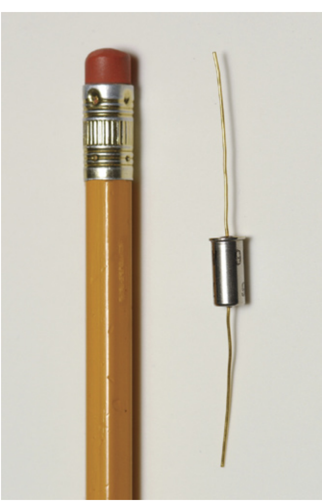
Genesis Bounces Back

U. S. Air Force 388 Range Squad



NASA/Lockheed Martin

Above: The pocket-watch-shaped capsule hit the desert floor edge-on and buried itself to about half its diameter.

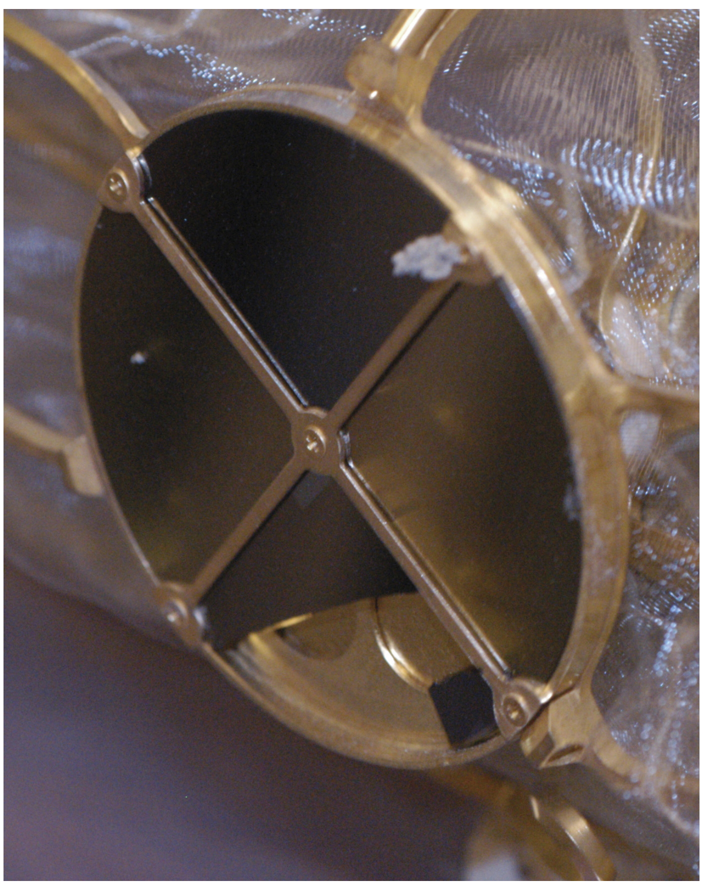
Left: The culprit is believed to be a gravity switch like this one, which was supposed to sense the capsule's deceleration when it hit the top of the atmosphere and initiate a sequence of events that would have deployed a drogue chute followed by a winglike parafoil such as skydivers use. The switch was apparently installed backward.

JPL's Genesis mission to bring back atoms from the solar wind deviated from the script when it delivered its cargo to the empty expanse of the Utah Test and Training Range on September 8. As written, one of a pair of helicopters piloted by Hollywood stuntmen was to snatch the parachuting capsule out of the sky to avoid jarring the delicate contents. But the chute missed its cue and the payload "geobraked" into the desert floor at a speed of 311 kilometers per hour.

Things didn't look good when the recovery team arrived minutes later. The shell had split open, and the inner canister was cracked. Switching to Script B, the crew secured the charge that should have released the parachutes. Only then could the capsule be dug out and trucked to a clean room at the nearby Dugway Proving Grounds. The bulk of the wreckage was sent on to Genesis's builder, Lockheed Martin, for analysis, while the science team tried to salvage something—anything!—from the 26 months' worth of material that had been collected atom by laborious ion and whose chemical composition mirrors that of the material from which the solar system formed.

But this cliffhanger has a happy ending. The top scientific priority, the concentrator that collected oxygen atoms to measure their isotopic ratio, was in pretty good shape. The second priority, a sheet of gold foil to collect nitrogen atoms for the same purpose, was undamaged. And although most of the wafers of sapphire, diamond, and other brittle materials that made up the five rotating collector arrays were in smithereens, the wafers from each array were of a different thickness, so each piece can be traced back to its original array—essential for determining which sample had been collected when. The fragments were meticulously photographed, numbered, and packaged—in more than 3,000 small containers—and shipped to the Johnson Space Center for decontamination, archival preservation, and eventual distribution to various labs. Since the latter would have involved sawing up the wafers anyway, one could say we're actually ahead of the game. □—*DS*

Left: Caltech professor of nuclear geochemistry Donald Burnett, Genesis's principal investigator and lead scientist, picks through desert dirt for bits of the arrays, each of which was designed for a different particle stream.
Below: The shards were sorted, and samples from all 14 types of wafer were recovered. A few of the silicon-on-sapphire and gold-on-sapphire wafers actually survived intact.
Bottom: Three of the solar wind concentrator's four segments were unscathed. About 85 percent of the fourth segment was salvageable.

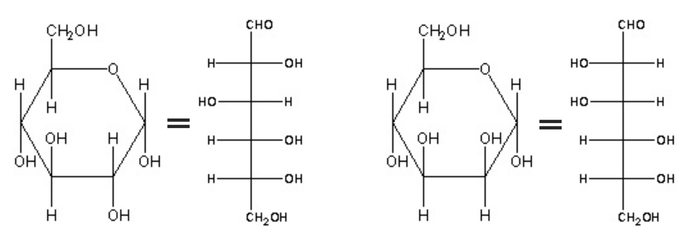


Above: In the *Friends* series finale last May, dimwit actor Joey Tribbiani (Matt LeBlanc, at right) moved to Hollywood. He now shares an apartment with nephew Michael (Paulo Costanzo, center), a grad student at guess where? Clever, sympathetic writing gives this odd couple plenty to do, and Joey's brassy sister Gina (Drea de Matteo, late of *The Sopranos*) and neighbor Alex Garrett (Andrea Anders, at left) earn a lot of laughs as well. *Joey* airs Thursdays at 8:00 p.m. on NBC.

ATKINS, SCHMATKINS

A health-conscious public may be shunning carbs, but Caltech chemists are embracing them. Professor of Chemistry David MacMillan and his graduate student Alan Northrup have discovered a simple way to make their basic unit—the six-carbon sugar—in two steps. This is a major improvement over current methods, which can require a dozen or more reactions. Natural carbohydrates range from these simple sugars up to long-chain molecules containing a thousand or more sugar units. (The latter include chitin, the stuff of insect exoskeletons; glycogen, a source of ready energy for muscles and other tissues; starch; and cellulose.)

"For the last 100 years, scientists have needed many chemical reactions to differentiate five of the six oxygen atoms" in the basic sugar unit, explains MacMillan. "We simplified this to two steps



Above: Six-carbon sugars have five carbon atoms that can be either "right-handed" or "left-handed." This "handedness" determines which groups of atoms end up above and which end up below the ring plane; the rings have also been drawn unclosed. Glucose is at left, mannose at right.

by the invention of two new chemical reactions that are based on an old but powerful chemical transformation known as the aldol reaction." There are eight naturally occurring sugar structures in carbohydrates, and the method works for four of them.

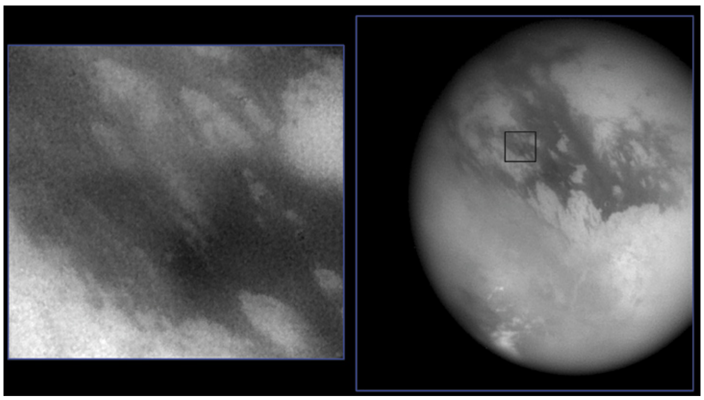
The method also allows easy access to sugars not found in nature, which is invaluable for medicinal chemistry, biology, and a number of diagnostic techniques. For example, a rare form of carbon known as carbon-13 is widely used as a tracer. Starting with ^{13}C-labeled ethylene glycol, which is cheap and readily available, MacMillan and Northrup made a sugar molecule that contained ^{13}C exclusively in only four chemical steps—a feat that previously took 44.

"Carbohydrates are essential to human biology, playing key roles in everything from our growth and development to our immune system and brain functions," says John Schwab, a chemist at the National Institute of General Medical Sciences, which supported the research. "They also play critical roles in plants, bacteria, and viruses. But because they are so difficult to work with, carbohydrates are not nearly as well understood as DNA and proteins. MacMillan's technique will allow scientists to more easily synthesize and study carbohydrates, paving the way for a deeper understanding of these molecules, which in turn may lead to new classes of drugs and diagnostic tools."

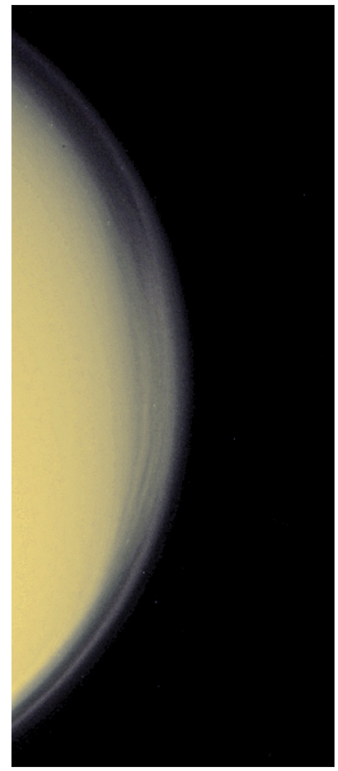
The paper was published online August 12 by the *Science Express* website, and will appear in the journal *Science* at a later date. □—*RT*

Postcards from Titan

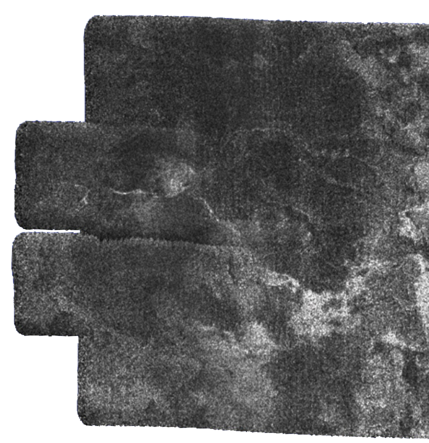
JPL's Cassini spacecraft had its first close encounter with one of Saturn's moons on October 26, when it buzzed by Titan at an altitude of 1,200 kilometers. Larger than Mercury, Titan fascinates scientists because its dense, opaque atmosphere of nitrogen and hydrocarbons—thicker than a Stage 3 smog alert—is believed to resemble the one from which life's precursor compounds formed on Earth. (But with a surface temperature of −180 °C, we don't expect Titan to be inhabited.) Here are a few of the first pictures released from the flyby.



Above: These near-infrared images show the surface at a wavelength sensitive to methane. The large, bright feature in the center right of the right-hand image is a "continent" named Xanadu, although whether the dark stuff adjoining it is really a slushy methane ocean remains to be seen. The dark, narrow streaks in Xanadu may be rivers or glaciers of gasoline. The fact that they and the broad dark features run west to east (upper left to lower right) means that they are probably wind-driven. On its next visit to Titan, Cassini will release the European Space Agency's Huygens probe, which on January 14, 2005, will parachute into the black square, a region shown enlarged in the left-hand image. Huygens will explore Titan's atmosphere all the way down, and if the probe doesn't drown—it has legs but is also designed to float—it may transmit data and pictures from the surface for up to 30 minutes before it freezes to death.



Above: This near-ultraviolet photo of the global haze that hangs hundreds of kilometers above Titan has been processed to approximate natural color.



Right: Cassini's radar scanned a region some 150 by 250 kilometers at a resolution of about 300 meters. Few, if any, craters can be seen, showing that the surface is geologically young. But aside from the fact that it's clearly a very complex place, and that the darker areas are probably smoother than the bright ones, not much else has been deduced yet.

The SWAT Team

If you think it doesn't do much good to swipe at the fly that's going after the potato salad, guess again. You may be discouraging the fly's colleagues from taking up the raid. Caltech's David Anderson, the Sperry Professor of Biology and an Investigator at the Howard Hughes Medical Institute; Seymour Benzer, the Boswell Professor of Neuroscience, emeritus, and a Crafoord Laureate; along with Columbia University's Richard Axel (who shared this year's Nobel Prize in Physiology or Medicine for work on the olfactory system) have found that the act of shaking or shocking flies causes them to emit carbon dioxide as one component of a previously unknown chemical signal that makes other flies avoid the space in which the stressful event occurred. The research involved the fruit fly, *Drosophila melanogaster,* which has been used for decades in genetics experiments. However, the mechanism could be more widespread.

The team, led by Caltech postdoc Greg Suh, found that CO_2 activates a single class of sensory neurons in the flies, and that these neurons seem to be dedicated to the sole task of responding to it. By inhibiting these neurons' synapses, the researchers were able to block the ability of flies to avoid CO_2. "This shows that there is probably a genetically determined, or 'hard-wired' circuit mediating CO_2 avoidance behavior in the fly," Anderson says.

Mosquitoes, on the other hand—or perhaps arm—are attracted to the CO_2 exhaled by their warm-blooded hosts. "Given the evolutionary conservation of olfactory mechanisms in insects, if we learn about the molecular details involved in CO_2 sensing in fruit flies, it could potentially lead to repellents that act by interfering with the reception of CO_2," Anderson says. Such a repellent could benefit third-world countries where mosquitoes carry malaria—or even in the United States, where the mosquito-borne West Nile virus has become a concern.

The paper appeared in the October 14 issue of *Nature*. □—*RT*

It's IST!

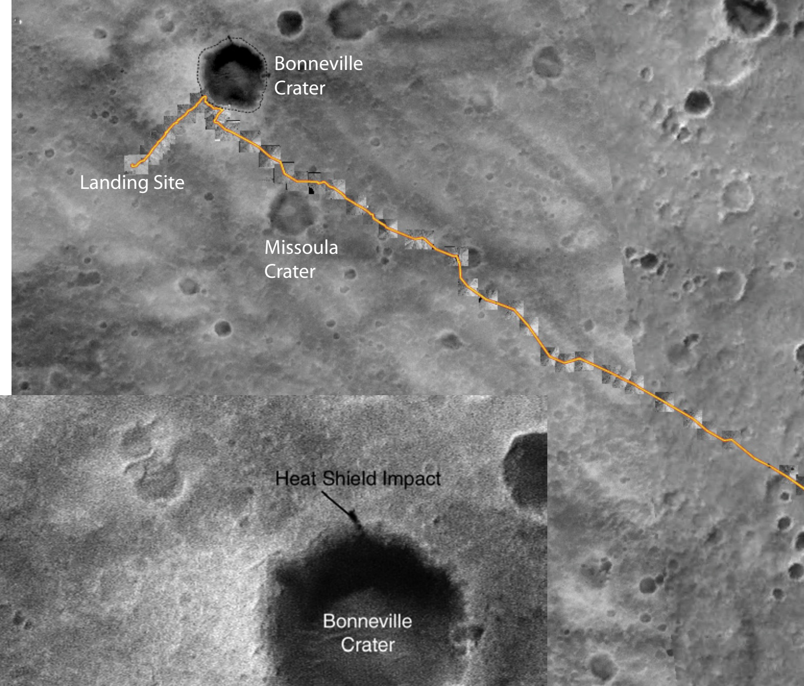
Information is everywhere. It's not just facts and words, but things like the instructions in our genome that tell our cells when to divide and when to die, and the daily flow of data into the stock market that somehow motivates people to buy and sell. In an unprecedented effort, Caltech has launched a university-wide initiative called Information Science and Technology (IST) to draw back the curtain on the nature of information itself and how we use it.

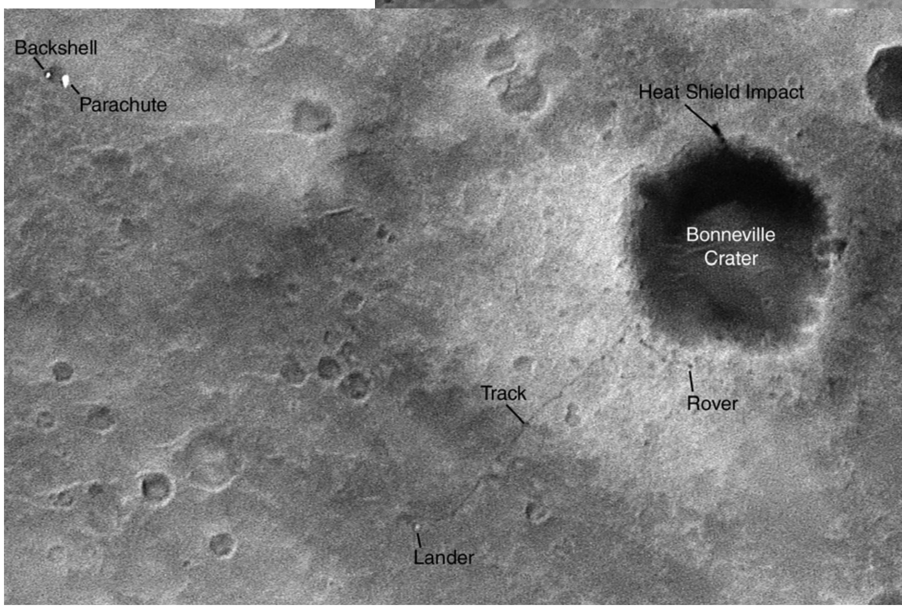
While other universities offer computer science and software development, IST will build information-based research and instructional programs across the academic spectrum. "To maintain preeminence in science, the U.S. needs new and unified ways of looking at, approaching, and exploiting information in and across the physical, biological, and social sciences, and engineering," says Jehoshua (Shuki) Bruck, the Moore Professor of Computation and Neural Systems and Electrical Engineering and founding director of IST.

In the same way that the printing press heralded the start of the Renaissance, and the study of physics helped to foster the Industrial Revolution, technological advances in computation and communication in the 20th century have set the stage for the Age of Information. Scientific and technological changes are outpacing our institutions— schools, media, industry, and government among them—which were originally designed for the Industrial Age. "We need a new intellectual framework to harness these advances," says Bruck.

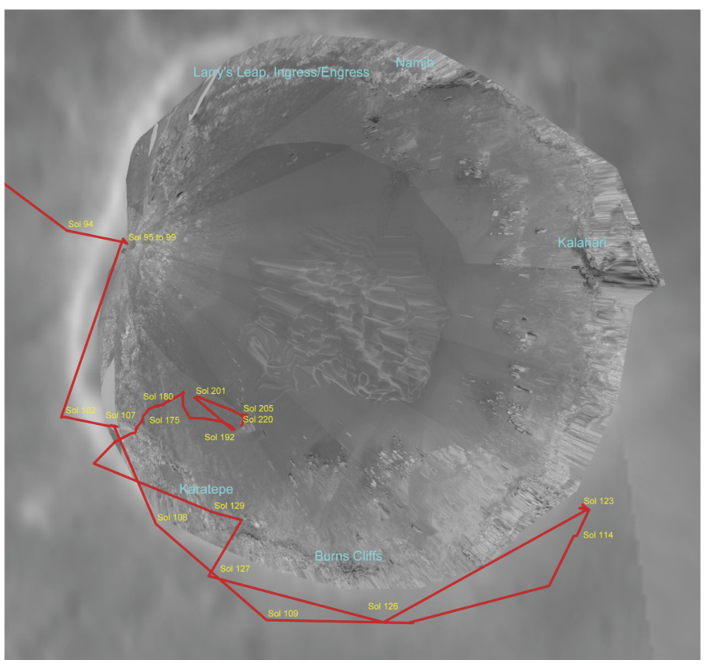
"Some say biology is the science of the 21st century, but information science will unify all the sciences," says Caltech president and Nobel Prize-winning biologist David Baltimore. "It will be like physics in the 20th century, where Einstein went beyond the teachings of Newton—which were enough to put people on the moon—and allowed us to reach into the atom and out into the cosmos. Information science, the understanding of what constitutes information, how it is transmitted, encoded, and retrieved, is in the throes of a revolution whose societal repercussions will be enormous. The new Albert Einstein has yet to emerge, but the time is ripe."

Caltech has committed to raising $100 million for IST as part of the Institute's five-year, $1.4 billion capital campaign. Nearly $50 million has already been raised, in the form of separate grants of $25 million from the Annenberg Foundation and $22.2 million from the Gordon and Betty Moore Foundation. The Walter and Leonore Annenberg Center for Information Science and Technology, expected to be completed in 2007, will join Watson and Moore labs as the physical home of IST. The Moore gift will provide seed money to establish four new interdisciplinary research centers, joining the Lee Center for Advanced Networking and the Center for Neuromorphic Systems Engineering as IST's conceptual anchors. The Center for Biological Circuit Design will address how living things store, process, and share information; the Social and Information Sciences Laboratory will investigate how social systems such as markets efficiently process immense amounts of noisy information, and how a better understanding of them can help improve society; the Center for the Physics of Information will examine the physical qualities of information and design computers and materials for the next generation of information technology; and the Center for the Mathematics of Information will formulate a common language of information that researchers from different fields can use. □—*JP*



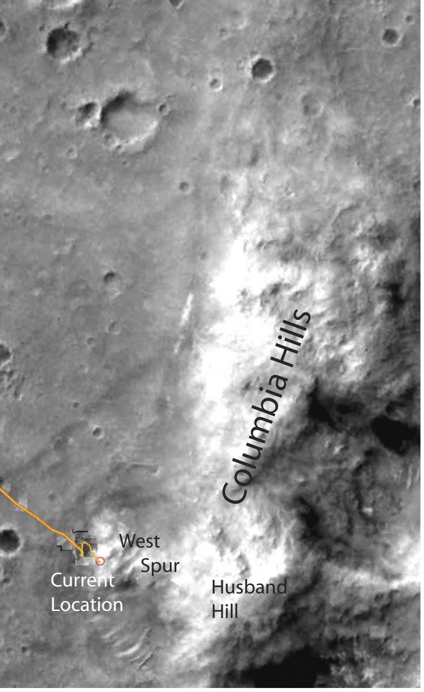


NASA/JPL/MSSS



NASA/JPL/Cornell/OSU/MSSS

JPL's Mars rovers keep on truckin' despite wonky wheels and other signs of middle age. At top is Spirit's trek as of its 238th martian day, or sol (September 3), superimposed on images from JPL's Mars Global Surveyor. Spirit continues to climb into the Columbia Hills, and now has more than two miles on its odometer. Meanwhile, the folks who run the Mars Orbiter Camera have figured out a way to sharpen its gaze so that the rover and its tracks can actually be seen from orbit (above left), as in this shot from March 30. And Opportunity's exploration of Endurance Crater from sol 94 through sol 205 (August 21) is shown at left. In honor of the rovers' unprecedented successes, on September 28 asteroids 37452 and 39382 were officially renamed Spirit and Opportunity, respectively.



NASA/JPL/New Mexico Museum of Natural History

Science By the Seat of the Pants

Sliding down a sand dune on your derrière might at first take seem a bit undignified for a Caltech professor. But for Professor of Mechanical Engineering Melany Hunt, it's all in the name of science. Hunt wants to know why many desert sand dunes give off sound—and a loud, droning sound to boot—whenever the dune avalanches, or a strong wind blows, or a scientist slides down its side. While the phenomenon has been known for centuries, what causes it remains a mystery. Most believe the answer is friction as grains of sand rub together. But the sound continues even after the movement has stopped, and differs from winter to summer.

Hunt, who studies the flow of particulates and granular materials, has spent the last few summers investigating booming dunes as a mentor with Caltech's Summer Undergraduate Research Fellowships (SURF) program. Several times each summer, Hunt, Professor of Mechanical Engineering Chris Brennen, and their students make the long drive to the Eureka or the Dumont Dunes in the Death Valley area, or to the Kelso Dunes in the Mojave Desert. Once there, they slog up to the dune's crest line, carting a ground-penetrating radar unit, geophones (a type of microphone), and lots of drinking water. The radar was used to confirm the subsurface existence of a band of wet, hard sand; the geophone recorded the noise as students and faculty alike slid down the dune.

Hunt believes the sound is a resonance effect, much like a string being plucked on a musical instrument. Over time, whatever rain falls percolates into the dune, eventually forming a band of moisture some two meters down. In time this sand hardens, says Hunt, forming a cement-like crust. When the dune's surface is disturbed, friction between sand grains creates reverberations between the dry sand on the surface and the wet sand below.

"That may be why smaller dunes don't make sound," says Hunt, "because they haven't been around long enough to form that hard layer of sand." The minimum needed is about two meters of thickness, she says. The loudest dunes are the tallest and the steepest, those with a maximum 30-degree angle of repose; that is, the steepest the dune's face can be without collapsing. It's also the reason she believes the sound varies by the season, which affects the moisture content. □—*MW*

Below: Brennen holds a sand sampler as grad student Angel Ruiz Angulo pounds it into the Dumont Dunes and Hunt hunches over her notebook. The operation is being taped for the debut of a new PBS series called *NOVA Science Now*. The show is set to air on January 25, 2005. Check your local listings.