Carnegie*Science*

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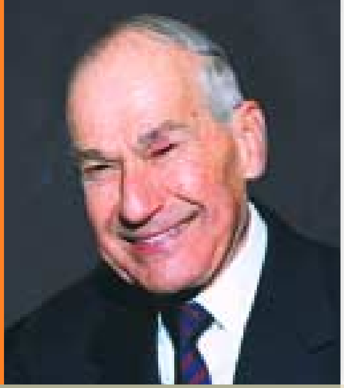

(Photo courtesy Richard Holden Photography.)

This spring we celebrate one hundred years of extraordinary science at the Geophysical Laboratory (GL). In the early days, the lab studied intriguing questions relating to our origins. Initially, GL scientists explored the origins of our planet through physical and chemical studies of rocks. Today the outlook is far more expansive. Lab researchers study the geophysical properties of the Earth and other planets, matter under the extreme pressures and temperatures of planetary interiors, and even the origins of life.

Although the Geophysical Lab was officially established as a department in 1905, its scientists were funded by the institution for several years before that through a system of grants. Despite the fact that Andrew Carnegie strongly believed that "no big institution should be erected anywhere," President Robert Woodward and the trustees established a laboratory nonetheless. The reason was simple. The lab was founded to investigate uncharted scientific territory and required unusual facilities. The Geophysical Laboratory was a perfect fit for a Carnegie enterprise.

The lab was built on Upton Street in Washington, D.C. It was occupied in 1907 and its scientists have provided a phenomenal number of important discoveries. The history of the lab exemplifies the essence of the Carnegie mission. Over the decades, the GL staff has defined the fields of petrology, geochemistry, geophysics, high-pressure/high-temperature physics, and origins. When the lab relocated to the Broad Branch Road Campus, joining the Department of Terrestrial Magnetism (DTM) in 1990, a new synergy was born.

It is striking that a lab with a history of studying the physics and chemistry of rocks is now at the forefront of studying how life might have begun. Today, researchers Doug Rumble and Marilyn Fogel use different atomic species, or isotopes, to investigate a variety of questions relating to life's origin. Rumble is learning how oxygen evolved in Earth's atmosphere, while Fogel is identifying "fingerprints" that indicate past and present life. Bob Hazen looks at how minerals might be involved in organizing essential molecules of life, while Andrew Steele and his group are harnessing biomedical tools to develop instrumentation and protocols for finding life on Mars. Most recently, the Stardust team—with George Cody and DTM colleagues Conel Alexander and Larry Nittler—are among the first scientists to analyze particles from a comet, those perennial visitors from space that may have ferried the ingredients of life to this planet.

The high-pressure and high-temperature team is unsurpassed in its discipline. Led by world-renowned scientists Dave Mao and Russell Hemley, the team consistently breaks pressure and temperature records to discover new properties of matter and to create previously unknown materials. They are also at the forefront of developing new techniques and instrumentation for their work, including the ability to produce exceptionally large diamonds, faster than anyone else.

Other researchers, such as Bjørn Mysen, are advancing our understanding of how Earth evolved and how events such as earthquakes and volcanoes arise. Yingwei Fei and his team look at planetary interiors and probe how the core of our planet generates its protective magnetic field. And Ronald Cohen, in his theoretical work, is exploring the dynamics of the deep Earth and the underlying physics of ferroelectrics, important materials used in medical imaging and sonar.

The key to the lab's century of success is that it has been populated by outstanding scientists who have been supported in the conduct of novel, sometimes high-risk research. Carnegie seeks to free its staff to pursue ideas unencumbered by the distractions found in most other institutions. When a surprising result arises, Carnegie researchers can change their direction and follow new leads. Andrew Carnegie's underlying conviction that excellent researchers beget excellent results has proven true time and again for more than a hundred years.

I am honored to be affiliated with such a world-class laboratory, and I look forward to its next century of discoveries.

—Michael E. Gellert, *Chairman*

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More Forests Not the Answer for **Global Warming**


New climate modeling research from the Carnegie Institution and Lawrence Livermore National Laboratory shows that northern temperate forests (left) may contribute to global warming, while tropical forests (right) can help keep global temperatures cool.

As the threat of global warming looms, some ecologists and activists have suggested planting new forests on unused cropland, since trees draw carbon dioxide from the air and release cool water from their leaves. But trees also absorb sunlight, which can warm the surrounding air. In fact, planting forests at certain latitudes could make the entire Earth warmer, according to a study from the Carnegie's Department of Global Ecology.

Carnegie's Ken Caldeira and colleagues at Lawrence Livermore National Laboratory used complex modeling software to simulate changes in forest cover, and then examined the effects on global climate. Their results, published in the journal *Geophysical Research Letters* in December, were surprising. "We were hoping to find that growing new forests in the United States would help slow global warming," Caldeira said. "But if we are not careful, growing forests could make global warming even worse."

All trees remove carbon dioxide from the air and lock it up in complex organic molecules—especially when they are young and growing rapidly. Yet this is only one of many effects forests can have on climate. Wet, tropical forests help keep Earth cool by evaporating a great deal of water, while drier, northern forests can warm the Earth because they absorb warm sunlight without releasing much moisture. In a stark illustration of this effect, the researchers simulated what might happen if the Northern Hemisphere above 20° latitude was covered with forests. Surface air temperatures jumped by more than 6°F in this model. In contrast, covering the entire planet's landmass with trees led to a more modest increase of about 2°F.

When Caldeira's team restricted the simulation to middle latitudes such as the continental United States, the picture was not quite so clear. At first, cooling due to decreased carbon dioxide would offset warming from sunlight absorption. But after several decades, carbon dioxide would begin diffusing from the ocean into the atmosphere, diminishing the cooling effect and warming the Earth in the long term.

Based on these results, Caldeira warns against planting new forests on old croplands as a strategy to combat global warming. But he also recognizes the importance of protecting natural forest ecosystems. Ultimately, he believes the only effective way to combat global warming is to cut emissions of greenhouse gases such as carbon dioxide.

"I like forests. They provide good habitats for plants and animals, and tropical forests are good for climate, so we should be particularly careful to preserve them," Caldeira commented. "But in terms of climate change, we should focus our efforts on things that can really make a difference, like improving efficiency and developing new sources of clean energy."

—BY MATTHEW EARLY WRIGHT

Global Ecology's **Ken Caldeira** Speaks Out

A STUDY I LED concluded that some forests might have a warming influence on Earth's climate due to the absorption of solar radiation by the dark forest canopy.

Several newspapers ran stories about that study, and interpreted our results to mean that preserving and maintaining natural forests might be a bad thing. However, a primary goal of preventing climate change is to help protect natural ecosystems. It would therefore make no sense to fail to protect an ecosystem in the name of preventing climate change. Forests provide many benefits. In addition to storing carbon and providing wood, they provide aesthetic and recreational opportunities for people and habitat for a wide range of plants and animals.

As a result of carbon dioxide emissions and unwise exploitation of the land and oceans, natural ecosystems may be under greater threat today than at any time since a comet wiped out the dinosaurs some 65 million years ago. It is essential that we do as much as we can to halt this ongoing mass-extinction event. This means we must preserve and maintain natural ecosystems, and stop unsustainable exploitation of the land and ocean. This also means we must end the release of fossil fuel carbon to the atmosphere.

Forests are a valuable part of the global ecosystem, and should be preserved and managed wisely.

—KEN CALDEIRA

Stardust Lands at Carnegie

In the above artist's rendering of the Stardust spacecraft, the sample collection grid (paddle-like structure raised on a boom at the left-hand side) is ready to collect comet dust.
(Image courtesy NASA.)

Bottom left, Larry Nittler of the Department of Terrestrial Magnestism inspects the Stardust collection grid at Johnson Space Center.
(Image courtesy Larry Nittler.)

Bottom right, Terrestrial Magnetism's Ion Microprobe Research Specialist Jianhua Wang poses with the new NanoSIMS instrument, which will help analyze comet samples from Stardust.
(Image courtesy Michelle Martin.)

Carnegie scientists breathed a sigh of relief on Sunday, January 15, when NASA's Stardust mission landed safely with the first solid comet samples ever brought back to Earth. As members of the mission's Preliminary Examination Team, Larry Nittler and Conel Alexander (both from the Department of Terrestrial Magnetism), with Marc Fries and George Cody (both from the Geophysical Laboratory), are among the first to get their hands on these precious samples, captured from the coma of comet Wild 2. These tiny bits hold clues to the formation of the solar system and might even reveal how organic molecules—the ingredients of life—first arrived on Earth. "It has been an exciting week," Nittler said. "No one quite knew what to expect when the team at Johnson Space Center opened the capsule. When we heard the collection grid was filled with particles, we could hardly contain ourselves."

Scientists believe comets like Wild 2 are the oldest solid bodies in the solar system. Yet until now, no one had seen a piece of a comet up close. Researchers expect to retrieve less than one thousandth of an ounce of material from Stardust's collection grid, but this tiny puff of dust might yield scientific gold: by comparing the structure and chemistry of Stardust grains to interstellar dust and rare meteorites rich in organic material, researchers may be able to fill in some significant holes in what we know about the evolution and history of our solar system. "It is likely that some of the carbon in our bodies was originally bound up in comets and delivered to the early Earth through impacts," Fries explained. "So when we say that 'we are stardust,' we are literally talking about the type of material that Stardust has

The Stardust collection grid (left) is filled with aerogel, a special "foamed glass" that is 99.8% air by volume. This close-up of the grid reveals a comet-dust impact large enough to be seen with the naked eye.

(Image courtesy NASA.)

returned to our laboratories for analysis."

Carnegie's share of the bounty arrived in early February, and the researchers are ready with a brand-new $2.8 million NanoSIMS ion probe. Ion probes can reveal the chemical makeup of a sample by vaporizing tiny target areas with a stream of ions, allowing an accurate count of the atoms emitted as a result. Since it has greater sensitivity than previous ion probes, the NanoSIMS is an ideal tool for analyzing minuscule Stardust grains.

Nittler, Alexander, Fries, and Cody also plan to study the physical and chemical details of Stardust grains using two different spectroscopic techniques. First, by analyzing laser light reflected from a sample, Raman spectroscopy can reveal both the structure of minerals and the forms of carbon present. Second, a unique soft X-ray microscope at Lawrence Berkeley National Laboratory's Advanced Light Source facility in California enables a technique called XANES spectroscopy, which can help characterize the carbon, nitrogen, and oxygen species in organic matter. Since the carbon-containing materials from Wild 2 are likely to be little changed since the birth of the solar system, these analyses are especially important.

"We can't wait to get going on these experiments," Cody said. "Stardust is really just the beginning; Carnegie now has the tools to take a leading role in sample-return analysis for decades to come."

—BY MATTHEW EARLY WRIGHT

NASA provided funds in support of this work through the Stardust Participating Scientists Program. NASA's Sample Return Laboratory Instruments and Data Analysis Program (SRLIDAP) funded both the Raman instrument and a portion of the cost of the NanoSIMS ion probe. NASA also provided partial support for work at the Advanced Light Source, a facility funded by the U.S. Department of Energy.

Bugs and Humans: The Same on the Inside?

Despite their looks, fruit flies are really just tiny six-legged distant cousins to humans. Scientists at Carnegie's Department of Embryology have found that the stem cells in the gut of adult fruit flies are much the same as ours. The research is important for understanding digestive disorders, including some cancers, and for developing cures for these conditions.

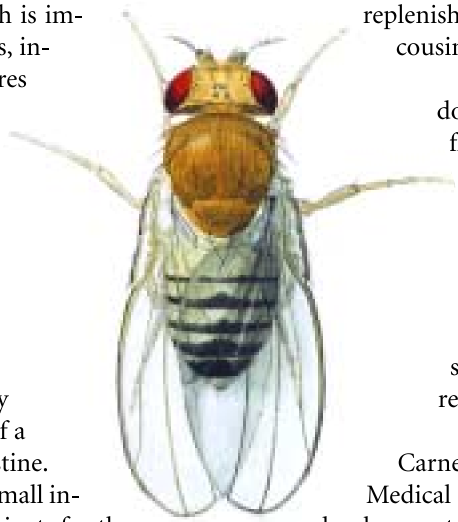
"The fact that fruit flies have the same genetic programming in their intestines as humans strongly suggests that we were both cut from the same evolutionary cloth more than 500 million years ago," said Benjamin Ohlstein, lead author of a study published in *Nature* in December 2005.

Insects have the same basic structure of their gastrointestinal tract as vertebrates. They have a mouth, an esophagus, the equivalent of a stomach, and both a large and a small intestine. The Carnegie researchers looked at the flies' small intestines, where food is broken down into nutrients for the body to absorb. They focused on two cell types—those that line the intestines in a single layer to help break up and transport food molecules, called enterocytes, and those that produce hormones, called enteroendocrine cells. These hormones serve to regulate gastric motility as well as growth and differentiation of the gut, among other functions.

In humans and other vertebrates, intestinal cells are continually replaced by stem cells. But until now, nobody had observed stem cells in the gut of the fruit fly. To investigate, Ohlstein and colleagues labeled both enterocytes and enteroendocrine cells, then observed how successive generations of the cells transformed. They found for the first time that the fly cells are replenished by stem cells, much as in their vertebrate cousins.

The similarity to vertebrate stem cells does not end there. Like vertebrate stem cells, fly stem cells are multipotent, which means that they can turn into different cell types. Also, a signaling receptor called Notch helps determine which type of intestinal cells will form in fly guts, a function it also serves in humans. In a surprising departure from known vertebrate functions, the researchers found that Notch signaling also directly instructs stem cells.

Coauthor Allan Spradling, director of the Carnegie department and a Howard Hughes Medical Investigator, is looking forward to future developments. "We're excited because we know from previous experience that studying a process in a model system, such as the fruit fly, can greatly accelerate our understanding of the corresponding human process."



The fruit fly *Drosophila melanogaster*

(Image courtesy Carnegie Supernova Project.)

Supernovae have recently been discovered in these five nearby galaxies as part of the Carnegie Supernova Project. Astronomers found them using the 40-inch Swope telescope at Carnegie's Las Campanas Observatory in Chile.

SHEDDING LIGHT ON DARK ENERGY: THE CARNEGIE SUPERNOVA PROJECT

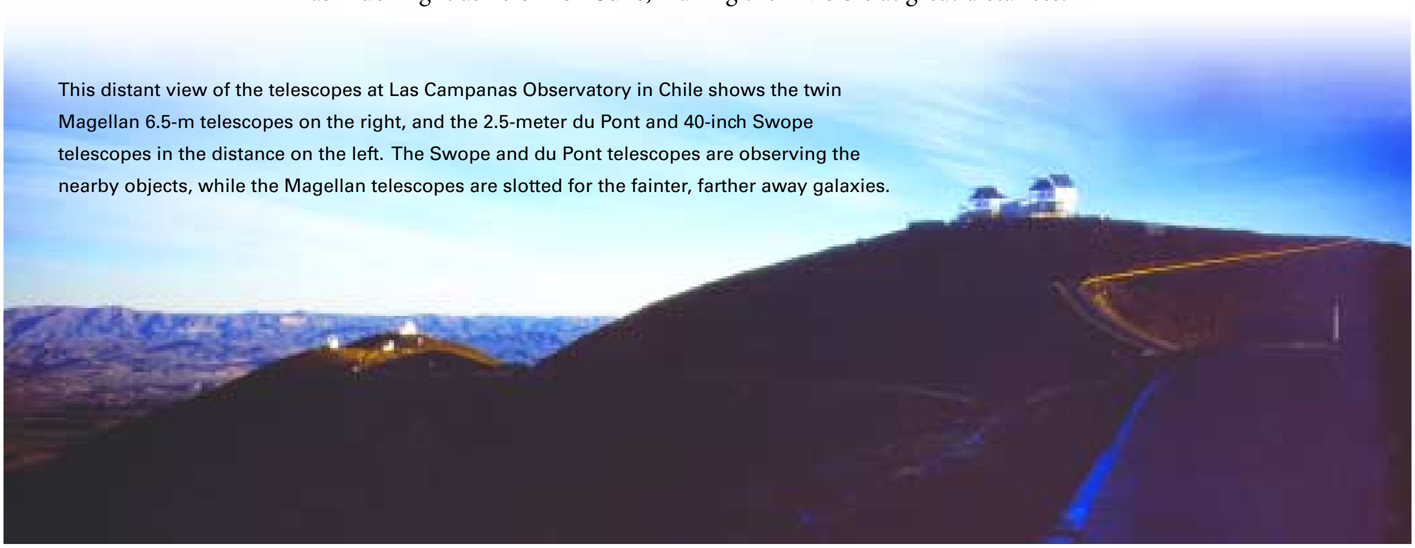
Humans really are in the dark. It was bad enough to find out that we can "see" only about 15% of the matter in the universe. In the last few years, the news has become even more perplexing. There is mounting evidence that some mysterious form of energy is making the universe expand at an accelerating rate—points in space-time are moving away from each other faster now than they did in the past. This phenomenon, believed to be a repulsive force dubbed dark energy, has called into question our understanding of basic physics and is one of the most confounding issues confronting both astronomy and physics today. It now appears that two-thirds of all the mass and energy in the universe is in the form of this dark energy, most of the remaining one-third is dark matter, and the leftover smattering is all we are able to discern.

To grapple with this predicament, astronomers at the Carnegie Observatories have embarked on an ambitious five-year program called the Carnegie Supernova Project (CSP), a National Science Foundation-funded research effort they hope will help clarify the riddle.

Dark Energy Rears Its Head

Until 1998, astronomers thought that the expansion rate of the universe (called the Hubble constant, for Carnegie's Edwin Hubble's discovery) was slowing down. They assumed that since the Big Bang, gravity would be reining matter in, just as it does to keep us on Earth. In the late 1990s, technology had improved to the point where researchers could look farther into space and thus farther back in time to detect how fast the expansion was when the universe was younger, billions of years ago.

Two teams of astronomers independently homed in on special types of celestial objects that are used for such measurements. These beacons are supernovae—massive stars that explode spectacularly at the end of their lives. Their violent death comes with a spike of brilliant light that gradually fades over weeks or months. At the peak of their detonation, these dying stars can outshine their home galaxies with as much light as 10 billion Suns, making them visible at great distances.



This distant view of the telescopes at Las Campanas Observatory in Chile shows the twin Magellan 6.5-m telescopes on the right, and the 2.5-meter du Pont and 40-inch Swope telescopes in the distance on the left. The Swope and du Pont telescopes are observing the nearby objects, while the Magellan telescopes are slotted for the fainter, farther away galaxies.

(Image courtesy Luis Poirot.)

Astronomers divide supernovae into two main types based on the presence or absence of the most abundant element in the universe, hydrogen. Type I do not have hydrogen, while Type II do. Further subdivisions are made for Type I supernovae based on more details of the chemistry. Although Type Ia supernovae, the brightest type, have similar characteristics, their luminosities can differ by a factor of 3 or more. In 1993, Mark Phillips, associate director of Carnegie's Las Campanas Observatory and CSP team member, realized that the rate at which their brightness declines from their peak is proportional to their luminosity. This fortuitous discovery makes it possible to use Type Ia supernovae as "standard candles," permitting astronomers to calculate the distance and the speed with which they are moving away from us over the dark vastness of space.

Expecting to pinpoint how much the universe was slowing down, both astronomy teams were dumbfounded by their results. They found that supernovae from the distant past were farther away than they should be if the expansion were decelerating. Since then, other types of data from such projects as the Wilkinson Microwave Anisotropy Probe (WMAP) and the Sloan Digital Sky Survey (SDSS) have had the same result—the expansion of the universe is like a runaway train going faster and faster.

Is It Really Like That?

"Some argue that the supernovae observations may not mean that the universe is accelerating and other factors may be at work," said Phillips. "One thought is that the techniques used on nearby, younger supernovae may not apply to very distant, older ones. Or, perhaps, chemical differences in the low-mass stars that produce Type Ia supernovae have made the peak luminosities evolve over time. Another possibility is that dust, over great distances and with properties different from dust in our own Milky Way, may be making the supernovae simply *appear* fainter and farther away."

The Carnegie Supernova Team gathers in Pasadena. From left to right are: Miguel Roth, Barry Madore, Nidia Morrell, Mark Phillips, Pamela Wyatt, David Murphy, Wendy Freedman, Eric Persson, Nick Suntzeff, Gaston Folatelli, and Mario Hamuy.

(Image courtesy Scott Rubel.)

To sort out these and other conundrums, a team of researchers including Phillips and Observatories director Wendy Freedman, Carnegie's Eric Persson, Miguel Roth, Barry Madore, and former Hubble Fellow Mario Hamuy joined forces in 2004 to begin a survey of over 200 nearby and distant Type Ia and Type II supernovae. Their goal is to see if supernovae really can be used as references for measuring distance and the evolution of the rate of expansion.

A Trio of Telescopes on the Job

The two-part Carnegie Supernova Project is harnessing the observing power of the Swope 1-meter, the du Pont 2.5-meter, and the 6.5-meter Baade telescopes at Las Campanas. Subject to approval by the Observatories' Time Allocation Committee, the team has access to an unprecedented 300 nights per year on the Swope and du Pont telescopes to observe the nearby objects, which are up to 500 million years old. Over the first five years, team members will investigate some 100 nearby Type Ia and 100 Type II supernovae, at a range of colors from near-ultraviolet to near-infrared wavelengths. They are plotting the luminosity of each object over time and gathering data on its chemistry. The objective is to determine if Type Ia supernovae appear consistently as they evolve, and to determine if Type II supernovae can be used as independent verifications of distance.

The data from the first part of the survey will be compared with about 50 farther-away Type Ia supernovae, which are between 2 and 6 billion years old. These vestiges of a long-gone era are being probed with near-infrared measurements using the Magellan Baade 6.5-meter telescope. "The infrared observations are particularly important because they overcome the masking effects of dust and are less sensitive to effects from the differences of chemical composition," commented Roth. Eric Persson's PANIC infrared camera is particularly suited for capturing information on these most distant objects.

The Army of Observers

The intense observing regime—beginning with observations nearly every night, laborious data reduction, analysis, and interpretation—requires a large group. To cope with the project's huge size, the supernova group established a major mentoring program. Undergraduate and graduate students from California and Chilean universities are working side by side with postdoctoral fellows and other team members at every step. "Currently the dark energy remains a complete mystery. To understand its nature requires precise attention to many details," remarked Freedman.

Closing In on Answers

Thus far, the team has captured information from over 70 supernovae in the nearby "local" universe. Among the surprises, it discovered that one supernova (named 2005bf) had two peaks in its luminosity, one 25 days before the main maximum light—a phenomenon never seen before. This enigmatic object, which resulted from the explosion of a star approximately eight times more massive than the Sun, originally was classified as a Type Ic but eventually transformed into a Type Ib. Supernova 2005bf appears to have been closely related to an exotic class of objects called gamma ray bursters, which are currently the subject of intense study by astronomers.

"Carnegie provides an ideal place to work on problems of this kind," Freedman said. "Here is a huge challenge for fundamental physics—where sustained efforts over a long time, using our smallest and our largest telescopes, can yield powerful constraints on this phenomenon." •

Hot Spring Bacteria Flip a Metabolic Switch

The near-boiling pools of Octopus Spring in Yellowstone National Park are ringed with microbial mats—highly organized communities where photosynthetic cyanobacteria serve as the main power plants. Researchers have found that the single-celled cyanobacterium *Synechococcus* drops its day job of photosynthesis, and surprisingly fixes nitrogen gas (N_2) into biologically useful compounds at night.

Photosynthetic bacteria living in scalding Yellowstone hot springs have two radically different metabolic identities, according to a new study. As the Sun goes down, these cells quit their day job of photosynthesis and unexpectedly begin to fix nitrogen, converting nitrogen gas (N_2) into compounds that are useful for cell growth. The study, published in the January 30 early online edition of the *Proceedings of the National Academy of Sciences*, is the first to document a single-celled organism that can juggle both metabolic tasks at high temperatures; the work will also help answer long-standing questions about how hot spring microbial communities get essential nitrogen compounds.

Arthur Grossman, Devaki Bhaya, and Anne-Soisig Steunou of Carnegie's Department of Plant Biology, along with colleagues from several partner institutions, are studying the tiny single-celled cyanobacterium *Synechococcus*. Cyanobacteria evolved about 3 billion years ago, and are the oldest organisms on the planet that can turn solar energy and carbon dioxide into sugars and oxygen via photosynthesis. In fact, ancient cyanobacteria produced most of the oxygen that allows animals to survive on Earth.

Cyanobacteria such as *Synechococcus* are often found in the microbial mats that carpet hot springs, where life exists at near-boiling temperatures. These mats are highly organized communities where different organisms split up the work, with cyanobacteria serving as the main photosynthetic power plants. Microbial mats in Yellowstone National Park's Octopus Spring contain *Synechococcus* that can grow in waters of temperatures up to around 160°F, while other microbes in the hot spring can tolerate temperatures that exceed 175°F. But until now, it was unclear which organisms could fix nitrogen—especially in the hotter regions of the mat.

"The cyanobacteria are true multitaskers within the mat community," Grossman said. "We had assumed that the single-celled cyanobacteria growing at elevated temperatures were specialized for photosynthesis, but it looks like they have a more complicated metabolism than we initially suspected."

All cells require nitrogen for making proteins and nucleic acids, but N_2 gas from the atmosphere cannot be directly used for this purpose; it must first be reduced or fixed into larger, carbon-containing compounds. N_2 fixation is a problem for photosynthetic cells, since the oxygen produced during photosynthesis inhibits the nitrogenase complex—the enzyme factory that fixes N_2. Other organisms have found creative solutions to this dilemma. For example, plants rely on symbiotic N_2-fixing bacteria that live in their roots, far away from the photosynthetic leaves. A different type of cyanobacteria grows in multicellular strands and makes specialized N_2-fixing cells called heterocysts that are walled off from the photosynthetic cells.

Many researchers believed these filamentous cyanobacteria were the major N_2 fixers in microbial mats. But they are not tolerant of extremely high temperatures, and only live at the cooler edges of the mat, raising the question of whether N_2 fixation was critical for organisms in the hotter regions of the mat. Because heat-tolerant, single-celled cyanobacteria like *Synechococcus* specialize in photosynthesis, many researchers had dismissed them as candidates for N_2 fixation. "*Synechococcus* cannot spatially separate photosynthesis and N_2 fixation, as some photosynthetic organisms do," Bhaya explained. "Instead, they solve the problem by temporally separating the tasks."

Lead author Steunou and her collaborators tracked the activity of genes involved in photosynthesis and N_2 fixation over a 24-hour period. They found that photosynthetic genes shut down shortly after nightfall, and N_2-fixation genes switch on shortly thereafter. The nitrogenase enzyme complex snaps into action at about the same time, following the same pattern as the N_2-fixation genes.

Fixing N_2 requires a lot of energy, which raises another problem for *Synechococcus*. When photosynthesis shuts down at night, the mat becomes oxygen starved, making it difficult to perform respiration—an efficient energy-generating pathway that requires O_2 to release the energy stored in sugars. Instead, the cells must rely on fermentation—a less efficient energy-generating pathway that can proceed without oxygen. Steunou and colleagues found that at night, *Synechococcus* turns on genes for specific fermentation pathways that release energy from polyglucose, which probably powers N_2 fixation.

"These results add to our understanding of microbial mats as complex, integrated communities that are exquisitely adapted to life in the tough hot spring environment," Grossman commented. "There may be several different organisms living in a given mat, but it seems that they are engaging in community metabolism that changes depending on the time of day. Perhaps it is more correct to consider the mat as a single functional unit rather than as a group of individual organisms."

—BY MATTHEW EARLY WRIGHT

This work was supported by a grant from the National Science Foundation's Frontiers in Integrative Biological Research Program, with additional support from the Danish Natural Science Research Council, the National Institutes of Health, and NASA.

Carnegie Welcomes
Two New Additions to the Administration

"Our two senior staff appointments provide an excellent opportunity to bolster the institution's financial systems. I am confident that this new team will take Carnegie to the next level of growth."

—*Richard Meserve*
President, Carnegie Institution

Christine D. Smith
Becomes First Chief Advancement Officer

The new advancement office, headed by Smith, was created by merging the offices of external affairs and publications, and will bring together Carnegie's fundraising, marketing, and communications efforts. Smith comes to Carnegie from Georgetown University, where she was associate vice president for Main Campus development and senior director of development for the School of Foreign Service. She served there from 1997 through 2005. Prior to 1997, she worked in advancement at Lehigh University, Purdue University, and Stanford University. She received her B.A. in sociology at Tulane University and a master's in education at Purdue.

Smith brings a broad range of expertise to Carnegie. She is experienced in individual, corporate, and foundation fundraising, campaign planning and execution, international fundraising, board management, prospect management, advancement communications, fiscal planning and accountability, and much more. She was part of Georgetown's senior management team, which completed a $1 billion campaign in December 2003.

George Gary Kowalczyk
Appointed Director of Administration and Finance

Kowalczyk has over 20 years of management experience in the federal government. He is well versed in finance and administrative services, budget supervision, human resources oversight, grants management, and policy operations. Most recently, Kowalczyk has been advising nonprofit organizations on strategic planning, finance, and policy.

From 1994 through 2003, Kowalczyk worked for the Corporation for National and Community Services (CNCS), the umbrella organization that oversees AmeriCorps, Senior Corps, and other similar programs. He served as the chief financial officer and then led the coordination and management of the organization's national field offices. He developed and analyzed budgets and policies for the CEO, served as liaison to the board of directors, and testified before the Office of Management and Budget, and Congress.

Earlier in his career, Kowalczyk worked at ACTION, the predecessor organization to the CNCS, where he became director in 1993. During the 1980s, he served at the Department of the Treasury and the General Services Administration.

Kowalczyk received a B.S. in political science at the State University at New Paltz in New York and a master's in education at the University of Illinois/Champaign. In the early 1970s he served in the Peace Corps, managing an agricultural development project in Ethiopia.

100 YEARS of EARTHSHAKING RESEARCH

Modern seismology was born in the smoldering ruins of San Francisco in 1906. Carnegie scientists have helped shape the course of tectonic research since.

On April 18, 1906, a massive earthquake along the San Andreas Fault destroyed over 3,000 acres in San Francisco and caused as many as 3,000 deaths. This picture shows a section of Union Street, directly west of Steiner Street, in ruins following the quake.

The first overseas installation of a Sacks-Evertson borehole strainmeter—a metal tube filled with liquid that can detect minute changes in the strain of surrounding rocks—took place at Matsushiro Observatory in Japan in 1971. Carnegie's Selwyn Sacks helped develop the instrument, which can track subtle changes in the shape of Earth's crust.

AT 5A.M. ON APRIL 18, 1906, the San Francisco peninsula convulsed as a 190-mile section of the San Andreas Fault ruptured from Point Arena to San Juan Bautista. The quake toppled buildings along the fault and severed gas lines in San Francisco, sparking a conflagration that reduced the city to cinders. With nothing to fight the blaze—water supply lines were also broken—much of the city burned out of control for four days.

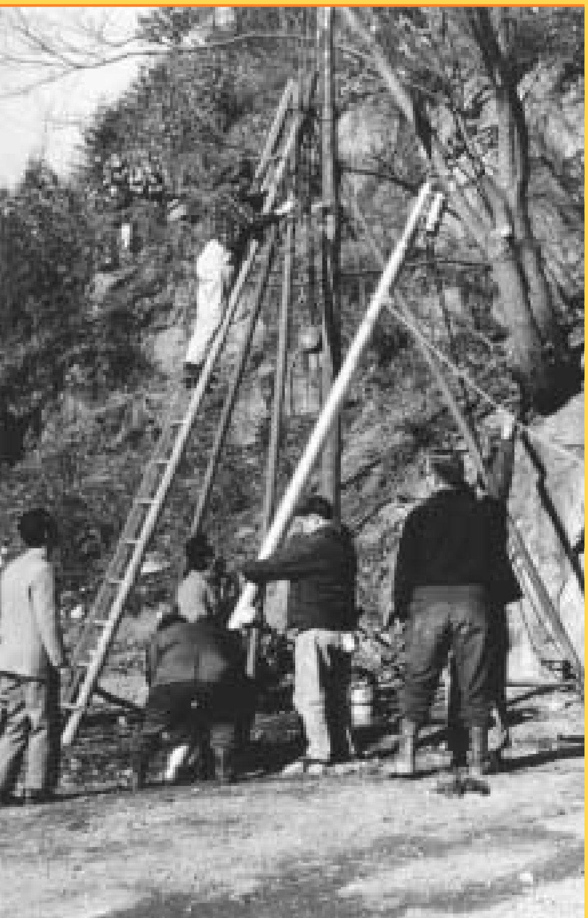
The near destruction of San Francisco that morning sparked a quiet scientific revolution. Many seismologists, previously focused on mapping the Earth's interior using low-frequency waves, shifted their attention to the practical study of earthquakes. If the physics of the Earth's crust could be understood, they reasoned, catastrophic events could be predicted in time to save lives and property.

The Carnegie Institution took the lead in this effort by funding the San Francisco investigation and publishing the final report in 1908, which stands today as the definitive account of the event. Predating the use of quantitative measures such as the Richter scale by several decades, the report relied heavily on qualitative firsthand observation to piece together the scope of the destruction.

Harry Oscar Wood, a veteran of the San Francisco investigation, began Carnegie's formal seismology effort in 1921 as a research associate. Driven by a desire to understand and predict earthquakes in California, Wood set up shop in Pasadena on Santa Barbara Street—then the headquarters of the Mount Wilson Observatory and now home to the Carnegie Observatories. While there, he collaborated with astrophysicist John Anderson to develop the Wood-Anderson torsion seismometer, which became a landmark instrument for recording local earthquakes. Wood installed a network of these seismometers around southern California, in effect creating the region's first earthquake monitoring system. Hundreds of these units are still in use today at seismic stations around the world.

In 1927, Wood relocated his operation to Caltech's newly minted Seismological Laboratory. While Carnegie provided funds for research and day-to-day operations, Caltech retained ownership of the facility. This partnership yielded precious scientific dividends, including Charles Richter's collaboration with Beno Gutenberg. Carnegie's Richter developed and tested his famous earthquake magnitude scale with data from California earthquakes, and Caltech's Gutenberg later adapted it for use anywhere in the world. In 1937, facing differences of opinion on the direction the lab should take, Carnegie turned the Seismological Laboratory fully over to Caltech; today, the Department of Terrestrial Magnetism (DTM) serves as the center of Carnegie's seismology efforts.

DTM scientists have maintained the standard set by Wood and his colleagues, both by developing instruments and by using them to answer bold new questions about the Earth. For example, teams at DTM have pioneered the use of portable broadband seismometers to investigate features of the planet's interior that are largely invisible to traditional fixed seismic networks. They have also created strain-monitoring tools capable of detecting movements in the crust so subtle they do not register on any standard seismogram. Carnegie's seismologists are in a better position than ever before to help realize Wood's goal of reliable earthquake prediction.



(Digital image courtesy U.S. Geological Survey.)

STRAINING TO SEE SLOW DEFORMATION

Plate tectonics—the theory that the Earth's crust is made of several large plates that move and grind against each other—gained popularity in the 1960s. As a result, earthquake-causing faults such as San Andreas could no longer be thought of as isolated features. The theory also led some geophysicists to ask whether faults can creep along slowly, giving rise to less violent "slow" earthquakes.

DTM's Selwyn Sacks eagerly took up this question. Limited by the sensitivity of seismic equipment available in the mid-1960s, he and Dale Evertson of the University of Texas developed the borehole strainmeter, a highly sensitive device filled with hydraulic fluid that changes shape along with the borehole within which it is seated. By measuring the flow of this fluid from a relatively large chamber into a smaller one, a strainmeter can detect otherwise imperceptible movements in rock.

Shortly after the first successful strainmeter test on the DTM grounds in 1968, the Japanese government installed a large network as part of their national earthquake prediction program. Soon, valuable scientific information started pouring in. “We began getting interesting results that suggested earthquake faults could move slowly as well as fast and destructively,” Sacks explains. “That changed our whole idea of stress redistribution in the Earth.”

Today, Sacks works closely with DTM’s Alan Linde to study tectonic strain in locales as varied as Taiwan, Iceland, and the Caribbean island of Montserrat. Linde, who previously focused on earthquakes, became interested in volcanic systems when Iceland’s Hekla volcano “started speaking” to him in 1991. An analysis of strain signals preceding that eruption allowed DTM’s Icelandic colleague Ragnar Stefansson to recognize similar strain signals in time to warn residents on the evening news before Hekla blew its top again in 2000.

Strainmeters allow Linde and Sacks to construct detailed images of volcanic plumbing that would be invisible with other methods. In contrast, many researchers depend on the Global Positioning System (GPS) to track deformation in the Earth’s crust, relying on the satellite network’s ability to precisely track the motion of any point on the globe. But “what we can see quite clearly, GPS can’t see at all,” Linde says. “Strain instruments give you sensitivity over a thousandfold.”

Most recently, Sacks and Linde have studied seasonal trends in strain and seismic activity. They have found that certain environmental changes on land, such as the drop in atmospheric pressure from a typhoon or increased pressure from masses of winter snowpack, can redistribute strain through an entire system. They have also found that prior tectonic events can build up and transfer strain. According to one analysis, strain energy stored during two major Japanese earthquakes in 1944 and 1946 may have broken free in 1995, causing an enormous quake in Kobe. And the story for that particular region is not over yet. “There’s no question that a lot of strain has accumulated that hasn’t been released,” Sacks says. “It has to go sometime.”

(Images courtesy EarthScope.)

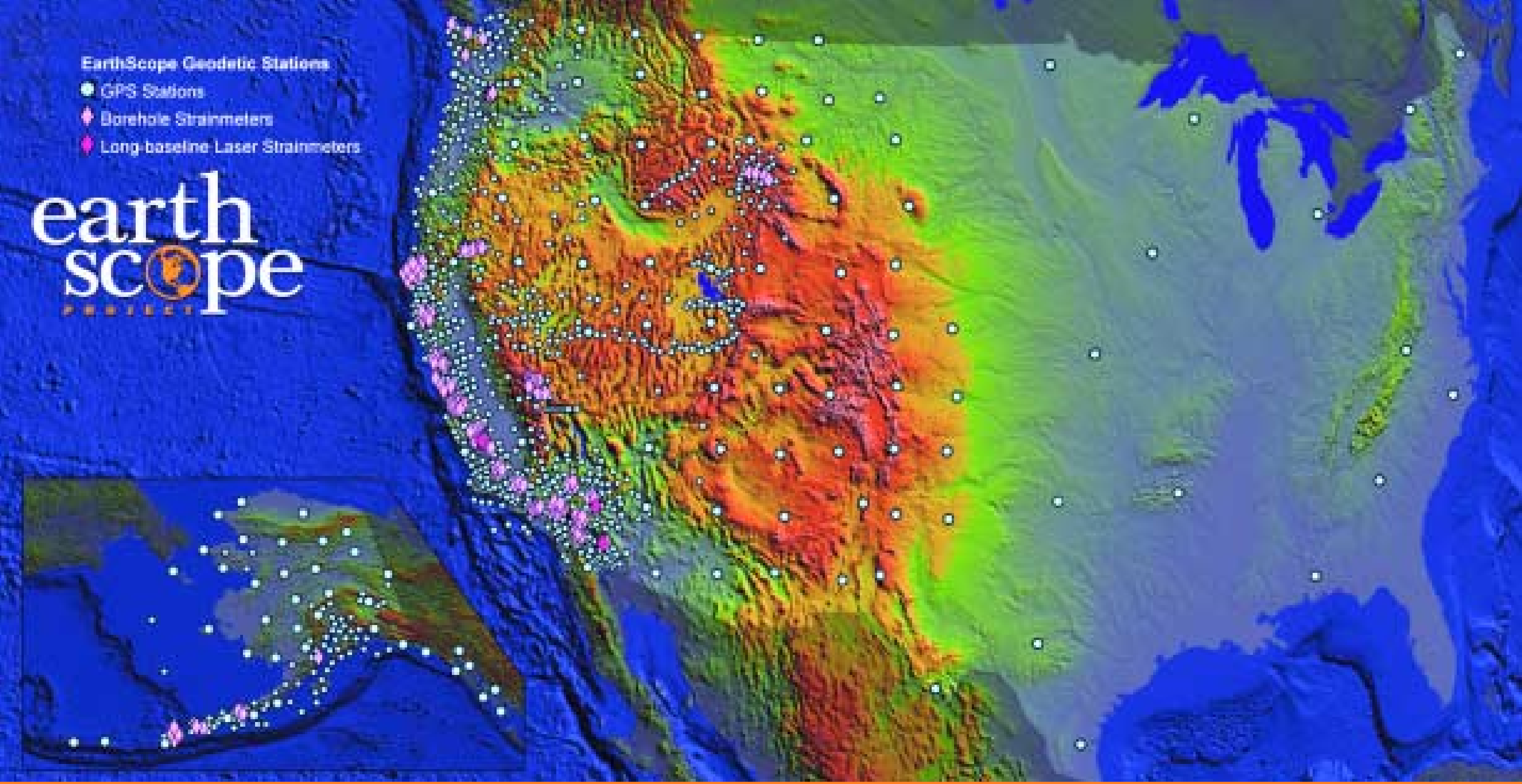
LOOKING DEEP AND WIDE

DTM’s Paul Silver looks far into the Earth to study enigmatic deep-source earthquakes. He became interested in 1994, when a DTM seismic experiment in Bolivia recorded—in unprecedented detail—a magnitude 8.3 quake that originated nearly 400 miles below the surface. Seismologists had long known of earthquakes at this depth but had been unable to conclusively determine the cause, since the “brittle failure” (the point at which a slab of rock bends at a fault until it finally snaps) believed to cause shallow earthquakes shouldn’t occur under the high pressures and temperatures at this depth.

Until the Bolivian event, the prevailing theory for deep earthquakes had implicated a rapid change in mineral structure at the source. When a tectonic plate is subducted, or pushed under another plate, the increased temperature and pressure cause large amounts of the mineral olivine to compress into a denser phase called wadsleyite. Some researchers believe this massive phase transition can release enough energy to cause a quake, but data from the 1994 Bolivian quake didn’t agree with this model.

As an alternative, Silver suggested that deep quakes can occur on old, preexisting faults in the subducted plate. To test this idea, he and his colleagues recreated a miniature deep earthquake in the lab by squeezing a rock sample in a high-pressure tool called a multianvil cell. When the rock had a preexisting crack or “fault,” the researchers were able to cause a miniquake, but when the rock was intact, it was difficult or impossible to do so, providing support for the preexisting-fault hypothesis.

Besides looking deep, Silver also likes to think wide—on a continental scale, to be precise. He is a driving force behind the Plate Boundary Observatory (PBO), a network of modified borehole strainmeters and GPS receivers that will blanket the western United States and track slow deformation with unprecedented precision. Silver, driven by the prospect of earthquake prediction, hopes it will illuminate connections between slow deformation and violent quakes.



"Earthquakes are only the most dramatic manifestation of plate boundary deformation," Silver says, noting that some quakes are preceded by slow "precursor" events. For example, he and his collaborators confirmed that a precursor occurred just before the Richter magnitude 9.5 Great Chilean Earthquake of 1960. It can be difficult to detect precursor events, however, since they do not produce the powerful and long-traveling waves associated with violent quakes. According to Silver, the key lies in location and timing.

"To see precursory deformation, it is best to be right where the earthquake is occurring," Silver explains. "PBO will allow this." Nearly 1,000 PBO stations will be concentrated along the San Andreas Fault and the Cascadia subduction zone along the Pacific Northwest coast, where the Juan de Fuca tectonic plate is slipping underneath the North American plate.

The partly completed PBO has already revealed new and exciting forms of slow deformation. For example, a set of instruments that are now part of the network allowed Silver and colleagues to detect an acceleration of the San Andreas Fault in 1993, even before the PBO officially existed. This marked the beginning of a complex multiyear event that demonstrated that slow quakes can occur along a spectrum of time from minutes to years.

By inventing technology and probing fundamental questions, Sacks, Linde, and Silver are demystifying our dynamic—and occasionally violent—planet's inner workings. Harry Oscar Wood's dream of reliable earthquake prediction may remain elusive, but clear and predictable patterns in tectonic activity might yet emerge as Earth's crust becomes more wired with instrumentation. Even if such information can only provide minutes of advance warning, local authorities will be better equipped to mitigate the damage from another catastrophe like the one that leveled San Francisco that fateful morning in 1906.

—BY MATTHEW EARLY WRIGHT

An engineer welds one of five GPS stations on the flanks of Mount St. Helens as part of the Plate Boundary Observatory, a network of tectonic monitoring instruments being installed across the western United States. These five stations in particular will precisely monitor deformation associated with magma movement within the volcano.

This map of western North America shows stations proposed for the Plate Boundary Observatory (PBO), for which Carnegie's Paul Silver serves as a primary investigator. About 40% of these stations are already installed and producing data. When finished, the PBO will be able to generate composite time-lapse imagery of tectonic changes along the West Coast and in Alaska.

Are Tougher Electronic Components on the Way? Materials Science Gets a Nitride Boost

Alexander Goncharov (left) and a colleague conduct research at the HPCAT Beamline. Crystals of iridium nitride (top right) and of platinum nitride (bottom right) are visible in this pair of scanning electron microscope (SEM) images.

(Image courtesy Veronica O'Connor, High Pressure Collaborative Access Team.)

Like modern-day alchemists, materials scientists often turn unassuming substances into desirable ones. But instead of working metal into gold, they create strange new compounds that could make the electronic components of the future smaller, faster, and more durable. Alexander Goncharov of the Carnegie's Geophysical Laboratory and colleagues* have used extreme temperatures and pressures to make two durable compounds called noble metal nitrides; they are the first to succeed in making one of them, and the first to accurately determine the chemical formula of the other. Both nitrides possess a diamond-like hardness, and some compositions might have very low, nearly superconductive electrical resistance—a blend that could prove quite valuable to industry.

The two nitrides—one containing iridium and another containing platinum—could eventually replace the titanium nitrides currently valued by the semiconductor industry as surface coatings because of their strength and durability. The researchers believe iridium and platinum nitrides might be even more durable. The group's work is presented in the March 3, 2006, issue of *Science*.

Like several other metals such as gold, silver, and palladium, platinum and iridium are noble metals. Such metals are resistant to corrosion and oxidation, and do not easily form compounds with other elements unless coaxed to do so under very high temperatures and pressures. Goncharov and his colleagues used a special tool called a diamond anvil cell to compress the samples to nearly half a million times the atmospheric pressure at sea level. Then they used a focused laser to heat the samples to over 3000°F, or roughly the temperature of a steel mill blast furnace. Under such extreme pressure and temperature the rules of chemistry begin to change, and noble metals can be made to form compounds with other elements such as nitrogen, as in the case of iridium and platinum nitrides.

"We are still attempting to ascertain the electronic properties of these new materials," Goncharov said. "Generally speaking, these nitrides are likely to exhibit several properties that will make them attractive for technological applications. They are potentially important for the electronics industry as durable and reliable coatings, substrates, and conductors. One can also envisage optoelectronic devices, sensitive magnetometers, and other metrological equipment that employ these materials."

Though other researchers have previously made platinum nitride, Goncharov's group is the first to discover that for every platinum atom, there are two nitrogen atoms rather than just one. The group is also the first to make iridium nitride, which it found has the same basic chemical formula as platinum nitride. In both cases, strong bonds that the dual nitrogen atoms make with the metal atom contribute to the nitrides' hardness and durability. The noble metals, in turn, contribute unusual electronic properties.

So far, Goncharov's group has only created small quantities of iridium and platinum nitrides in the lab. There is much work to do before these compounds can contribute to engineering and manufacturing the technology of tomorrow. But, as Goncharov explains, "The present work is useful because it proves that these exotic nitrides exist, even if they were synthesized in a manner that is not practical on an industrial scale."

—BY MATTHEW EARLY WRIGHT

*Scientists from the Lawrence Livermore National Laboratory and the Atomic Weapons Establishment in England collaborated on this work.

"Survivin" Cell Division

When a cell divides, so does its genetic material; ideally, both new cells will receive a full set of gene-carrying chromosomes. Researchers at the Department of Embryology have found that one protein is particularly vital for organizing this process. This discovery will help researchers better understand cell division and could have implications for future work on cancer.

Previous studies found that a protein called survivin attached to chromosomes during cell division, then separated from them once the cell had split. Suspecting that the protein might actively help coordinate chromosome division, scientists in Yixian Zheng's lab looked at survivin and related proteins. They found that survivin's ability to bind to a chromosome is flipped on or off like a switch. When this switch is disrupted, so is chromosome division.

The switch is a small protein called ubiquitin that acts by attaching to, or tagging, other proteins. Its best-known function is to tag old proteins that the cell no longer needs, signaling enzymes to break them down. But ubiquitin tagging also helps with other processes such as DNA repair. The researchers found another role for ubiquitin: when a ubiquitin tag attaches to a survivin molecule it prompts survivin to attach to a chromosome; when the ubiquitin tag detaches, so too does the survivin molecule.

Working with cultured human cells, the team blocked survivin from attaching to chromosomes during cell division and separately blocked an enzyme that removes ubiquitin tags from survivin. In both cases, errors in chromosome separation occurred.

Previous studies have found increased levels of survivin in some cancers. While Zheng and her colleagues have not studied survivin's role in cancer cell division, their work makes it clear that survivin is vital for normal cell division.

IN Brief

❶ In Jan., Carnegie president Richard Meserve, third from right, co-led a group to the Las Campanas Observatory in Chile. From left to right attendees are Sheridan Lorenz, Martin Gellert, Jacqueline Michaud, Nicholas Suntzeff, Observatories director Wendy Freedman, Las Campanas director Miguel Roth, Charles Alcock, Perry Lorenz, President Richard Meserve, associate director of Las Campanas Mark Phillips, and director of external affairs in Pasadena Arnie Phifer. *(Image courtesy Martin Gellert.)*

Trustees and Administration

❶ In Jan. Carnegie president **Richard Meserve,** Observatories director Wendy Freedman, and Las Campanas director Miguel Roth led a group of Carnegie supporters to the Las Campanas Observatory in Chile.

On Jan. 11 Meserve spoke at the Nuclear Security Executive Forum, sponsored by the Nuclear Sector Coordinating Council. He presented comments regarding a simulated meeting to respond to a terrorist attack on a nuclear plant by the National Security Council. The simulation took place on Dec. 11 at Andrews Air Force Base and was sponsored by the Center for Strategic and International Studies. In the simulation he acted as chairman of the Nuclear Regulatory Commission.

Meserve was invited to become a member of two new committees of the National Academies: the Committee on a New Government-University Partnership for Science and Security and the Committee on Scientific Communication and National Security (CSCANS). He also recently became a member of the National Commission on Energy Policy.

On Jan. 27 he participated on a panel to discuss "Decision Making in the Real World" as part of the 6th National Conference on Science Policy and the Environment: Energy for a Sustainable and Secure Future, sponsored by the National Council for Science and the Environment.

Meserve has made several presentations on the nuclear renaissance in the United States—at the Los Alamos National Laboratory in NM on Feb. 9, the Philosophical Society of Washington on Feb. 24, and Vanderbilt U. on Mar. 6.

He completed his term as a director of the American Association for the Advancement of Science at the annual meeting held in Feb. in St. Louis.

As chairman of INSAG (International Nuclear Safety Group), which is chartered by the International Atomic Energy Agency, Meserve and his committee traveled to Korea in mid-April for meetings, site inspections, and participation in the 21st KAIF/KNS Annual Conference, jointly hosted by the Korea Atomic Industrial Forum and the Korean Nuclear Society.

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In Jan. **Christine D. Smith** joined Carnegie as chief advancement officer (see page 9 for profile).

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G. Gary Kowalczyk joined the administration on Feb. 21 as director of administration and finance (see page 9 for profile).

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Jeff Lightfield left the administration's accounting department to join the Geophysical Laboratory as business manager.

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Codirector of CASE **Toby Horn** was recently appointed chair of the Biotechnology Industry Advisory Committee of the DC Public Schools Office of Career and Technical Education.

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CASE has received a $100,000 grant from the Fannie Mae Foundation to continue its Elementary Summer Institute for DC K-6 teachers. Since 1994, the institute has delivered intensive teacher professional development programs that teach teachers how to improve math, science, and technology instruction.

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❷ "Exploring Ice in the Solar System," an educational CD developed by Richard Shope, III from Jet Propulsion Laboratories and **Julie Edmonds** at CASE for the Carnegie MESSENGER and Astrobiology projects, was rated "outstanding" in a NASA space science education product review. A large printing is in the works and information on the disc will be available at http://teachspacescience.org.

Embryology

Embryology director **Allan Spradling** spoke to 400 California high school students about stem cell research at the ASCB annual meeting in San Francisco Dec. 10-14. At the same meeting, Spradling and Carnegie president emerita **Maxine Singer** participated in a panel discussion on the length of time young cell biologists should spend on graduate and postdoctoral training.

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Marnie Halpern is chairing the Educating about Evolution subcommittee of the FASEB Science Policy Committee. The subcommittee drafted FASEB's official policy statement on teaching evolution. Halpern was invited to speak at a special symposium at the SICB annual meeting in Orlando Jan. 5-8.

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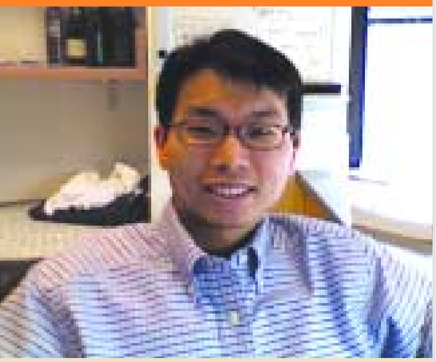
❷ "Exploring Ice in the Solar System" CD developed by CASE and JPL.



❸ Embryology staff associate Jeff Han.

❹ George Cody

❸ **Jeff Han** is a new staff associate from Johns Hopkins U. School of Medicine, where he earned both his M.D. and his Ph.D.

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Koshland lab technician **Eileen Hogan** retired after 31 years. Members of her family and many Carnegie alumni attended a luncheon in her honor on Jan. 27.

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Johns Hopkins U. graduate student **Julio Castaneda** is doing a rotation in the Gall lab.

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New postdoctoral researchers include **Joanna Paterson**, who joined the Farber lab from Princeton U.; **Matt Berezuk**, who joined the Zheng lab from Johns Hopkins U.; and **Lucy Morris**, who joined the Spradling lab from U. Edinburgh.

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Mark Milutinovich has accepted a job as a program associate with the AAAS Research Competitiveness Program, which provides review, evaluation, and guidance to the scientific and engineering community on the development of quality research programs.

Geophysical Laboratory

GL director **Wes Huntress** was appointed U.S. representative to a United Nations committee organizing an Oct. 2007 U.N. celebration for the 50th anniversary of the inauguration of the space age with the launch of Sputnik. Huntress testified before the House Committee on Science, Mar. 2., advocating more support for science.

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On Feb. 25-26 **Bjørn Mysen** signed the renewal of the collaborative agreement between GL and the Institute for the Study of the Earth's Interior in Misasa, Japan. Bjørn also gave a keynote lecture at the symposium "The Evolution of Early Stage of Earth and Solar System" in Kurayoshi, Japan, Feb. 25-26.

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Bob Hazen delivered a lecture, "Emergence: The Mystery of Life's Origins," for the Smithsonian Associates Jan. 24. He also presented a seminar on science education reform and a public lecture on life's origins at Iowa State U. on Feb. 2.

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Russell Hemley gave an invited talk at the fall 2005 AGU meeting. He was also invited to speak at MIT on Feb. 6 and at the Frontiers in High Pressure Research school in Israel in Mar.

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Ho-kwang (Dave) Mao gave an invited talk at the fall 2005 AGU meeting. In Nov. he delivered a keynote talk at the 3rd International Workshop on Water Dynamics in Sendai, Japan.

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❹ Stardust mission team member **George Cody** is analyzing some of the first recently returned cometary particles using a scanning transmission X-ray microscope at the Advanced Light Source. He is looking at the molecular structure of cometary organic materials through the X-ray absorption edges of carbon, nitrogen, and oxygen.

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Nabil Boctor presented two papers at the Lunar and Planetary Science Conference Mar. 13-17.

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HPCAT research scientist **Haozhe Liu**, with Rudy Wenk (UC-Berkeley) and Tom Duffy (Princeton U.), organized an international workshop, "Rheology and Elasticity Studies at Ultra-High Pressures and Temperatures," at Argonne National Laboratory on Oct. 21-23. Liu chaired the session of "Pressure Induced Phase Transitions and Structural Refinement Studies" in the Third Meeting on Study of Matter at Extreme Conditions held in Miami on Apr. 17-21, 2005.

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Joseph Lai has been appointed a CVD laboratory scientist in the CVD laboratory working with Hemley and others.

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Wenge Yang has been appointed beamline scientist at HPCAT at the Argonne National Laboratory.

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Chang-Sheng Zha has been appointed CDAC research scientist. For the past seven years Zha has headed the high-pressure program at the Cornell High Energy Synchrotron Source. He was a postdoctoral associate at GL in 1986-1987 and then a CHiPR research associate from 1991 to 1998. He designed and carried out the first very high pressure Brillouin experiments, setting the stage for current work in the field worldwide. At GL Zha will continue high pressure/high temperature technology development, especially as it relates to studies of planetary gases under extreme conditions. He will also serve the growing number of visitors at CDAC, assisting in HP/HT techniques.

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Burkhard Militzer uses computer simulations to study the interior of gas giant planets, which are mainly composed of hot, dense hydrogen and helium at high pressure. Militzer's recent simulation results show that hydrogen and helium behave very differently in shock-wave experiments. Hydrogen becomes hot very quickly, while helium stays comparatively cold and is much more compressed. **Jan Vorberger** (U. Greifswald, Germany) recently joined GL as a postdoc to work with Militzer and his computer simulations.

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Pierre Beck (Ecole Normale Supérieure de Lyon) has been appointed research associate and will join Russell Hemley and others to work on the problem of bridging the gap between static and dynamic compression processes and the interpretation of natural-impact phenomena.

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Alexander Gavriliuk (Institute for High Pressure Physics, Russian Academy of Sciences) has been appointed research associate working with Viktor Struzhkin and others on the investigation of magnetic and superconducting materials.

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Qing Peng has been appointed a postdoctoral research associate and will be working with Ronald Cohen.

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Sergey Tkachev has been appointed postdoctoral research associate to collaborate with Alex Goncharov on pioneering spectroscopic (Raman, IR, and Brillouin) studies of materials, such as planetary gases and liquids, at very high pressures and temperatures.

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Nancy Chabot (APL, The Johns Hopkins U.) has been appointed visiting investigator to work with Yingwei Fei. She will investigate the formation and evolution of rocky planetary bodies.

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Yu. S. Ponosov (Institute of Metal Physics, Russia) is a visiting investigator working with Alexander Goncharov and Viktor Struzhkin on measuring Raman spectra of transition metals (rhenium and osmium) to trace electronic excitations and renormalization of the optical phonons depending on pressure, temperature, and wave vector.

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Yann Le Gac has been appointed predoctoral associate working with Bjørn Mysen on kinetics of iron isotope fractionation among metals and silicates at high temperature and pressure.

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Matthieu Galvez has been appointed predoctoral associate and will be working with Bob Hazen on a project on chirality as part of the astrobiology effort.

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Visiting predoctoral students **Yajie Lei** and **Xiaowei Zeng** are working with Ron Cohen.

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Minh-Phuong Huynh-Le, a 17-year-old Montgomery Blair High School intern working in George Cody's laboratory, is a finalist in the national Intel Science Talent Search for her work on soil organic matter related to the global carbon cycle. The work was done in collaboration with Cody and scientists in Germany.

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Ellis Truesdale Bolton,

former director (1966-1974) of the Carnegie Institution's Department of Terrestrial Magnetism (DTM), died on January 6, 2006. He lived in Sykesville, Maryland, and would have been 83 on May 4.

Bolton was born in Linden, New Jersey. He received his B.S. in 1943 from Rutgers University and then served as a captain in the Marine Corps from 1943 until 1946. After his term of service he returned to Rutgers, where he received his Ph.D. in zoology in 1950. He joined Carnegie as a fellow in 1949 and was appointed a staff member in 1951.

Bolton's early work used immunology to determine the degree to which different species are related. When he became part of the biophysics group at Carnegie, he looked at the biosynthesis of precursor molecules of proteins and nucleic acids such as DNA and RNA. Those investigations contributed to an understanding of the steps in a key metabolic cycle known as the Krebs cycle. With colleagues, he also developed an important agar gel technique that isolated single strands of DNA. Among other luminaries, he worked with the legendary Philip Abelson, former Carnegie president and editor of *Science* magazine.

In March 1966 the Carnegie board appointed Bolton director of DTM, a post he held from July of that year until July of 1974. After his directorship, he continued working with Carnegie support as a staff member while simultaneously serving on the faculty of the College of Marine Studies at the University of Delaware, where he was director of the Mariculture Laboratory. There he studied the biosynthesis and growth of algae as the primary food source for many marine animals.

Bolton was a member of many professional organizations, including the American Geophysical Union, the American Society of Plant Physiologists, and the Biophysical Society. He retired in 1984. His wife, Vera, died in October 2005.

Postdoctoral associate and Carnegie Fellow **Olga Degtyareva** and CDAC research scientist **Eugene Gregoryanz** have both joined the School of Physics, U. Edinburgh.

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Postdoctoral associate **Shantanu Keshav** has taken a position at the Bayerisches Geoinstitut at U. Bayreuth.

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Postdoctoral associate **Zhigang Wu** has taken a postdoctoral position at UC-Berkeley.

Global Ecology

Chris Field participated in a panel discussion on environmental sustainability at the Carnegie Medal of Philanthropy ceremony in Edinburgh, Oct. 3-4. He also presented a keynote lecture at the 11th Japan-US Workshop on Global Change in Yokohama, Oct. 31-Nov. 2.

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Greg Asner and **Dave Knapp** spoke about selective logging in the Amazon at the LBA-ECO Science Team Meeting in Sao Paulo, Brazil, Nov. 10-12.

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The Asner lab began a new project, funded by the MacArthur Foundation, to study rain forest disturbances in the Peruvian Amazon. Asner and colleagues also began the design phase of the new Carnegie Airborne Observatory.

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Ken Caldeira spoke about human-induced changes in climate and ocean chemistry at a meeting of the Society of Petroleum Engineers in Galveston, TX, on Nov. 15. He also participated in a planning meeting for the Bush administration's effort to develop a Climate Change Technology Program in Washington, DC, on Nov. 21. Caldeira discussed climate change and policy on San Francisco NPR affiliate KQED's *Forum with Michael Krasny* on Jan. 4 and on CBC radio's *As It Happens* on Jan. 9.

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Berry lab technician **Larry Giles** spent several weeks in Kruger Park, South Africa, servicing instruments that measure CO_2, energy, and water.

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Global Ecology hosted the Jasper Ridge Global Change Experiment's annual Data Fest Nov. 14-15.

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Five members of Global Ecology—staff member **Ken Caldeira**, postdoctoral fellows **Ben Houlton, Maoyi Huang,** and **Ulli Seibt,** and predoctoral fellow **Adam Wolf**—presented papers at the AGU fall meeting in San Francisco Dec. 5-9.

Observatories

❶ In Jan. Observatories director **Wendy Freedman,** and Las Campanas director **Miguel Roth** led a group of Carnegie supporters to the Las Campanas Observatory in Chile. Participants saw firsthand the research conducted with Carnegie's current instruments, including the twin Magellan telescopes, and discussed plans for the proposed Giant Magellan Telescope (GMT). Freedman was also an invited keynote speaker at the TAMEST Conference in Houston on Jan. 6. She spoke at the Institute for Astrophysics, U. Hawaii at Manoa, on Jan. 30, and at Vassar College on Mar. 6. She also gave the Cecilia Payne-Gaposchkin Lecture at the Harvard-Smithsonian Center for Astrophysics on Mar. 16. Bob Berman of *Astronomy Magazine* interviewed Freedman on the future of astronomy and on the GMT. On Mar. 20 National Geographic filmed an interview with Freedman as part of their *Universe* documentary.

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Staff astronomer **Patrick McCarthy** presented a talk at a conference on "Galaxies and Structures through Cosmic Times, Mapping the Universe" in Venice, Italy, Mar. 26-31.

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Andrew McWilliam participated in a Space Interferometry Mission (SIM) science team meeting in Nov.

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Luis Ho gave colloquia at Caltech and NOAO/Steward, and a public lecture at Sonoma State U. He gave an invited talk, "Active Galactic Nuclei: From Atoms to Black Holes," at Tel Aviv U., and attended a workshop to plan the scientific agenda of the Chinese Hard X-ray Modulation Telescope in Sanya, Hainan. He gave a colloquium and a research seminar at the Academica Sinica Institute of Astronomy and Astrophysics, in Taipei, Taiwan, and returned to the institute to serve on an advisory panel for development of optical/IR astronomy in Taiwan.

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John Mulchaey continued to lead the Observatories' community outreach to local elementary school students. In Oct. he visited four classes of fifth graders at Pasadena's Longfellow Elementary to teach them about planets. He has almost finished renovating the school's discovery science room.

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On Mar. 21 **Barry Madore** kicked off the fourth season of the popular Carnegie Astronomy Lecture Series held at the Huntington Library, Art Collections, and Botanical Gardens in San Marino, CA, with a talk, "What, If Anything, Is a Galaxy?"

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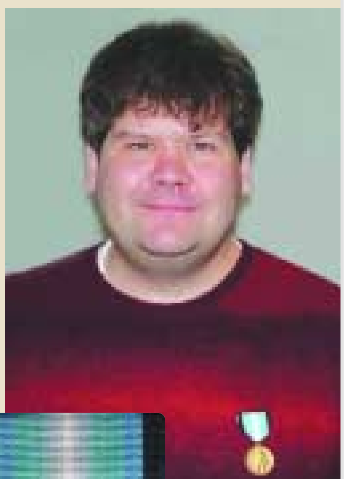
❺ Department of Terrestrial Magnetism director, Sean Solomon (right), receives the Harry H. Hess Medal from AGU president John Orcutt.

(Image courtesy Lawrence Lauterborn Photography.)



❻ Larry Nittler with the Antarctica Service Medal.

Carnegie-Princeton Fellow **Inese Ivans** gave a colloquium on "New Insights into the Nature of r-Process-Rich Stars" at CTIO/Gemini South, La Serena, Chile, in Dec. In Jan. she gave invited colloquia at the Herzberg Institute of Astrophysics, in Victoria, BC, and at U. Washington in Seattle. Also at U. Washington, she gave a talk to graduate students as part of the school's Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers program. In Feb. she participated in the VIII Torino Workshop on Nucleosynthesis in AGB Stars in Granada, Spain, where she gave a talk. She also gave an invited colloquium and worked with colleagues at the Dipartimento di Fisica Generale of the University of Turin in Italy. She gave invited colloquia at the Institut für Kernchemie at U. Mainz, Germany, and at the Dept. of Astrophysical Sciences, Princeton U.

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Carnegie Fellow **Ivo Labbé** attended the telescope mirror casting at the Steward Observatory Mirror Laboratory at U. Arizona in Tucson on July 23, 2005. He attended the Extreme Starbursts conference in Lijiang, China, Aug. 14-20, 2005, and was part of the FIRES group meeting Oct. 31 through Nov. 4 in Leiden, Netherlands. He contributed a talk to the Spitzer Space Telescope Conference 2005: Infrared Diagnostics of Galaxy Evolution, Nov. 13-15, in Pasadena, CA, and gave an invited talk at the Rencontre de Moriond conference in La Thuile, Italy, Mar. 12-18. He attended the "Galaxies and Structures through Cosmic Times, Mapping the Universe" conference in Venice, Italy, Mar. 26-31

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On Oct. 16 the Observatories hosted 250 guests from around Southern California at the 4th Annual OCIW Open House. Visitors explored the past, present, and future of Carnegie astronomy through tours, exhibits, speakers, films, games, and hands-on demonstrations coordinated by **Arnold Phifer**, regional director of external affairs.

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Linda Sparke (U. Wisconsin) spent the month of Jan. as a visiting scientist and presented a colloquium, "Bars in Bars and Rings 'round Stars."

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Chung-Pei Ma (UC-Berkeley) visited for five weeks in Jan.-Feb. and gave a colloquium, "Dark Matter Substructures and Centers of Elliptical Galaxies."

Plant Biology

On Dec. 6 **Chris Somerville** gave a talk at UC-San Diego, "Outcomes from the *Arabidopsis* Genome Sequencing Project." On Dec. 7 he spoke at a workshop on biofuels convened by the U.S. Dept. of Energy in Washington, DC. On Dec. 17 he gave a talk at the International Society for Plant Microbe Interactions in Merida, Mexico, and in Jan. he gave two talks at Lawrence Berkeley Laboratory, one on biofuels from plants and another on cellulose synthesis.

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Winslow Briggs gave a seminar, "Phototropins: A New Photochemical Pathway for Activating Signal Transduction by Blue Light in the Model Plant *Arabidopsis thaliana*," on Sept. 15 at U. Texas, Austin, and at the Catholic U. of Santiago, Chile, on Nov. 24. He gave a guest lecture, "Plant Photoreceptors," at Santa Clara U. in early Nov.

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Shauna Somerville and **Matt Humphry** attended the XII International Congress on Molecular Plant-Microbe Interactions in Merida, Mexico, Dec. 14-19, where Shauna gave a talk, "Penetration Resistance to Inappropriate Pathogens," and Matt gave a poster presentation, "An MLO Homolog Required for Normal Growth of Powdery Mildew on *Arabidopsis*."

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On Jan. 31 and Feb.1, the department was reviewed by a visiting committee chaired by Carnegie trustee **Christopher Stone**. The committee included President **Richard Meserve**, Chairman **Michael Gellert**, trustee **Bruce Ferguson**, Ken Keegstra (Michigan State U.), Natasha Raikhel (UC-Riverside), Paul Schultze-Lefert (Max Planck Institute, Cologne), and Sarah Hake (USDA Plant Gene Expression Center, Albany, CA).

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Shaolin Chen joined Chris Somerville's lab as a postdoctoral fellow in Dec. He comes from Cornell U., where he studied protein biochemistry.

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Sue Rhee's group welcomed two new members in Jan. **Tom Walk** joined the group as a postdoctoral research associate, and **Noah Whitman** joined the group as a lab technician.

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As part of a collaborative project with Prof. Frantisek Baluska at the Institute of Cellular and Molecular Botany in Bonn, predoctoral researcher **Yinglang Wan** joined the Briggs lab on Sept. 21 for a short-term appointment, leaving Jan. 31.

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Matt Humphry ended his appointment in Shauna's lab on Dec. 31, but stayed on as a visiting investigator until leaving on Feb. 8 to take up a position in Cologne, Germany. **Melanie Hilpert** also left the Frommer lab on Feb. 8 to return to Cologne.

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Postdoctoral fellow **Thorsten Hamann** left on Jan. 16 to return to Germany. He will be collaborating with Carnegie alumni **Mark Stitt** and **Alisdair Fernie** at the Max Planck Institute in Golm, Germany.

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Chunxia Xu left the Rhee group on Jan. 15 to stay home with her new child, Joshua, born Sept. 28.

Terrestrial Magnetism

❺ In Dec. **Sean Solomon** received the Harry H. Hess Medal at the American Geophysical Union fall meeting in San Francisco "for his outstanding and influential scientific achievements in planetary science, seismology, and marine tectonics." He delivered papers on the upcoming MESSENGER flybys of the planet Venus at the Chapman Conference on Exploring Venus as a Terrestrial Planet in Key Largo in Feb., and at the Lunar and Planetary Science Conference in Houston in Mar.

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❻ **Larry Nittler** was awarded the Antarctica Service Medal in Dec. for his work with the 2000-2001 Antarctic Search for Meteorites (ANSMET) team, which searched for meteorites under severe weather conditions in the isolated Meteorite Hills region of Antarctica.

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Senior Fellow **Vera Rubin** gave a talk, "The Beginning," at a reception for undergraduates who presented posters at the AAS meeting in Washington, DC, in Jan. In Feb. she spoke on the "Polar Ring Galaxies" at the meeting of the Washington, DC, National Capital Astronomers, and gave a talk to George Washington U. freshmen involved in the school's women's leadership program.

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❼ In Jan. **David James**, field seismologist **Peter Burkett**, former postdoctoral fellow **Matthew Fouch** (now at Arizona State U.), and others installed the first four broadband seismic stations in what will be a 170-station array slated for completion in 2007 as part of the High Lava Plains (HLP) project. HLP is a multidisciplinary/multi-institutional effort led by DTM geochemist **Rick Carlson**.

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❽ In Sept. **Rick Carlson** became an editor of the journal *Earth and Planetary Science Letters*.

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❼ Shown at the January groundbreaking for the first broadband station installed as part of the High Lava Plains project seismic experiment are, from left to right, field seismologist Peter Burkett (digging), David James, and former postdoctoral fellow Matthew Fouch.

The team installs a broadband station at Squaw Butte, Oregon, in a driving snowstorm. From left are Peter Burkett, David James, Matthew Fouch, three ASU graduate students, and, at far right, Steven Golden, recently hired DTM field seismologist.

❽ Rick Carlson

❾ Paul Silver

❾ **Paul Silver** gave a talk at the Geological Society of Washington in Jan. In Mar. he attended the annual UNAVCO workshop in Denver and traveled to Tibet to help retrieve instruments from DTM's ongoing portable seismic experiment there.

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In Jan. **Alan Boss** spoke to the Geological Society of Washington about whether an extrasolar Earth has been found. In Mar. he gave colloquia at the U.S. Naval Observatory in Washington, DC, on the theoretical and observational debate over giant planet formation. Also in Mar., he talked about isotopic heterogeneity in the solar nebula at the Lunar and Planetary Science Conference in Houston. At the Astrobiology Science Conference (AbSciCon) 2006 in Washington, DC, Boss spoke on planetary system formation around M dwarf stars and gave an invited talk about discovering habitable worlds elsewhere in our galaxy.

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Alycia Weinberger hosted the Giant Magellan Science Working Group meeting at DTM in Nov. She gave colloquia at George Mason U. and Drexel U. in Nov., and at Northwestern U. in Jan. She attended the Giant Magellan Telescope Conceptual Design Review in Pasadena, CA, Feb. 22-23. In Mar. Weinberger had an observing run at Gemini North in Hilo, HI.

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In Mar. **John Chambers** gave invited talks on planet formation at the AbSciCon meeting in Washington, DC.

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Vera C. Rubin Fellow **Alceste Bonanos** spoke at U. Crete, Greece, on Dec. 21, and at the Pontificia Universidad Católica de Chile in Santiago in Jan.

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Postdoctoral fellows **Hannah Jang-Condell** and **Margaret Turnbull** coorganized a symposium, "Exploring Exoplanetary Systems," at the AbSciCon in Washington, DC, in Mar.

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Postdoctoral fellow **Brian Savage** participated in the Jan. "MARGINS: Rupturing of the Continental Lithosphere" conference in Ensenada, Mexico.

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In Oct. postdoctoral fellow **Scott Sheppard** gave an invited talk at the New Horizons Symposium in Austin, TX. In Nov., using the 2.5-meter du Pont telescope, he determined that object 2004 YJ35 has a cometary tail, indicating that it is not an asteroid as was originally thought. In Jan. Sheppard, along with collaborator David Jewitt of the U. Hawaii, discovered 2006 AB3, an asteroid that may pass within 0.03 AU of the Earth.

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In Feb. **Margaret Turnbull** was featured on the *Earth and Sky* radio program discussing the idea of a habitable stellar system and the target selection for NASA's Terrestrial Planet Finder. Also in Feb., Turnbull gave an invited talk at AAAS and participated in the International Space Science Institute's workshop on "Strategies for Life Detection" in Bern, Switzerland.

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The 2005 AGU fall meeting was held Dec. 5-9 in San Francisco. Several DTM researchers delivered papers, including director **Sean Solomon**, **Rick Carlson**, **Erik Hauri**, **Steve Shirey**, **Paul Silver**, and postdoctoral fellows **Catherine Cooper**, **Brian Savage**, **Taka'aki Taira**, and **Dayanthie Weeraratne**.

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The 207th American Astronomical Society meeting was held in Washington, DC, Jan. 8-12. **Alan Boss**, **John Chambers**, **Sara Seager**, **Alycia Weinberger**, and postdoctoral fellows **Alceste Bonanos** and **Hannah Jang-Condell** delivered papers at the event. Postdoctoral fellows **John Debes**, **Mercedes López-Morales**, and predoctoral fellow **Ben Hood** presented posters. Librarian **Shaun Hardy** presented a talk on the Carnegie Legacy Project at a special session.

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The geochemistry group received shipment of the new Cameca NanoSIMS 50L ion probe in Jan. to analyze dust particles collected from comet Wild 2 by NASA's Stardust mission.

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New arrivals at DTM include machinist **Michael Crawford**, who arrived in Oct.; predoctoral fellow **Ben Hood** of U. St. Andrews, Scotland, in Nov.; and Carnegie Fellow **Fred Ciesla**, who arrived in Jan.

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NSF postdoctoral associates **Alison Shaw** and **Maria Schönbächler** left DTM in Dec. Shaw joined the staff in Jan. at Woods Hole Oceanographic Institution. Schönbächler took a position at Imperial College, London.

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Machinist **Jay Bartlett** left DTM in Jan.

GL/DTM

Librarian **Shaun Hardy** has been reelected for a three-year term to the Advisory Committee on the History of Physics by the governing board of the American Institute of Physics.

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Apprentice building engineer **Jerry Davis** left BBR in Jan.

Global Ecology Team Gets Major Support from **MacArthur and Keck Foundations**

The discovery by Greg Asner's Global Ecology team—that rain forest destruction from logging in Brazil is twice that of previous estimates (Winter 05/06 *CarnegieScience*)—captured the interest of, and a grant from, the MacArthur Foundation last fall. With MacArthur support, the team is beginning to perform similar remote sensing research in the tropical ecosystem of Peru. They will analyze satellite images of the Peruvian rain forest using one-of-a-kind technology that they developed—the Carnegie Landsat Analysis System (CLAS). CLAS analyzes satellite data unlike any previous method—it can penetrate the canopy to see previously hidden changes to the environment below. MacArthur cites the Peruvian program in its annual report as "a stunning new monitoring and enforcement tool."

The Asner team is also leading the way on a new type of observatory. The Carnegie Airborne Observatory (CAO) is a revolutionary approach to understanding ecology by examining the links among the smallest and the largest ecosystems in three dimensions. The instrument-intensive airplane will enable these Carnegie researchers to study the smallest molecular components of vegetation, soil, and aquatic species over vast areas and discern ecosystem responses to environmental changes such as drought and fires. Asner's group received $1.5 million from the W. M. Keck Foundation and will receive additional funds from Carnegie trustee Will Hearst to develop this remote sensing technology. •

Carnegie Gets **Moody's Highest Rating**—Rare for Not-for-Profits

On January 20, 2006, Moody's Investors Service assigned an Aaa/VMIG1 rating to the Carnegie Institution's Series 2006 bonds issued through the California Educational Facilities Authority. It is the highest rating the service assigns—only 10 other not-for-profit organizations are currently rated in that category.

Moody's rating is based on the institution's strong financial profile. Carnegie has a large, very liquid balance sheet; it has lowered its endowment spending rate; and funds from external sources have recently increased. According to the investor's service, "Moody believes that the Carnegie Institution's . . . total financial resources provide very strong coverage of outstanding debt and annual operations . . . The stable outlook reflects our expectation that the institution's balance sheet will continue to grow and provide a solid cushion for debt and operations."

The bonds are being issued to refinance the 1993 Series A bonds for interest-rate savings. The original bond was used to upgrade facilities at the Carnegie Observatories in Pasadena, California, and for the Magellan telescopes located in Chile. •

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