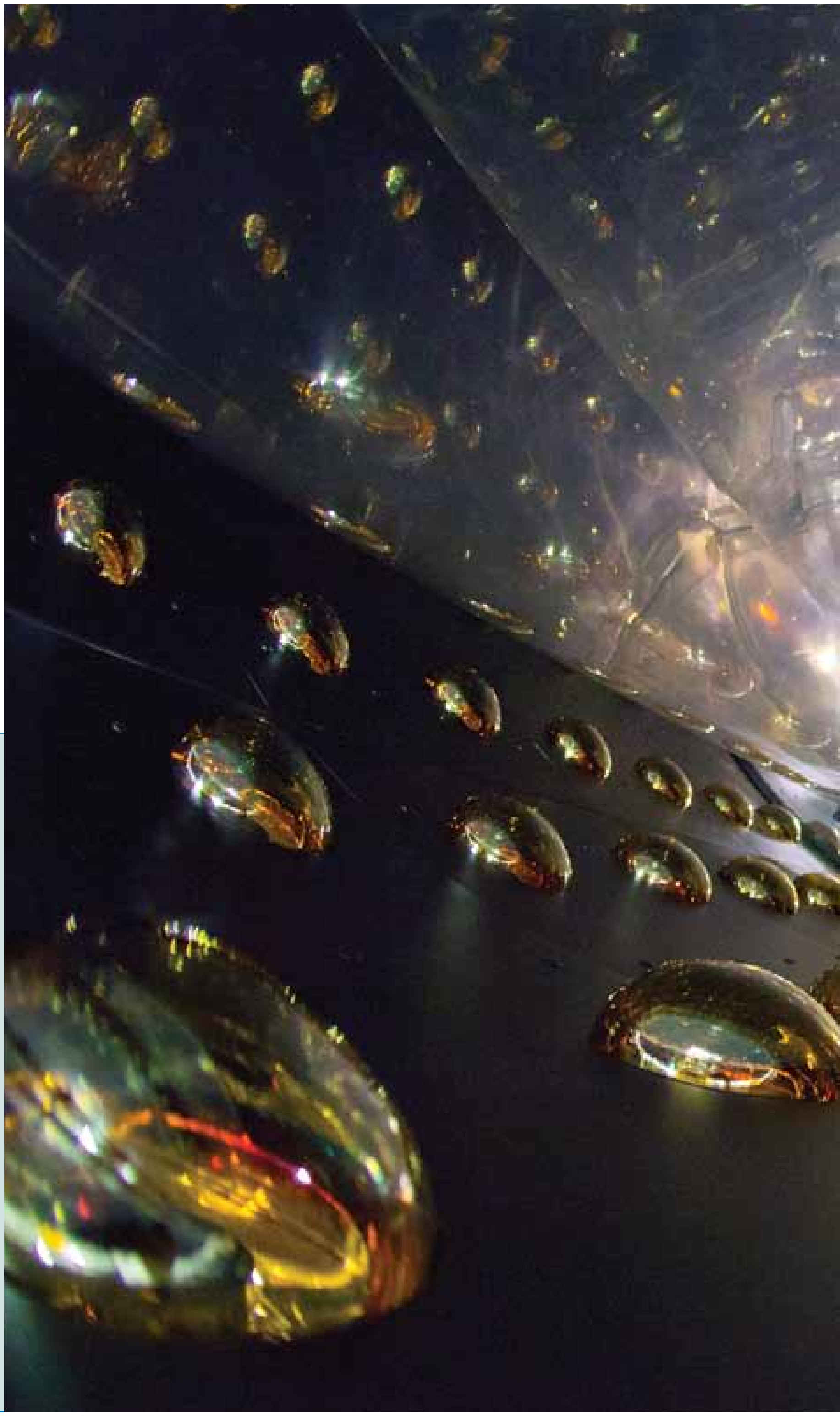
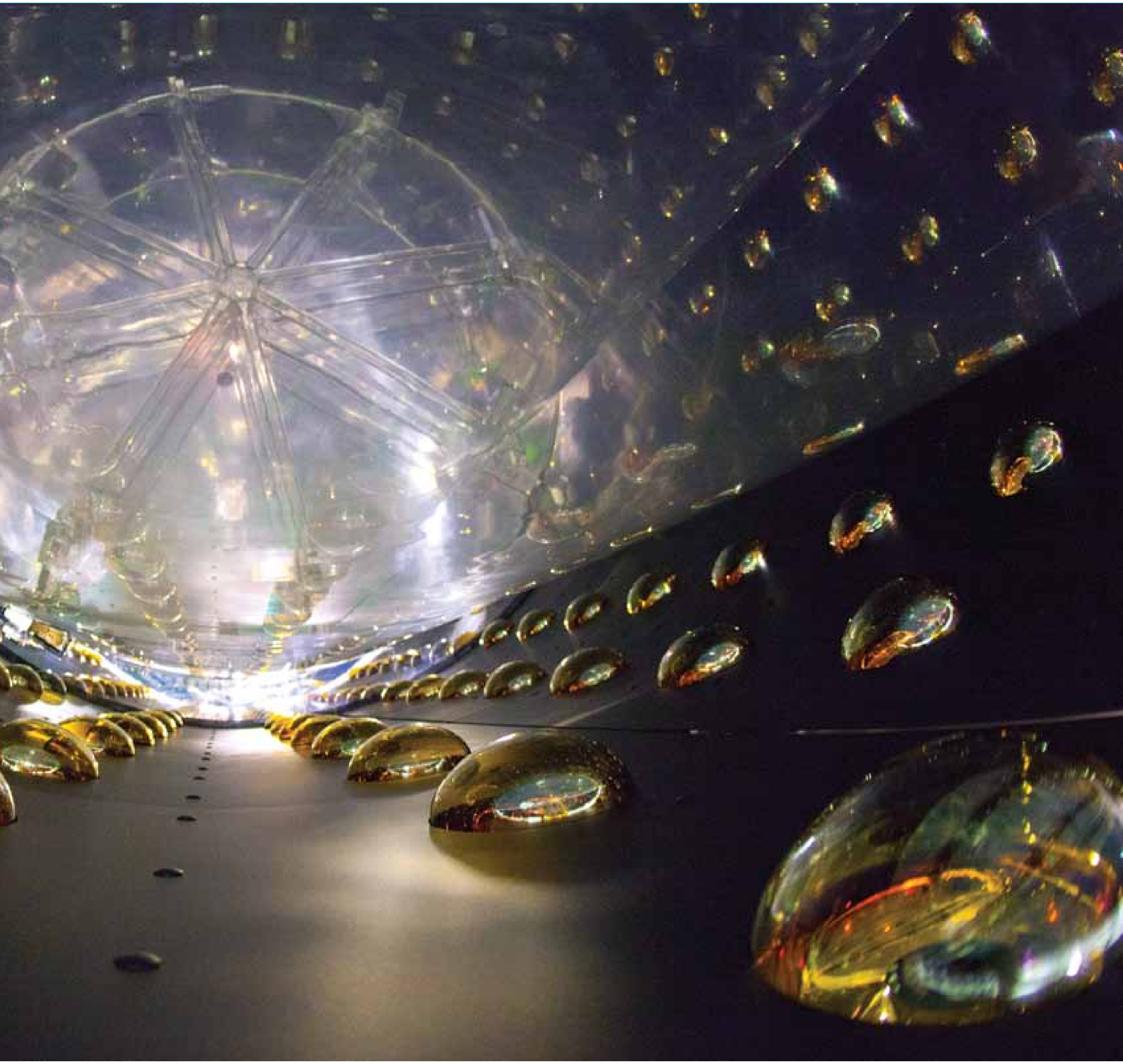
# Random

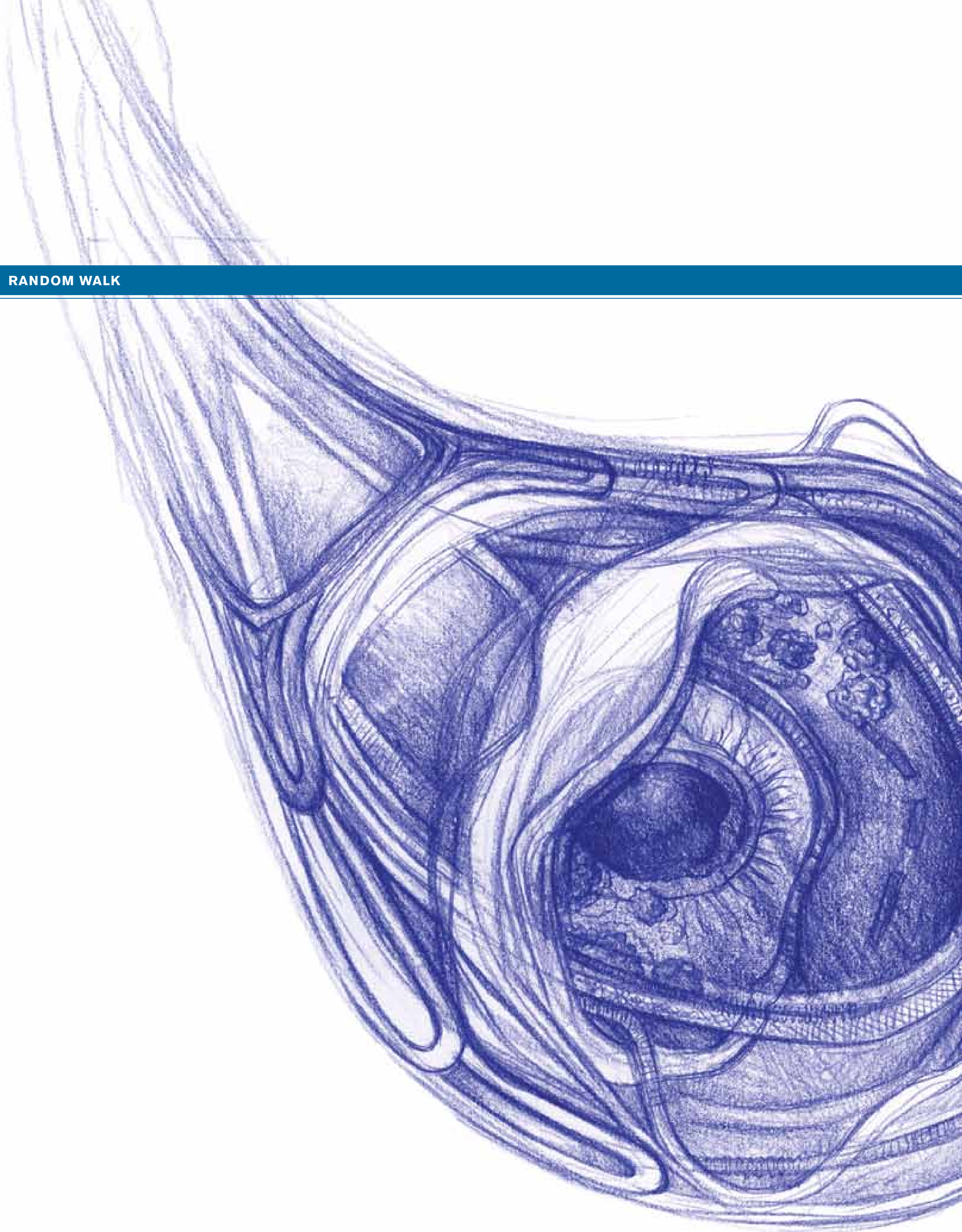


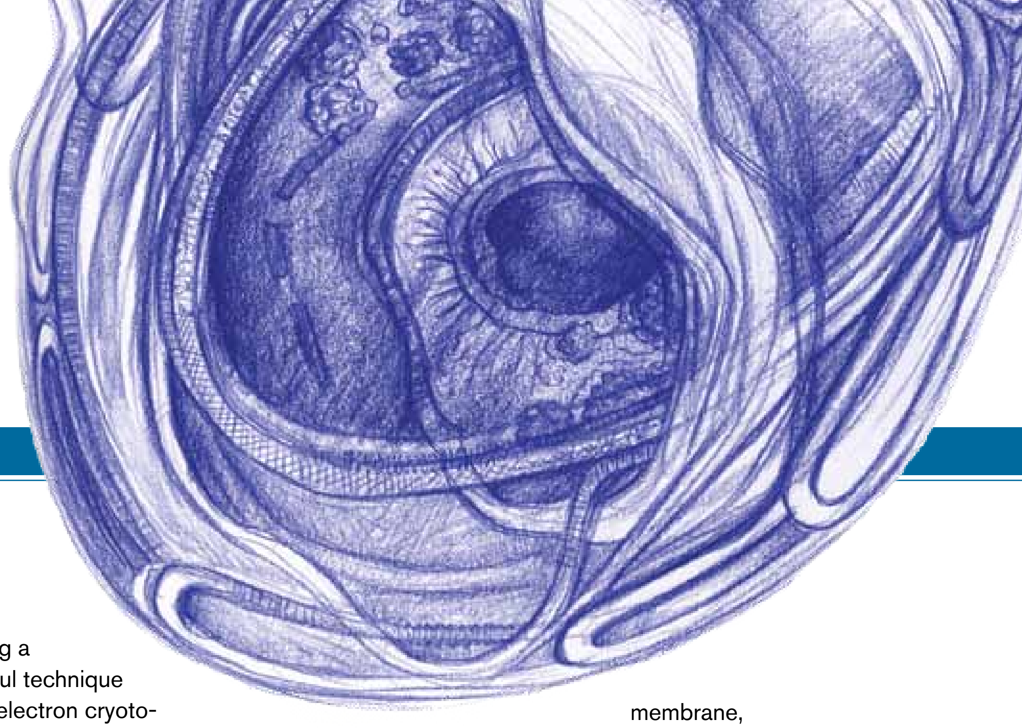
This image is a glimpse into the depths of a neutrino detector that's part of the Daya Bay Neutrino Experiment, buried under the mountains of southern China near Hong Kong. The detector consists of two inner nested transparent acrylic cylinders. Each of the experiment's eight 100-ton detectors is filled with a clear, liquid scintillator that flashes when an antineutrino—a neutrino's antimatter counterpart—zips through and interacts. The alien-looking globules along the inner walls are photomultiplier tubes that amplify and record the signals. The experiment, for which Caltech designed and built the 24 calibration devices, started taking data last August, probing the nature of the neutrino, that elusive particle that flies through the cosmos at nearly the speed of light. Physicists hope the small particles will help reveal answers to big questions—for example, why the universe has more matter than antimatter.

# Walk

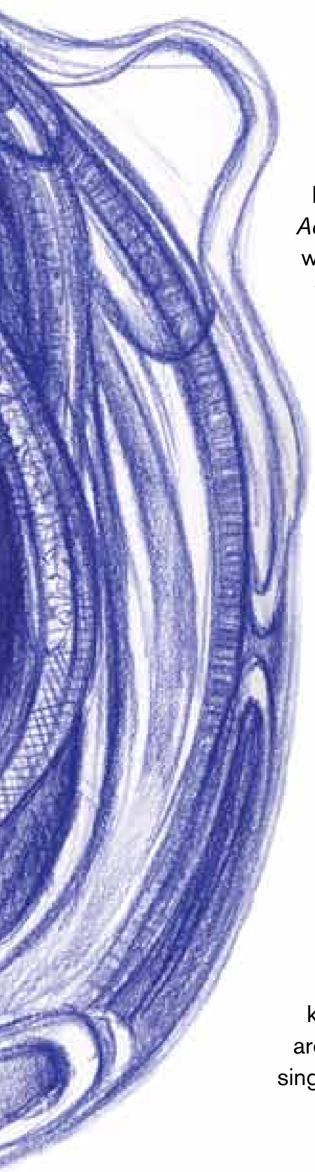
THINGS THAT CAUGHT OUR EYE . . .







## FLIP IT AND REVERSE IT



A team of Caltech researchers has found what it's calling a "missing link." No, not *that* missing link—a link you probably didn't know was missing in the first place.

The group is referring to a bacterium, called *Acetonema longum*, which seems to be the link between bacterial species with two membranes and those with just one.

*A. longum* belongs to a little-known family of bacteria that have two membranes and respond to extreme environmental stresses by forming protective spores, a process known as sporulation. Outside of this small family, the only bacteria known to sporulate are those with a single membrane.

Using a powerful technique called electron cryotomography (ECT), Professor of Biology Grant Jensen and members of his lab captured the first high-resolution images of *A. longum* undergoing sporulation. The results were surprising: "We saw that a piece of the inner membrane actually becomes the new cell's outer membrane," says Jensen, who is also a Howard Hughes Medical Institute investigator.

In the case of a double-membraned bacterium such as *A. longum*, sporulation begins with the inner membrane pinching together asymmetrically, creating a mother cell and a smaller daughter cell, both covered by the outer membrane. Next, the mother cell engulfs the daughter, giving the daughter a second layer of what was originally inner membrane. At this point, the daughter is a spore, surrounded by two membranes within the mother cell. Having done her maternal duty, the mother cell dies away, leaving the spore protected by those two membranes and a protein coat.

When conditions improve and the spore germinates, part of its protective protein coat cracks open and the new cell outgrows its former shell. Unlike a single-membraned bacterium, which would at this point also shed its outer membrane, the double-membraned bacterium retains it.

Jensen's group found that the new outer membrane has the structure and all of the functions of a typical outer membrane, even though it originated as part of the mother cell's inner membrane. This, they say, means that sporulation could have been the mechanism by which the bacterial outer membrane arose.

The whole study started after Jensen spoke with Professor of Environmental Microbiology Jared Leadbetter about the capabilities of ECT, which allows researchers to image biological specimens in a near-native state rather than requiring them to be dehydrated, embedded in plastic, sectioned, and stained. Leadbetter, who has long been interested in the process of sporulation, wondered if the technique might be used to image sporulating cells. Alas, the model organism for studying sporulation, *Bacilus subtilis*, is too thick to be imaged using ECT. But *A. longum* saved the day—in addition to its tendency to sporulate, it's also relatively skinny.

Elitza Tocheva, a postdoc in Jensen's lab, is the lead author of the paper describing the work, which appeared in the September 2 issue of *Cell*. The other authors include postdoc Eric Matson, grad student Dylan Morris, and Farshid Moussavi of Stanford. —*KF* E&S

An artist's representation of the entire sporulation process as a single drawing.

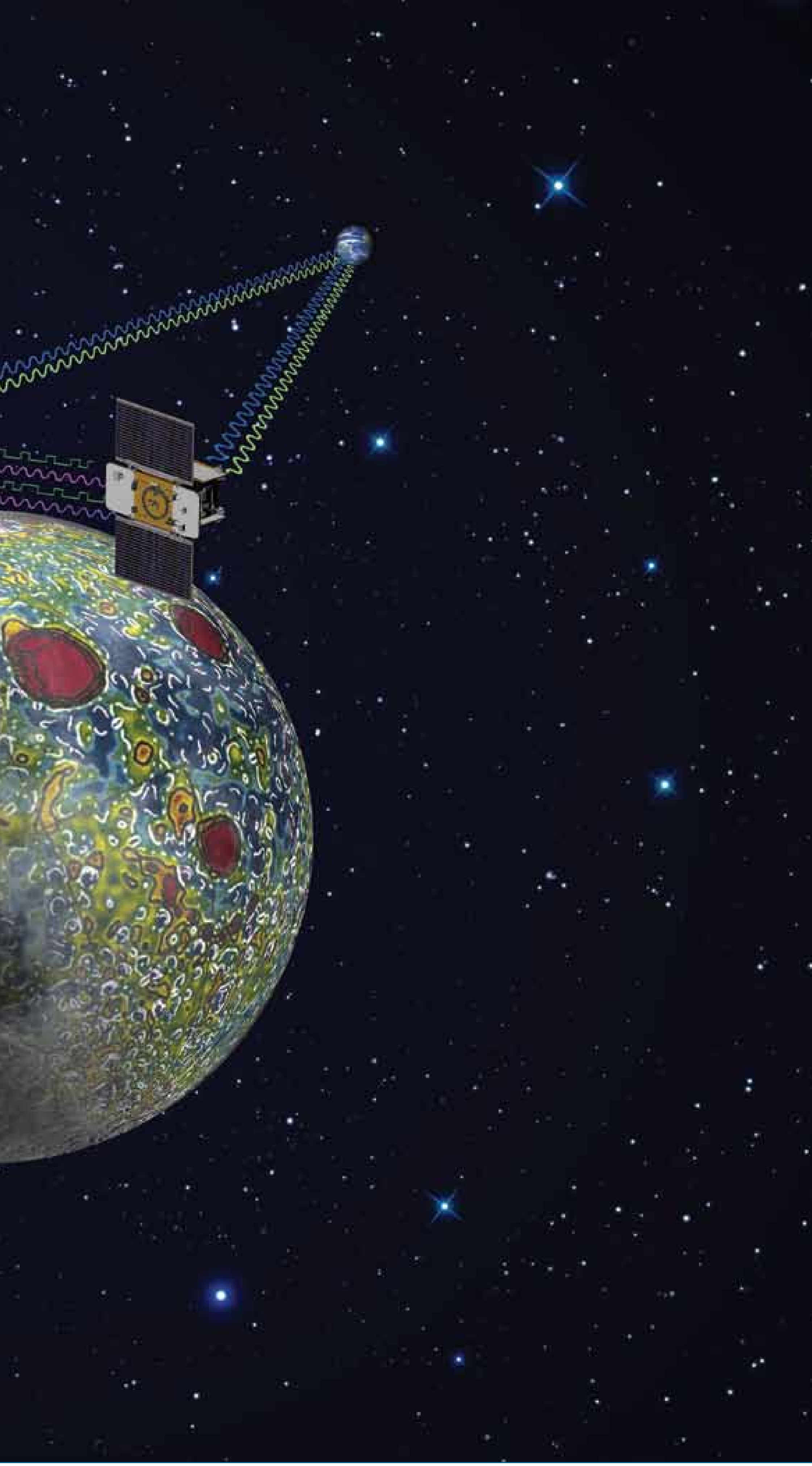
# MOONWARD BOUND

GRAIL, NASA's Gravity Recovery and Interior Laboratory, will answer longstanding questions about the moon and give scientists a better understanding of how Earth and other rocky planets in the solar system formed.

The twin spacecraft lifted off on a single rocket from Cape Canaveral at 9:08 a.m. Florida time on September 10, and they will fly in tandem orbits around the moon to measure its gravity field. GRAIL-A is scheduled to reach the moon on New Year's Eve 2011, while GRAIL-B will arrive New Year's Day 2012. The science-collection phase for GRAIL is expected to last 82 days.

This artist's conception shows the two spacecraft using radio links to each other to measure the distance between themselves while continuously relaying the information back to Earth—a feat they can accomplish even when the moon is between one of them and us. The inset photo was shot on August 23, as technicians were testing the clamshell fairing that protects the copper-foil-covered spacecraft during launch.

JPL manages the GRAIL mission, which is part of NASA's Discovery Program. Lockheed Martin Space Systems in Denver built the spacecraft. — *DN* e&s



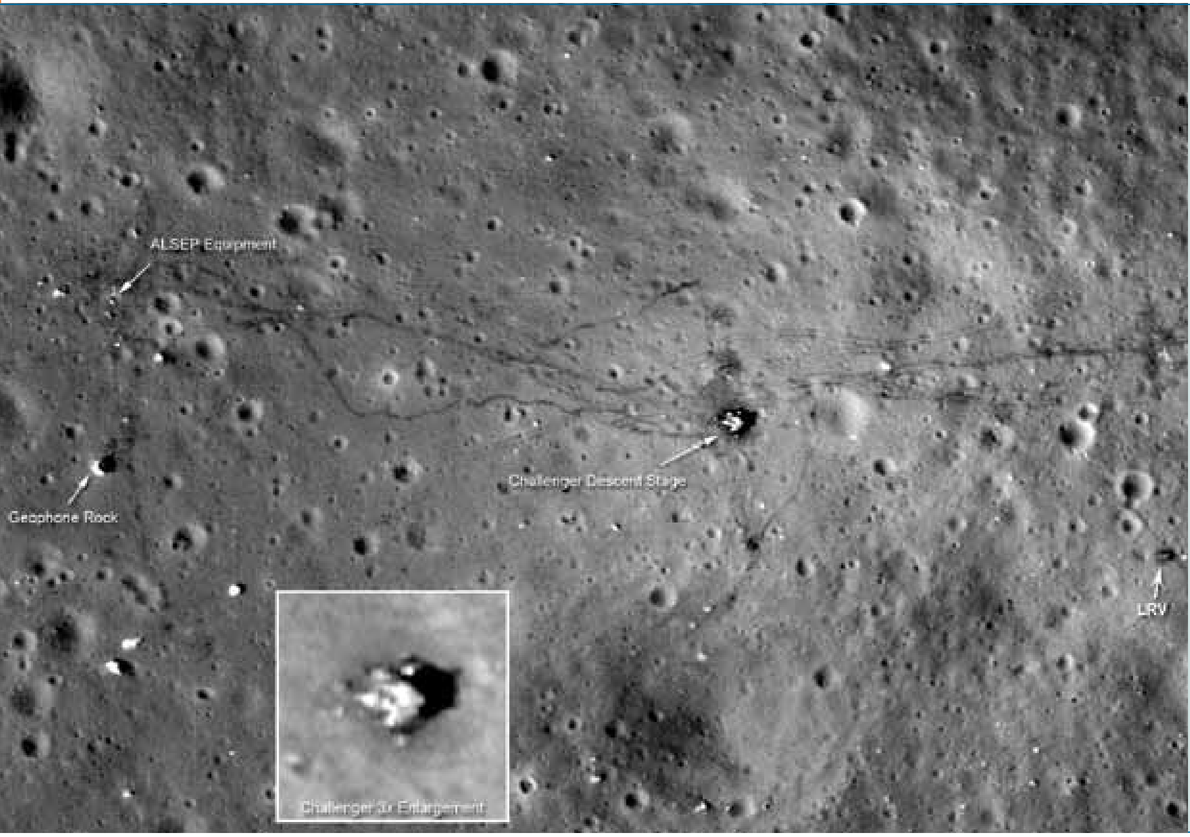
## JACKIE BARTON WINS NATIONAL MEDAL OF SCIENCE

Chemistry professor and division chair Jacqueline K. (Jackie) Barton has good reason to celebrate. She is one of a handful of recipients of this year's National Medal of Science, the highest honor bestowed by the United States government on scientists. The award recognizes her discovery of a new property of the DNA helix—long-range electron transfer.

Over more than 20 years, Barton has pieced together an understanding of how double-helical DNA can behave like a wire, allowing the transfer of electrons across long molecular distances. Her experiments have revealed that a single mismatch in the DNA's nucleic-acid sequence can prevent the transfer from happening. "The DNA's base pairs are something like a stack of pennies," Barton says. "If you interrupt the stack in some way—if you distort even one penny—it interrupts the conductivity of the stack."

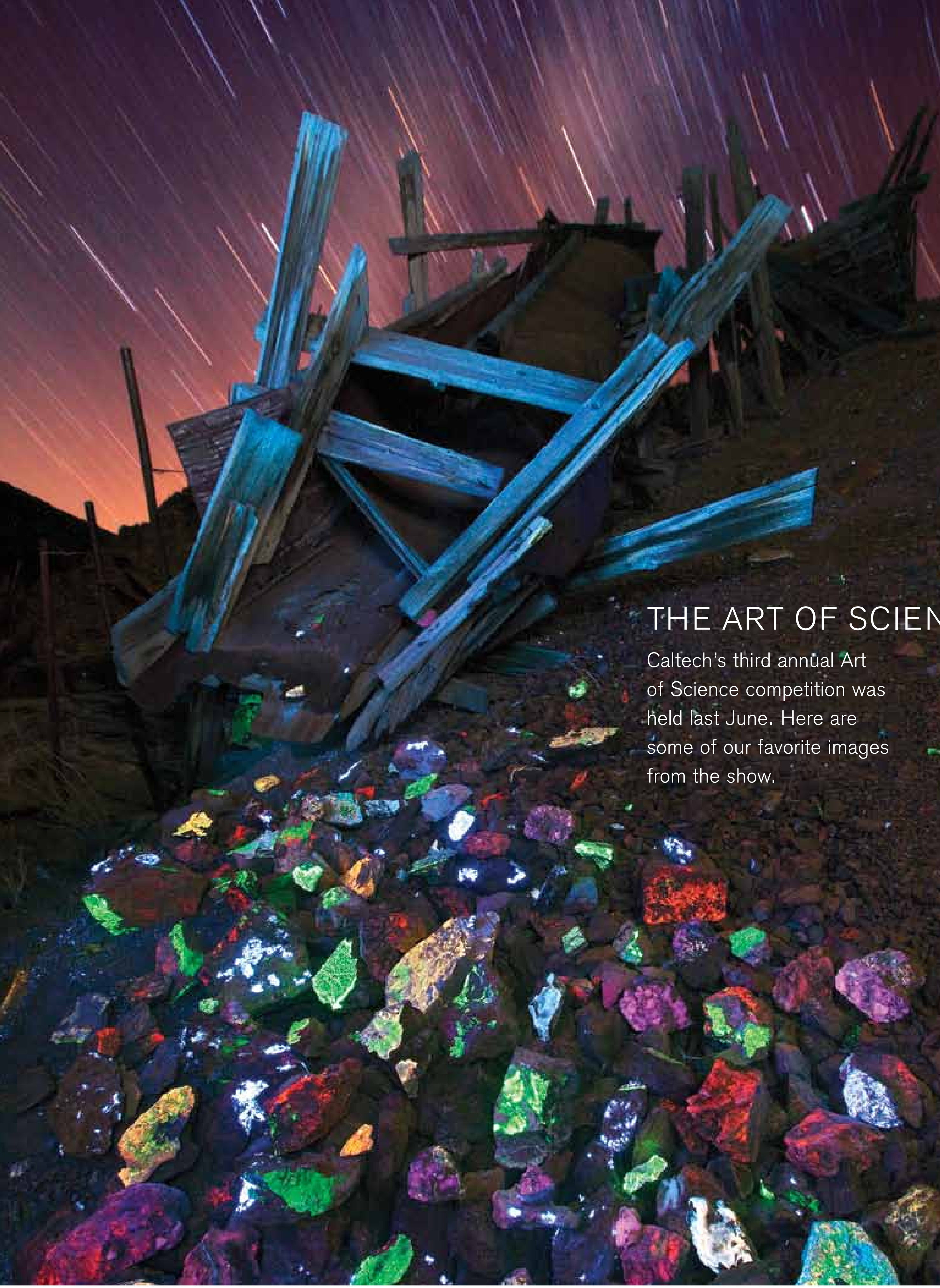
Nature might use this conductivity to locate and repair lesions in the DNA, Barton says. There are metal-containing proteins that are believed to be involved in the repair process; in her model, two of these proteins "test the wire" by attaching themselves to the DNA at widely separated points. Then, if one protein successfully sends an electron to the other, the wire is unbroken and the DNA is OK. Mutations in these proteins have been linked to predispositions to colon and breast cancer.

Barton joined the Caltech faculty as a professor of chemistry in 1989. She was named the Arthur and Marian Hanisch Memorial Professor in 1997 and became the chair of the Division of Chemistry and Chemical Engineering in 2009. Barton is also the recipient of the 1985 National Science Foundation Waterman Award, the 1988 American Chemical Society Award in Pure Chemistry, and a 1991 MacArthur Foundation Fellowship.
—*KF* e&s



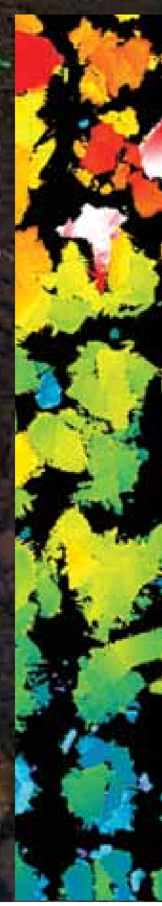

## THE MOON AND FOOTPRINTS

This high-resolution image of the Apollo 17 landing site, taken by the Lunar Reconnaissance Orbiter last September, has a pixel size of 27 by 56 centimeters—almost enough to distinguish the individual footprints left by astronauts Eugene Cernan and Harrison Schmitt (BS '57), who is the only geologist ever to walk on another world. The Apollo Lunar Surface Experiments Package (ALSEP), the descent stage of the lunar module *Challenger*, and the lunar rover (LRV) are all clearly visible, and the foot trails made by the astronauts are easily distinguishable from the dual tracks left by their rover.

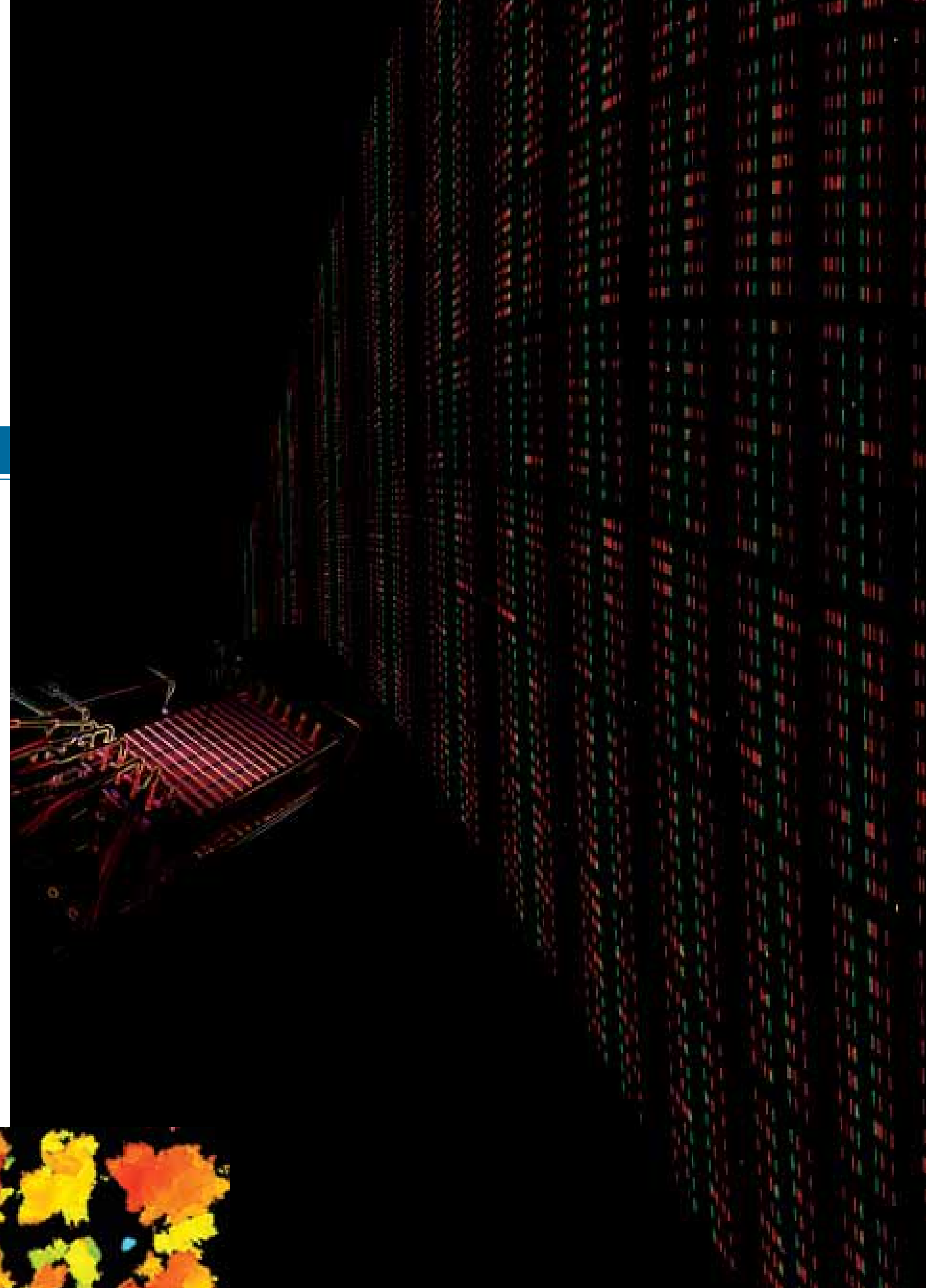


# THE ART OF SCIENCE

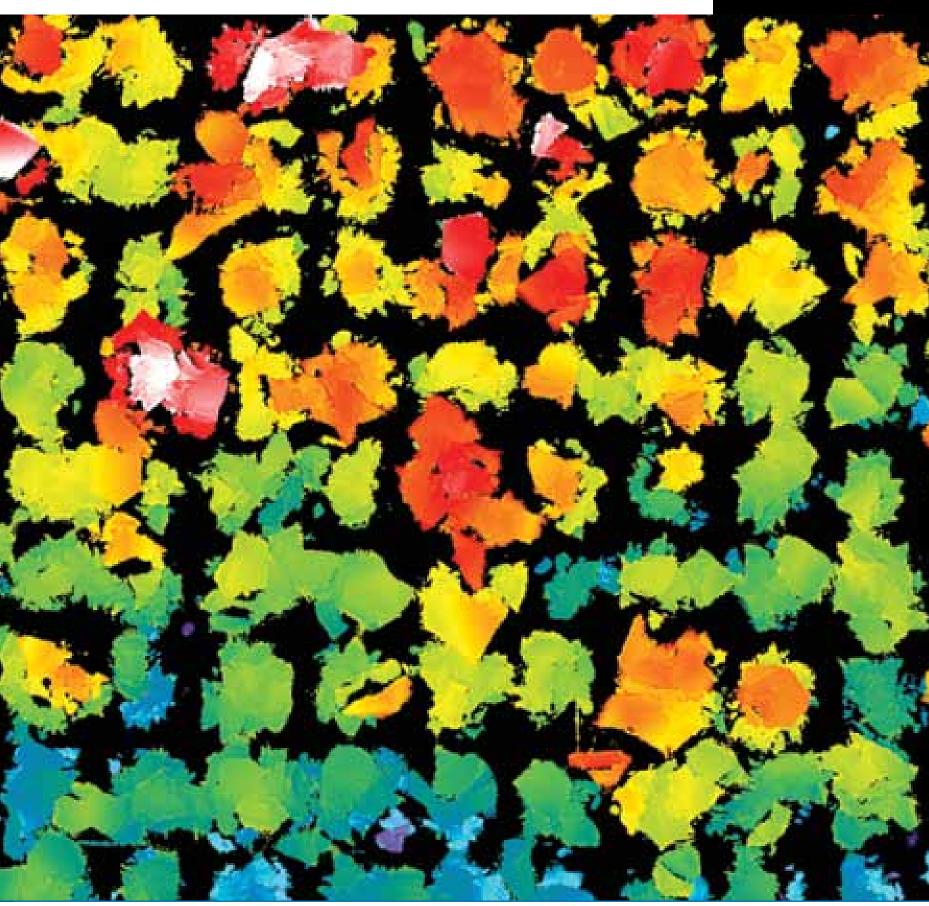
Caltech's third annual Art of Science competition was held last June. Here are some of our favorite images from the show.



FIRST-PRIZE WINNER (left)
ARTIST: Floris Van Breugel (grad student)
TITLE: *Fluorescent Treasures*
Scheelite (blue/white), calcite (red), uranyl ions (green), fluorite (pink), and “desert varnish” (yellow/orange) fluoresce under ultraviolet light in this 20-minute-long time-lapse exposure of tailings at a tungsten mine near Darwin, California.



SECOND-PRIZE WINNER (right)
ARTIST: Young Shik Shin (MS ’06, PhD ’11)
TITLE: *Single-Cell Barcode Chip*
This image shows 960 sets of protein data from individual cells in a microfluidic device. Each red bar represents a specific cancer-related protein; the green bars are reference proteins. Such analysis can offer information missed by a conventional cell screening in bulk.



THIRD-PRIZE WINNER (left)
ARTISTS: Andrew Leenheer (grad student) and Nick Strandwitz (postdoc)
TITLE: *Crystalrise*
The topography, as measured by confocal reflectance microscopy, of gallium phosphide crystals grown on a silicon microwire array to be used for photoelectrochemical solar fuels. The rainbow color scale covers 15 microns height.