then move in to a person with dissimilar MHCs, this second person should quickly mount an alloimmune response to the virus. Several lines of evidence confirm that HIV transfers less efficiently between MHC-mismatched people than between others, Hildreth points out.

> "The more we learn about exosomes, the more we will learn about HIV."
>
> — JAMES HILDRETH
> JOHNS HOPKINS
> MEDICAL INSTITUTIONS

Consequently, the researchers endorse a previously discussed but largely dismissed vaccine strategy: immunizing populations with MHC-based vaccines that would boost the alloimmune response. "We should start to see a dramatic drop in the rate of [HIV] transmission," says Hildreth. "This may be a very simple way to slow the virus down."

Gallo questions whether HIV researchers will be discussing the Trojan-exosome hypothesis a year from now, but Gould and Hildreth argue that their proposals will have a lasting impact. "There's a tremendous amount to be learned about the biology of exosomes," says Hildreth. "We're hoping this will shine a bright light on the exosome field. The more we learn about exosomes, the more we will learn about HIV." ■

Continued from page 362

center. Such shifts, absent among conventional fixed-wing aircraft, could make the plane spin or become otherwise unmanageable, says Daniel J. Inman of Virginia Polytechnic Institute and State University in Blacksburg.

"You could think of it like going out in a small fishing boat and trying to keep control of it while people jump around in front," he says. Working with Lockheed Martin engineers, Inman and his colleagues have used computers to simulate the wing transition and have come up with sequences of control-surface adjustments that they predict would maintain stability.

"Stability through the transition is an issue," says engineer Charles Chase of Lockheed Martin. However, he adds, wind tunnel tests—as well as computer simulations—indicate this transition can be managed. Going beyond DARPA's requirement of producing a demonstration wing, the Lockheed Martin team is constructing a radio-controlled, jet-powered, unmanned aerial vehicle with which to demonstrate the folding-wing capability, says Chase, a program manager of the Skunk Works' advanced development program. The researchers expect to start test flights of the vehicle, which will have a 9-foot wingspan, in the next few months.

As for the bat-wing structure proposed by NextGen, it would have to be "like an umbrella that you fold up and unfold back out," says Jayanth N. Kudva, an aerospace engineer who led the Smart Wing program when he was at Northrop Grumman in El Segundo, Calif. Kudva founded NextGen last January. Making the bat-wing structure even more challenging is the requirement that the covering of this novel wing must remain taut and smooth at all times, Kudva says, unlike an umbrella's fabric, which becomes taut only when the apparatus is fully open.

Compared with the bat wing structure, Raytheon's telescoping-wing design may seem relatively straightforward. However, because cruise-missile wings are extremely small, there is little space for actuators and wing portions that slide into others. Moreover, of all the wing types being modified in the DARPA program, the cruise missile wings sustain the greatest forces, says Raytheon aerospace engineer Patrick O'Hagan.

Although the Wright brothers launched morphing research a century ago, that engineering approach has caught on only in the past few years. With many aeronautical designers now bent on applying all the know-how and technological progress of the last century to the task, a new phase of aviation may be taking off. ■

OF NOTE

BIOMEDICINE

Two markers may predict heart risk

Two proteins that play a role in inflammation may serve as indicators of a person's risk of heart disease and stroke. The immune system proteins, called interleukin-6 and tumor necrosis factor-alpha (TNF-alpha), help orchestrate the body's response to injury.

Physician Matteo Cesari of the Wake Forest University School of Medicine in Winston-Salem, N.C., and his colleagues analyzed blood samples from 2,225 healthy people, all in their 70s. After an average follow-up period of 3.6 years, 188 of the participants had been newly diagnosed with heart disease, 92 had developed congestive heart failure, and 60 had had strokes.

The researchers found that, on average, people who encountered the heart problems had started the study with significantly higher blood concentrations of interleukin-6 and TNF-alpha than did participants who remained healthy. Higher interleukin-6 also correlated with higher stroke risk, the researchers report in the Nov. 11 *Circulation*.

The researchers say that although the two proteins' roles in heart disease and stroke aren't clear, measuring them in a person's blood could prove to be a better indicator of such problems than is measuring C-reactive protein, another inflammation-related compound that physicians consider a strong indicator of heart disease risk.

The new results on the proteins' diagnostic potential should spur researchers to develop better methods for measuring them in blood, Cesari says. —N.S.

ASTRONOMY

Martian sand ripples are taller than Earth's

New data gathered by a Mars-orbiting probe suggest that large ripples in sandy areas of the Red Planet are more than twice as tall as their terrestrial counterparts.

Single images taken from space rarely reveal the height of topographic features. However, by combining two orbital images taken from slightly different angles to create so-called stereo pairs of a region, researchers can calculate heights.

Kevin K. Williams and James R. Zimbelman of the Smithsonian Institution in Washington, D.C., analyzed stereo pairs garnered by the Mars Global Surveyor. Some regions revealed ripples 38 meters apart and 5.7 m high. On Earth, ripples with the same spacing reach only 2.5 m or so.

The taller sand ripples on Mars probably stem from a complex relationship among several factors, says Williams. Mars has a surface gravity that's only about 40 percent that of Earth's and a very thin atmosphere. Meanwhile, sand-moving winds on Mars can be much more intense than they are on Earth. The researchers presented their findings Nov. 3 in Seattle at the annual meeting of the Geological Society of America. —S.P.

BIOLOGY

Plants, bats magnify neurotoxin in Guam

Researchers have turned up new evidence that a natural toxin that grows more concentrated as it moves up the food chain might have caused a puzzling spike in a neurodegenerative disease in Guam.

Starting in the mid-20th century, this disease—which shares traits with Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease—began increasing among Guam's Chamorro people (*SN: 5/17/03, p. 310*). Last year, scientists proposed a new explanation: The presence of flying foxes, a type of bat, on the dinner plate rose with the availability of guns and then declined as the bats became extinct. Abundance of the delicacy exposed people to more of the neurotoxin beta-methylamino-L-alanine (BMAA) that comes from a local plant that these bats eat, researchers hypothesized.

Concentrations of the neurotoxin indeed rise along the food chain, report ethnobotanist Paul Alan Cox of the National Tropical Botanical Garden based in Kalaheo, Hawaii, and his colleagues in the Nov. 11 *Proceedings of the National Academy of Sciences*. The bottom link of the chain was a surprise, though. Botanists had assumed that cycad plants, which look like palm trees, produce BMAA. But Cox and his coworkers Susan Murch and Sandra Banack found that the BMAA in these plants derives from nitrogen-fixing cyanobacteria that live in certain roots.

The cycads transport BMAA to tissues around their seeds, the researchers say. Murch also found the neurotoxin in brain tissue from disease victims in Chamorro. Intriguingly, the researchers also detected BMAA in brain tissue from two Canadians who died of Alzheimer's disease. —S.M.

BOTTOM LINK Neurotoxin in a cycad derives from bacteria (green) living in specialized roots.

COX

SCIENCE AND SOCIETY

Nanotech bill gives field a boost

In a vote of confidence that nanotechnology might be the next big thing, Congress has passed the 21st Century Nanotechnology Research and Development Act. The law authorizes $3.7 billion in spending on nanotechnology over 4 years starting Oct. 1, 2004. It also calls for the creation of a national research hub—the American Nanotechnology Preparedness Center—charged with investigating the societal, ethical, and environmental implications of this rapidly growing field.

Nanotechnology is the study and manipulation of materials on atomic and molecular scales measured in billionths of a meter. Scientists propose that such research could lead to more-precise medical therapies, ultrafast computing devices, and new materials that can clean up the environment. However, the effects of nanomaterials on the body and the environment remain unclear.

Wary that nanotechnology could suffer the same political setbacks that have slowed adoption of genetically modified crops, researchers and policy makers are trying to get ahead of the game.

In August, the National Science Foundation awarded $1 million each to the University of South Carolina in Columbia and the University of California, Los Angeles to study the societal and ethical impacts of nanotechnology. Building on that, new interdisciplinary nanotechnology research centers authorized under the new act will be required to study the impacts of their work.

"With this congressional seal of approval, it gives nanotechnology a high profile in the government," says Kristen Kulinowski, executive director of the Center for Biological and Environmental Nanotechnology at Rice University in Houston. —A.G.

Books

A selection of new and notable books of scientific interest

AWESOME THINGS TO MAKE WITH RECYCLED STUFF

HEATHER SMITH AND JOE RHATIGAN

As the winter months set in and children look for something to do, this guide provides dozens of ideas for things to create out of recycled items around the house. With an emphasis on teaching kids to reduce, reuse, and recycle the items they use on a daily basis, this book includes directions for making a model snake from jar lids, jewelry from old compact disks, handmade paper from notebook scraps, and a shelf from old newspaper. Environmental lessons throughout encourage readers to think about how to dispose of the things they use. Recommended for ages 8 to 13. ***Lark Books, 2003, 144 p., color photos/illus., paperback, $14.95.***

A BENJAMIN FRANKLIN READER

WALTER ISAACSON

The author of a highly regarded biography of Franklin published earlier this year follows up with this collection of writings penned by Franklin himself, including his autobiography. The scores of essays and letters validate Franklin's impact as a writer in Colonial times and beyond. Isaacson prefaces each piece with contextual notes and explanations of the work that follows. The diversity of Franklin's interests and thoughts is apparent, as he traverses topics ranging from the fate of Canada to the causes of and cures for passing gas. This compendium is presented chronologically to reveal the evolution of Franklin's thinking. Entries reflect Franklin's roles as a politician, inventor, publisher, and diplomat. ***S&S, 2003, 551 p., hardcover, $21.95.***

DINOSAURUS: The Complete Guide to Dinosaurs

STEVE PARKER

Featuring profiles of more than 700 dinosaur species, this encyclopedia documents dinosaurs' natural habitats. Large, vivid illustrations grace every page and accompany data indicating how dinosaurs lived, what they ate, how big they were, where they roamed, and when they lived. Readers learn that the noisiest dinosaurs were probably the hadrosaurs, which had crests on their heads that could have resonated the animals' calls. The fastest was *Ornithomimus*, which resembled a modern ostrich and probably ran at speeds of more than 50 miles per hour. Once *Tyrannosaurus rex* was considered the biggest predator the planet has known, but *Giganotosaurus*—fossils of which were found in Argentina in 1994—was 3 to 6 feet taller and up to 2 tons heavier than *T. rex*. ***Firefly, 2003, 448 p., color photos/illus., hardcover, $49.95.***

EVERYTHING AND MORE: A Compact History of ∞

DAVID FOSTER WALLACE

Wallace is best known for his works of fiction, including *Infinite Jest,* but his interest in math and formal systems led him to tackle the confounding yet compelling story of infinity. His tone is different from that of most books with scientific themes. While Wallace appreciates his subject, he is somewhat puckish in recounting the accomplishments of Georg Cantor and other mathematicians who were pivotal in defining the inherently indefinable. He likens infinity to a tree with its roots in the ancient Greek "paradoxes of continuity and incommensurability and its branches entwined in the modern crises over math's foundations." From these roots, he tracks his subject's history and makes this arcane topic accessible. Most technical data are segregated in footnotes. Even these sections are rife with evidence of Wallace's wit. ***Norton, 2003, 319 p., hardcover, $23.95.***

THE SNOWFLAKE: Winter's Secret Beauty

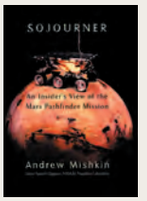
KENNETH LIBBRECHT AND PATRICIA RASMUSSEN

Ten thousand feet above Earth's surface, a snowflake—ice formed around a nucleus of dust—begins its long, winding descent to the ground. These symmetrical snow crystals fall by the billions, sometimes taking hours to make their journey. Growing up in North Dakota, Libbrecht took snow for granted. Today, he is a physicist at Caltech who studies the material properties of ice and the reasons why it develops such elaborate patterns. His data on these matters are accentuated here by dozens of Rasmussen's microphotographs of snowflakes. These color images are stunning examples of the diversity of the crystals. Libbrecht's text is an interesting introduction to complex structures in general and into the mysteries of how snowflakes are made. ***Voyageur Pr, 2003, 111 p., color photos, hardcover, $20.00.***

SOJOURNER: An Insider's View of the Mars Pathfinder Mission

ANDREW MISHKIN

The images sent back from Mars via the Sojourner rover granted Earthlings a thrilling first view of the Red Planet's terrain. Mishkin has worked for nearly 20 years as a senior systems engineer at NASA's Jet Propulsion Laboratory (JPL), where this rover and others have been developed. In *Sojourner*, he tells an engaging story of JPL, rovers in general, and how he and others created Sojourner. Drawing on conversations, e-mails, and his own experiences, Mishkin writes a text that reads like a screenplay. Readers will get caught up in the feverish effort to deploy a rover on Mars. Mishkin takes them behind the scenes as he and his team clear vexing hurdles and eventually share the elation of success. ***Berkley, 2003, 333 p., b&w plates, hardcover, $21.95.***



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

No surprise

The decline in delinquency, violence, disobedience, and truancy seen in the Cherokee children is quite predictable, and I doubt it has much to do with increased parental supervision ("Poor Relations: Casino windfall reveals poverty's toll on Cherokee kids' behavior" *SN: 10/18/03, p. 244*). The lack of money is a powerful factor in the lives of many parents, increasing spousal and child abuse. It is this variable (frequently getting hit) that causes the aggression in children in poverty. We have data showing that beaten children from affluent families are far more aggressive than unbeaten children from poor families. It is, therefore, not poverty, but how poverty frustrates people, especially those parents who were raised in a culture that encourages spanking.

RALPH S. WELSH, GEORGETOWN, CONN.

About two feet

"Magnets, my foot!" (*SN: 10/18/03, p. 254*) makes no mention of the type of magnetic insoles used—multipolar phased array or bipolar—nor the strength. I suffer from peripheral neuropathy, and a set of multipolar-phased-array-type magnetic insoles has been the only effective treatment.

JAMES WHITE, HILLSBORO, ORE.

The researchers used insoles containing a magnet with a bipolar multiple circular array, with a surface magnetization of 192 gauss. —N. SEPPA

Think snow

"Do Arctic diets protect prostates?" (*SN: 10/18/03, p. 253*) discusses the disease in Inuit men in arctic Alaska, Greenland, and Canada. Given the way temperature affects sperm production in the testicles, have the investigators considered any differences in hormone production between these men and populations in warmer climates? Not to say that diet isn't the key factor, but the geography gave me pause.

RICH MEWES, FORT COLLINS, COLO.

Men in northern climates who aren't Inuit don't have the low rates of prostate cancer seen in the Inuits in this study. This suggests that a protective effect stems from a cultural factor. —J. RALOFF

Correction *The image on page 332 in "Vision Seekers" (*SN: 11/22/03, p. 331*), to conform to the caption, should have had the top row of faces on the bottom. Also, Daphne Maurer and Catherine J. Mondloch should have been identified as psychologists at McMaster University.*