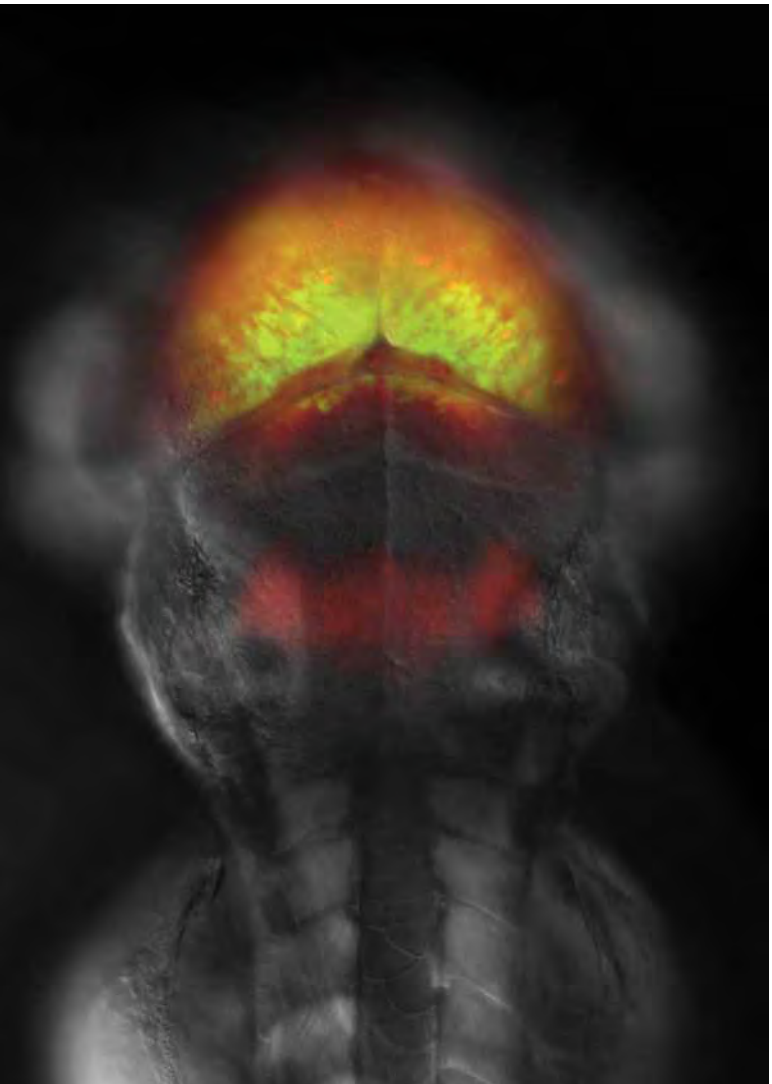
CarnegieScience

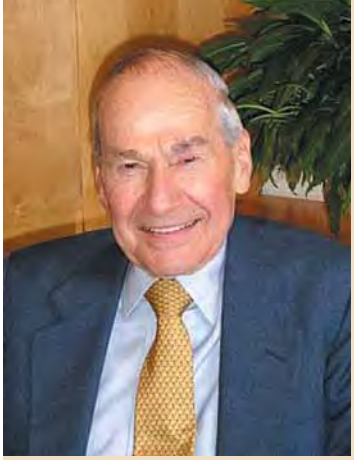
The Newsletter of the Carnegie Institution

FALL 2009

EMBRYOLOGY □ GEOPHYSICAL LABORATORY □ GLOBAL ECOLOGY □ THE OBSERVATORIES □
PLANT BIOLOGY □ TERRESTRIAL MAGNETISM □ CASE: CARNEGIE ACADEMY FOR SCIENCE EDUCATION

On the Inside





Scientists are popular with the American people, according to a recent Pew Research/AAAS survey.* The public also believes that scientific research is "overwhelmingly" positive for society and makes life better. The survey contained a short test, which indicated that the average person was fairly knowledgeable about everyday science and technology, such as the fact that GPS systems use satellites. But they fall short on more complex scientific concepts—for example, only 46% know that an electron is smaller than an atom. Scientists are aware that the public's science knowledge is lacking, and the majority see this as a major problem.

Carnegie scientists have been ahead of the curve in communicating and educating the public for some time. This year is a landmark 20th anniversary of the Carnegie Capital Science Evenings, a free lecture series held at our administration building in Washington, D.C. Lectures cover cutting-edge science and regularly entertain and inform full-house crowds. Recently, the Washington, D.C., chapter of Math for America (M*f*A) hit a milestone. An outgrowth of Carnegie's K through 12 education programs initiated in 1989, this program is a partnership between M*f*A, Carnegie, and American University to train fellows to teach mathematics in D.C. public and public charter secondary schools. With funding help from an NSF grant, the first six of 34 fellows arrived this June to begin training.

The Geophysical Laboratory and the Department of Terrestrial Magnetism cohost a neighborhood lecture series. Visitors have learned about the state of earthquake prediction, how organisms can live in extreme environments, the latest about the planet Mercury, the potential for life to exist elsewhere, and much more. Each summer they also run a summer scholars program for undergraduates.

Two researchers at Embryology are dedicated to educating and exciting the next generation. For years, Marnie Halpern has run a speakers program to encourage girls from Baltimore public schools to pursue science careers. Steve Farber's BioEYES uses the tiny, transparent zebrafish to teach inner-city students about genetics and the scientific method.

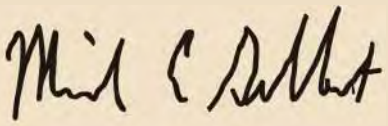
On the West Coast, Plant Biology's Kathryn Barton recently taught a Stanford freshman seminar about the science behind hunger. And the department's summer program for undergraduates gives students hands-on exposure to working in a first-rate lab.

In Southern California, the Observatories has joined forces with two underserved elementary schools to inspire young minds with the thrill of astronomy. Staff astronomers also teach Pomona and Harvey Mudd undergraduates. The department has its own lecture series at the Huntington Library and Gardens, and it hosts an open house for the Pasadena community annually.

Researchers at the Department of Global Ecology have been devoted to educating the public and policymakers about the science behind climate change and carbon budgeting since the department's inception in 2002. They have become respected sources for information on climate change throughout the world.

All of these education and outreach efforts are laudable. I thank everyone who has devoted time to this important pursuit. Science is not just relevant to everyday lives; economic prosperity depends on it.

Michael E. Gellert, *Chairman*



*The survey results are available online at http://people-press.org/reports/pdf/528.pdf

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MATH STIMULUS

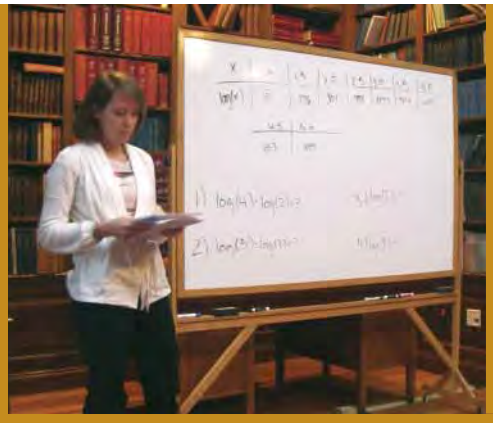
To combat the trend of a decline in qualified mathematics teachers in middle and high school, the Carnegie Academy for Science Education (CASE) launched a partnership in 2008 with Math for America (M*f*A) and American University (AU). Math for America in Washington, D.C. (M*f*A DC) is tasked to improve the mathematics education of the city's public and public charter secondary school students. The program selects, on a competitive basis, individuals with undergraduate degrees in mathematics or related disciplines to become M*f*A DC Fellows and educates them to become skilled teachers. Using stimulus funds from the American Recovery and Reinvestment Act of 2009, the National Science Foundation awarded M*f*A DC a $1.498 million grant to cover the tuition, stipend, and mentoring costs for the first 14 fellows. Carnegie president emerita Maxine Singer, a co-principal investigator (co-PI) on the grant, commented, "This support from the NSF will be a huge boost for math education in D.C. Research shows that rigorous mathematics education in secondary school correlates with success in jobs and college."

The academic program is a cooperative effort of AU's School of Education, Teaching, and Health and its Department of Mathematics and Statistics, and includes a 15-month master of arts in teaching (MAT) and a teaching certification program. Altogether, M*f*A DC plans to recruit 34 fellows over the next four years. In return for a full fellowship and stipend for the academic program, the fellows commit to teach in D.C. public and public charter secondary schools for four years after completing their training. During those years they will each be provided with a personal mentor, ongoing professional development, and a supplementary stipend to support them as new classroom teachers.

James H. Simons, a well-known mathematician and the president of Renaissance Technologies Corporation, founded Math for America in 2004 "to improve the quality of mathematics education in the country's public schools by recruiting, training, and retaining effective secondary school mathematics teachers." Currently, M*f*A has placed fellows in 96 New York City schools. Additional M*f*A sites have been created in San Diego and Los Angeles. The M*f*A program was the congressional model for creating the National Science Foundation Teaching Fellowships through the Robert Noyce Teacher Scholarship Program.

"The mission of the Math for America-D.C. program is aligned with AU's strategic commitment to improving D.C. schools, and we are thrilled to be involved," said co-PIs Sarah Irvine Belson of AU's School of Education, Teaching, and Health and John Nolan of the Department of Mathematics and Statistics. "We look forward to the arrival of our first group of M*f*A Fellows this summer." The first six fellows, who arrived in June, come from undergraduate colleges and universities across the country, and were qualified by high grades in undergraduate math courses, excellent recommendations, and outstanding performances in rigorous interviews. □

The selection process included an interview before a committee. The members of the interview committee *(left to right)* are Sarah Irvine Belson, School of Education at AU; Sarah Box, public school math teacher; Arturo Martinez, public charter high school academic dean; Alex Monte-Sano, public school math teacher; Sareeta Carter, public school math teacher; Michael Keynes, AU math professor; John Nolan, AU math professor; Guy Brandenburg, public school math teacher; and Maxine Singer, president emerita, Carnegie Institution.



Then-candidate Katherine Collins taught a lesson during her interview for an M*f*A DC Fellowship.

Shown here is the first group of the 2009 M*f*A DC Fellows. *Left to right:* Max Mikulec, Katherine Collins, Liza Styles, Lindsey Mann, Tom Fenske *(host, in back),* Krystn Hodge, Molley Kaiyoorawongs.

Images courtesy Bianca Abrams

Cracking the Cellulose Code

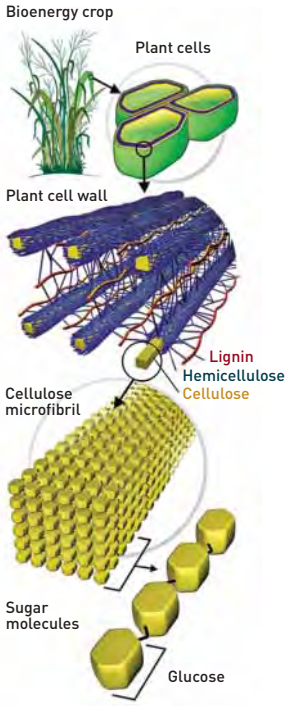
(Above left) Switchgrass microfibrils
Image courtesy Shi-You Ding/NREL

(Above right) By understanding how cellulose, the scaffolding of plant cell walls, is formed, researchers will be able to figure out how to break it down efficiently for biofuels. Cracking this riddle will pave the way for using nonfood crops such as switchgrass, shown here, for biofuels.
Image courtesy Missouri Department of Natural Resources

"Cellulose is the most abundant reservoir of renewable hydrocarbons in the world," observed Carnegie's David Ehrhardt of Plant Biology. Ehrhardt is a coauthor of a study on cellulose that was published in the advance online publication (AOP) of *Nature Cell Biology* on June 14. "To understand how cellulose might be modified and how plant development might be manipulated to improve crop plants as efficient sources of energy, we need to first understand the cellular processes that create cellulose and build cell walls."

Cellulose is a fibrous molecule that makes up plant cell walls, gives plants shape and form, and is a target of renewable plant-based biofuels research. But how it forms, and thus how it can be modified to design energy-rich crops, is not well understood.

The study, led by researchers at Carnegie's Department of Plant Biology, discovered that the underlying protein network that provides the scaffolding for cell-wall structure is also the traffic cop for delivering the critical growth-promoting molecules where needed. The research, conducted in collaboration with colleagues at Wageningen University in the Netherlands, is a significant step in understanding how the enzymes that make cellulose and determine plant cell shape arrive at the appropriate location in the cell to do their job.



This schematic shows the general process from crop to fuel.
Image courtesy Genome Management Information System/ORNL

Plant cells have rigid walls that cannot easily change shape. There are many cell types: spiky trichomes to fend off bugs and sausage-shaped guard cells that regulate the plant's breathing pores, as examples. In a previous study using the model plant *Arabidopsis*, Ehrhardt and team used groundbreaking imaging techniques to watch the molecules that create this array of shapes. It provided the first direct evidence for a functional connection between synthesis of the cell wall and an array of protein fibers—called microtubules—that provide the scaffolding allowing diverse plant cell shapes to be created as the cell wall pushes outward.

In that study, the group engineered plants to produce a fluorescent version of cellulose synthase, the enzyme that creates cellulose fibers. They also included a fluorescent version of tubulin, the protein from which microtubules are built. Using advanced imaging techniques, they tracked the motion of single fluorescent molecules, and found that cellulose synthase moves along "tracks" defined by the microtubules.

In this paper, the researchers looked at how the association between the cellulose synthase complexes and microtubules begins. The scientists were able to watch individual cellulose synthase complexes as they were delivered to the plasma membrane—the permeable film that surrounds the cell, but is inside the cell wall—and found that the microtubules not only guide where the complexes go as they build the cell wall, but also organize the trafficking and delivery of the cellulose synthase complexes to their place of action.

The researchers also looked at the role in trafficking of a structural element called the actin cytoskeleton that helps move organelles and maintains the cell's shape. They found that it appears to be required for the general distribution of the cellulose synthase complexes, whereas microtubules appear to be required for final positioning.

When there is a disruption of the complexes through a stressor such as a rapid change in water movement (osmotic stress), active cellulose synthase complexes disappear and organelles accumulate just under the plasma membrane. These organelles contain cellulose synthase and are tethered to the microtubules by a novel mechanism. Previously Ehrhardt and team found that plant microtubules move by shortening at one end while lengthening at the other end. They do this one tubulin molecule at a time, in a process the researchers call treadmilling. They now think that the tethering discovered in this research allows the cellulose synthase-containing organelles to stay with the treadmilling microtubules for prolonged periods in times of stress. They found that when the stress abates, these organelles deliver the cellulose synthase to the membrane. □

This work was supported by grants from the National Science Foundation and the EU Commission.

Putting Pressure on a "Colossal" Magnetic Effect

Millions of people today carry around pocket-sized music players capable of holding thousands of songs, thanks to the discovery 20 years ago of a phenomenon known as the giant magnetoresistance effect, which made it possible to pack more data onto smaller and smaller hard drives. Another phenomenon, called the colossal magnetoresistance effect (CMR), is up to a thousand times more powerful and could trigger another revolution in computing technology. But understanding CMR remains a challenge because of competing interactions in manganite, a form of manganese oxide in which CMR was discovered.

To study the magnetic properties of manganites, a research team led by Yang Ding of the Carnegie Institution's High Pressure Synergetic Center (HPSynC) applied techniques called X-ray magnetic circular dichroism (XMCD) and angular-dispersive diffraction at the Advanced Photon Source (APS) of Argonne National Laboratory in Illinois. High-pressure XMCD is a newly developed technique that uses high-brilliance circularly polarized X-rays to probe the magnetic state of a material under pressures of many hundreds of thousands of atmospheres inside a diamond anvil cell.

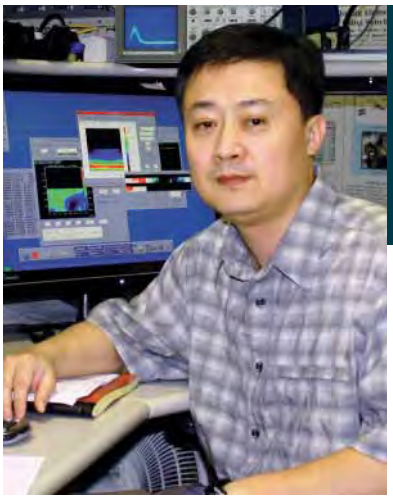
The discovery of CMR in manganite compounds has already made manganites invaluable components in technological applications. An example is magnetic tunneling junctions in soon-to-be-marketed magnetic random access memory (MRAM), where the tunneling of electrical current between two thin layers of manganite material separated by an electrical insulator depends on the relative orientation of magnetization in the manganite layers. Unlike conventional RAM, MRAM could yield instant-on computers. However, no current theories can fully explain the rich physics, including CMR effects, seen in manganites. "The challenge is that there are competing interactions in manganites among the electrons that determine magnetic properties," said Ding. "And the properties are also affected by external stimuli, such as temperature, pressure, magnetic field, and chemical doping."

"Pressure has a unique ability to tune the electron interactions in a clean and theoretically transparent manner," he added. "It is a direct and effective means for manipulating the behavior of electrons and could provide valuable information on the magnetic and electronic properties of manganite systems. But of all the effects, pressure effects have been the least explored."

The researchers found that when a manganite was subjected to conditions above 230,000 times atmospheric pressure, it underwent a transition in which its magnetic ordering changed from a ferromagnetic type (electron spins aligned) to an antiferromagnetic type (electron spins opposed). This transition was accompanied by a nonuniform structural distortion called the Jahn-Teller effect.

"It is quite interesting to observe that uniform compression leads to a nonuniform structural change in a manganite, which was not predicted by theory," said Ding. "Working with Michel van Veenendaal's theoretical group at APS, we found that the predominant effect of pressure on this material is to increase the strength of an interaction known as superexchange relative to another known as the double exchange interaction. A consequence of this is that the overall ferromagnetic interactions in the system occur in a plane (two dimensions) rather than in three dimensions, which produces a nonuniform redistribution of electrons. This leads to the structural distortion."

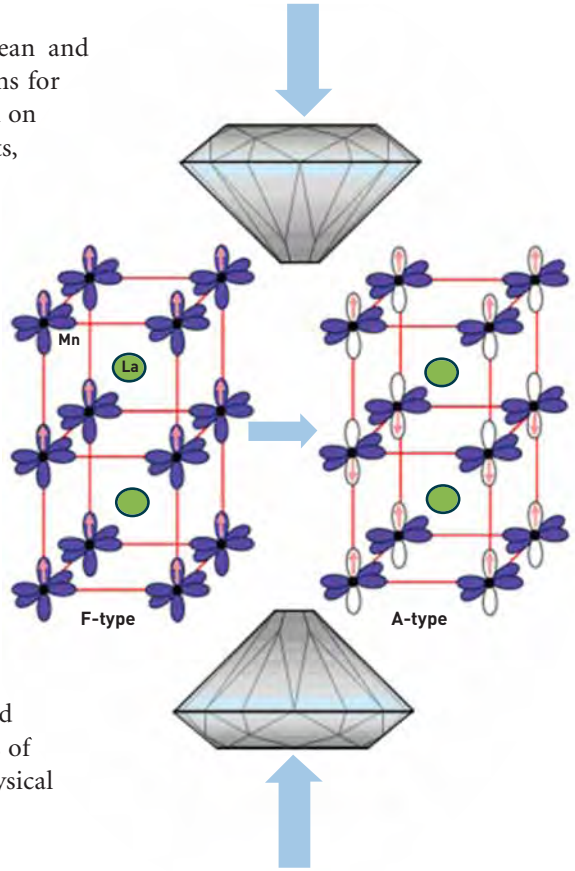
"This work not only displays another interesting emergent phenomenon arising from the interplay between charge, spin, orbital, and lattice in a strongly correlated electron system, but it also manifests the role of pressure in magnetism studies of dense matter," commented coauthor Ho-kwang Mao of Carnegie's Geophysical Laboratory, director of HPSynC. □



(Above) Yang Ding

(Below) Pressure causes the magnetic ordering in manganite to change from F-type (ferromagnetic) to A-type (antiferromagnetic). The effect of pressure on magnetic properties will help researchers unravel the intricate coupling between electrical conductivity and magnetism in these materials. The pink arrows inside orbitals indicate the spin direction of electrons.

Images courtesy Yang Ding



Surprises with SLOW QUAKES

You don't hear about slow earthquakes often, but recently two studies from the Department of Terrestrial Magnetism (DTM) were published on the subject. Slow earthquakes are nonviolent. They are fault slippage events that take hours or days instead of a few brutal seconds to minutes to release their potent energy.

Typhoons trigger slow quakes

Taiwan Image courtesy USGS

DTM's Alan Linde and Selwyn Sacks, with colleague Chi-Ching Liu (Academia Sinica, Taiwan), made the surprising finding that typhoons trigger slow earthquakes, at least in eastern Taiwan. The researchers discuss their data in a study published in the June 11, 2009, *Nature*.

"From 2002 to 2007 we monitored deformation in eastern Taiwan using three highly sensitive borehole strainmeters installed 650 to 870 feet (200-270 meters) deep. These devices detect otherwise imperceptible movements and distortions of rock," explained Sacks. "We also measured atmospheric pressure changes, because they usually produce proportional changes in strain, which we can then remove."

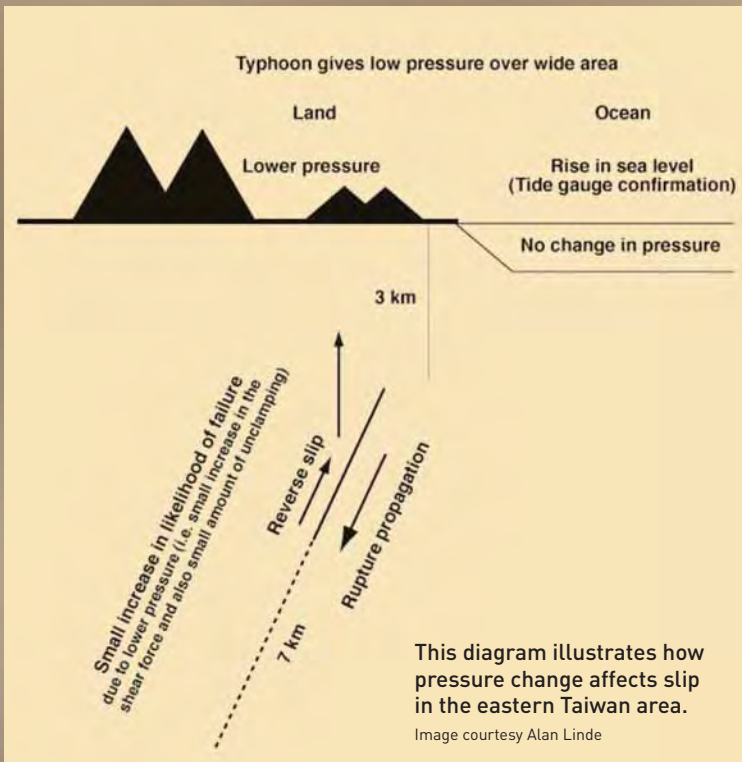
Taiwan has frequent typhoons in the second half of each year but is typhoon free during the first four months. During the five-year study period, the researchers identified 20 slow earthquakes that each lasted from hours to more than a day. The scientists did not detect any slow events during the typhoon-free season. Eleven of the 20 slow earthquakes coincided with typhoons. Those 11 were also stronger and were characterized by more complex waveforms than the other slow events.

"These data are unequivocal in identifying typhoons as triggers of these slow quakes. The probability that they coincide by chance is vanishingly small," said Linde.

How does the low pressure trigger the slow quakes? The typhoon reduces atmospheric pressure on land in this region, but does not affect conditions at the ocean bottom because water moves into the area and equalizes pressure. The reduction in pressure above one side of an obliquely dipping fault tends to unclamp it. "This fault experiences more or less constant strain and stress buildup," said Linde. "If it's close to failure, the small perturbation due to the low pressure of the typhoon can push it over the failure limit; if there is no typhoon, stress will continue to accumulate until it fails without the need for a trigger."

"It's surprising that this area of the globe has had no great earthquakes and relatively few large earthquakes," he continued. "By comparison, the Nankai Trough in southwestern Japan has a plate convergence rate of about 4 centimeters per year, and this causes a magnitude 8 earthquake every 100 to 150 years. But the activity in southern Taiwan comes from the convergence of the same two plates, and there the Philippine Sea Plate pushes against the Eurasian Plate at a rate twice that for Nankai."

The researchers speculate that the reason devastating earthquakes are rare in eastern Taiwan is that the slow quakes act as valves, releasing the stress frequently along a small section of the fault, eliminating the situation where a long segment sustains continuous high stresses until it ruptures in a single great earthquake. The group is now expanding its instrumentation and monitoring for this research.



This diagram illustrates how pressure change affects slip in the eastern Taiwan area.
Image courtesy Alan Linde

The photo at left shows colleague Chi-Ching Liu with the drill rig and the strainmeter on the ground front left. The small blue enclosure to the right houses the electronics. The picture was taken shortly before the installation of the strainmeter.
Image courtesy Alan Linde

The top part of the Earth, the lithosphere, consists of individual moving plates shown here.
Image courtesy USGS

Fingerprinting slow quakes

In another study, researchers think they may have found a signature that points to regions of slow quakes. The most powerful earthquakes happen at the junction of two converging tectonic plates, where one plate is sliding (or subducting) beneath the other. The team, led by Teh-Ru Alex Song of Terrestrial Magnetism, found that an anomalous layer at the top of a subducting plate coincides with the locations of slow earthquakes and nonvolcanic tremors. The research was published in the April 24 issue of *Science*.

The scientists analyzed 20 years of seismic data for southern Mexico, where the Cocos Plate is slipping beneath the North American Plate. From observations and modeling, the researchers found that 30 events had similar seismic waveforms and thus provided reinforcing information on structural details in the source region. In particular, they found a layer on top of the subducted plate where the speed of S-waves—which do not travel through liquids and are slower than P-waves—was some 30% to 50% slower than typical water-laden oceanic crust. The anomalous layer, dubbed the ultra-slow-velocity layer by the researchers, is found at depths of 15 to 30 miles (25 to 50 kilometers), somewhat deeper than the portion of the plate interface zone that is strongly coupled and is the site of great earthquakes in this region.

The scientists also examined the locations where slow earthquakes and nonvolcanic tremors have occurred. They found that slow earthquake areas and the ultra-slow-velocity layers cluster together, and that regions of nonvolcanic tremors are adjacent to those clusters.

Song and team believe that these areas may be subducted oceanic crust at unusually high levels of water saturation. The cause of such anomalously high pore pressures is unknown, but a clue might come from the fact that nonvolcanic tremors are concentrated in areas with temperatures around 840°F (450°C). The researchers think that at such temperature and under ambient pressures a combination of fluid release and reduction in permeability may give rise both to the high pore pressures and the stimulation of tremor activities. □

Capital Science Lecture Evenings Twentieth Season 2009-2010

All Capital Science Lecture Evenings are free and held at 6:45 p.m. at the Carnegie Institution's administration building, 1530 P Street, NW, Washington, D.C. 20005. For more information call 202-328-6988, or email at CapitalScienceInfo@ciw.edu, or visit our website at www.ciw.edu.

2009

September 24
Paul Fuchs, Johns Hopkins University, School of Medicine
How the Ear Hears, and Sometimes Doesn't

October 15
Kavli Lecture with Louis Brus, Columbia University, and Sten Grillner, The Karolinska Institute, Department of Chemistry The Nobel Institute for Neurophysiology
From Neural Circuits to Nanocrystals

October 28
Noam Elkies, Harvard University, Department of Mathematics
Canonical Forms: A Mathematician's View of Musical Canons

November 12
Balzan Lecture cohosted with the embassies of Italy and Switzerland Wallace Broecker, Columbia University, Department of Earth and Environmental Sciences
What Can We Do About Fossil Fuel CO_2?

December 3
A documentary film about Nicolas Copernicus by Michal Juszczakiewicz, cohosted with the embassies of Poland and Sweden
The Copernicus Tomb Mystery

2010

January 28
Jenny Graves, The Australian National University, Research School of Biological Sciences
Weird Animals: Genomes and Sex

February 11
Alejandro Sánchez Alvarado, Howard Hughes Medical Institute and The University of Utah School of Medicine, Department of Neurobiology & Anatomy
Dying Young as Late in Life as Possible: Stem Cells, Tissue Renewal, and Regeneration

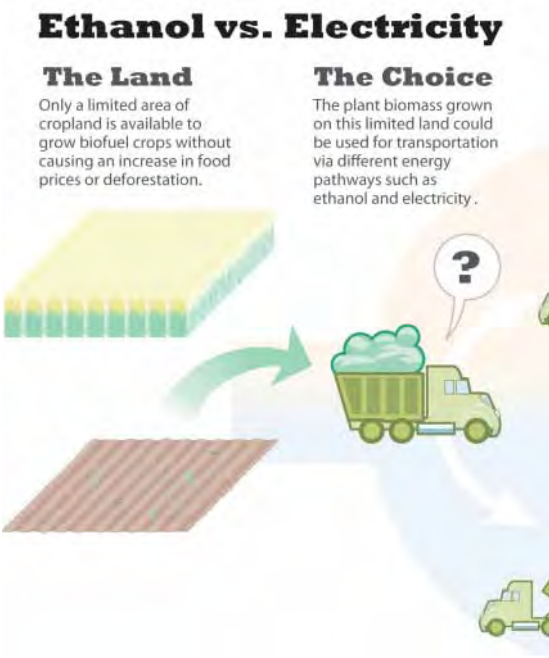
March 18
Robert Hazen, Carnegie Institution for Science, Geophysical Laboratory
From the Big Bang to Broadway: How Things Evolve

April 29
Raymond Jeanloz, University of California, Berkeley, Department of Astronomy and Earth and Planetary Science
From Earth to Stars...and Planetary Extremes

Bioelectricity Promises More "Miles Per Acre" than Ethanol

Biofuels such as ethanol offer an alternative to petroleum for powering our cars, but the energy crops that produce them can compete with food crops for farmland, and clearing forests to expand farmland will aggravate global climate change. How can we maximize our "miles per acre" from biomass? Research by Carnegie scientists published in *Science* magazine suggests that the best bet is to convert the biomass to electricity rather than ethanol. Compared with ethanol burned in internal combustion engines, bioelectricity used to charge battery-powered vehicles could deliver an average of 80% more miles of transportation per acre of crops. Using bioelectricity would also double the greenhouse gas offsets for mitigating climate change.

"It's a relatively obvious question once you ask it, but nobody had really asked it



before," said study coauthor Chris Field, director of Carnegie's Department of Global Ecology. "The kinds of motivations that have driven people to think about developing ethanol as a vehicle fuel have been somewhat different from those that have been motivating people to think about battery electric vehicles, but the overlap is in the area of maximizing efficiency and minimizing adverse impacts on climate."

The research team also included former Carnegie postdoc Elliott Campbell, lead author of the paper, now at the University of California, Merced, and former predoc David Lobell, now with Stanford's Program on Food Security and the Environment. The team performed a life-cycle analysis of both bioelectricity and ethanol technologies, taking into account not only the energy produced by each technology but also the energy consumed in making the vehicles and fuels. For the analysis they used publicly available data on vehicle efficiencies from the U.S. Environmental Protection Agency and other organizations.

In the transportation-miles-per-acre comparison, bioelectricity was the clear winner, regardless of whether the energy was produced from corn or from switchgrass, a cellulose-based energy crop. On average, a small SUV powered by bioelectricity could travel nearly 15,000 miles on the net energy produced from an acre of switchgrass, whereas a comparable internal combustion vehicle could travel only about 8,000 miles (see illustration). "The internal combustion engine just isn't very efficient, especially when compared with electric vehicles," said Campbell. "Even the best ethanol-producing technologies with hybrid vehicles aren't enough to overcome this."

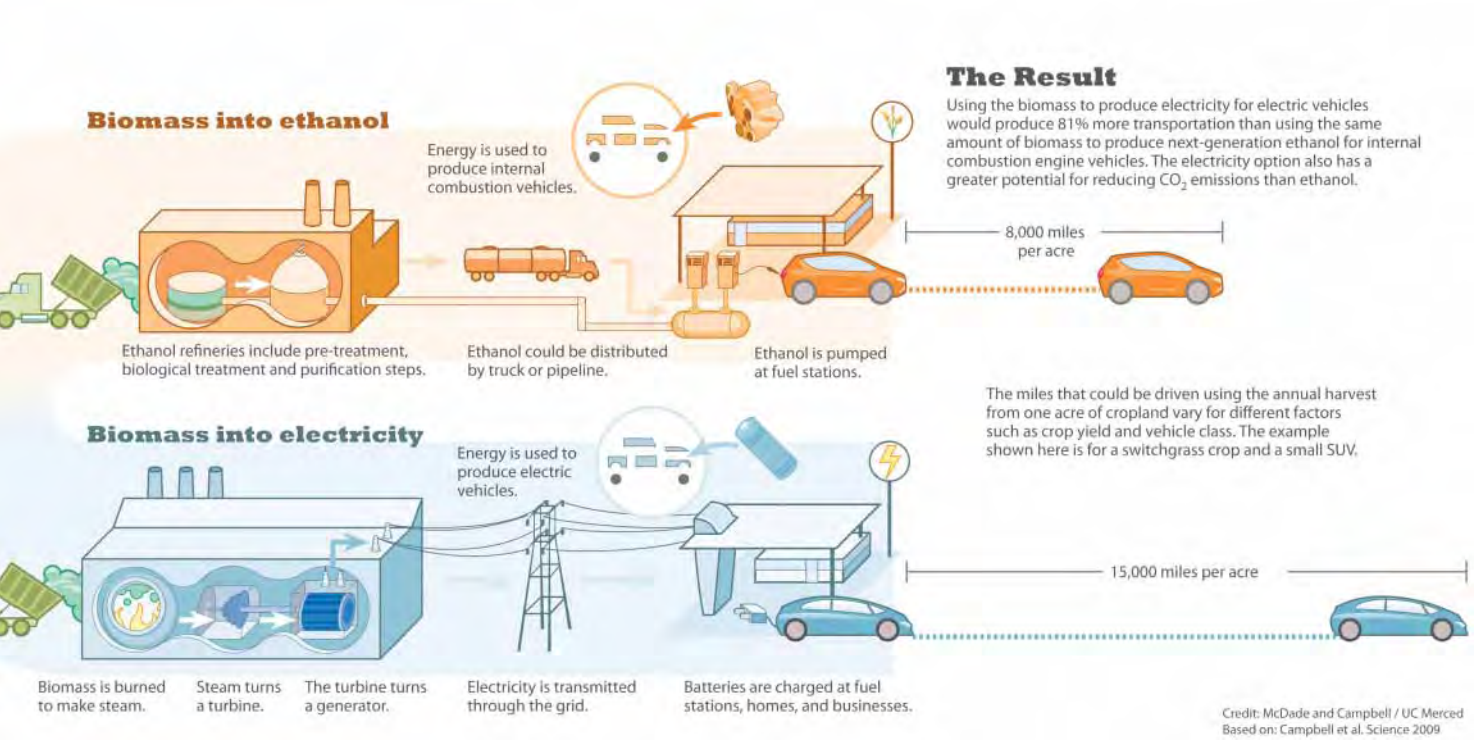
The researchers also looked at potential impact on climate change. "Some approaches to bioenergy can make climate change worse, but other, limited approaches can help fight climate change," said Campbell. "For these beneficial approaches, we could do more to fight climate change by making electricity than by making ethanol."

The energy from an acre of switchgrass used to power an electric vehicle would offset the release of up to 10 tons of CO_2 per acre, relative to a similar-sized gasoline-powered car. Across vehicle types and different crops, this offset averages more than 100% larger for the bioelectricity than for the ethanol pathway. Bioelectricity also offers more possibilities for reducing greenhouse gas emissions through measures such as carbon capture and sequestration, which could be implemented at biomass power stations but not in individual internal combustion vehicles.

While the results of the study clearly favor bioelectricity over ethanol, the researchers caution that the issues facing society in choosing an energy strategy are complex. "We found that converting biomass to electricity rather than ethanol makes the most sense for two policy-relevant issues: transportation and climate," said Lobell. "But we also need to compare these options for other issues like water consumption, air pollution, and economic costs."

"There is a big strategic decision our country and others are making: whether to encourage development of vehicles that run on ethanol or electricity," said Campbell. "Studies like ours could be used to ensure that the alternative energy pathways we choose will provide the most transportation energy and the fewest climate change impacts." □

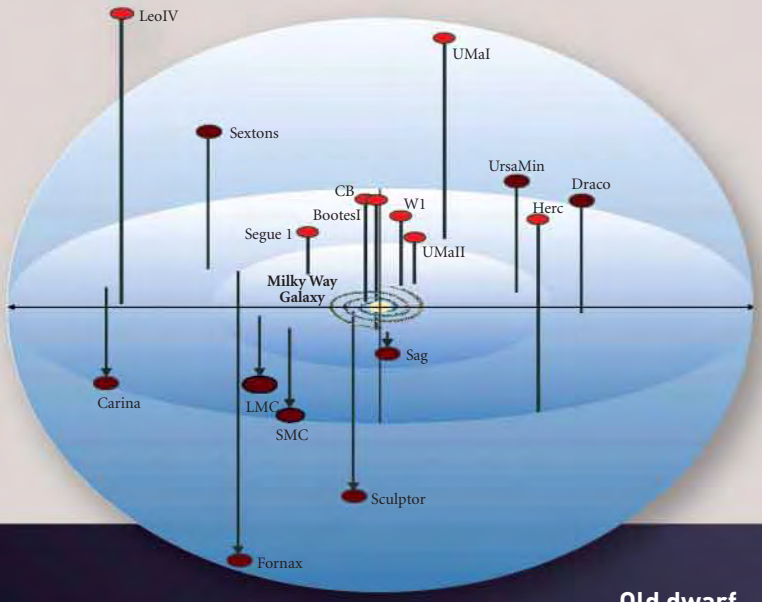
This research was funded through a grant from the Stanford University Global Climate and Energy Project, with additional support from the Stanford University Program on Food Security and the Environment, the University of California at Merced, the Carnegie Institution for Science, and a NASA New Investigator Program grant.



Dim Dwarfs Bespeak Dark Galaxies

The closest galactic satellites surrounding the Milky Way are shown in this diagram.

Image courtesy Marla Geha



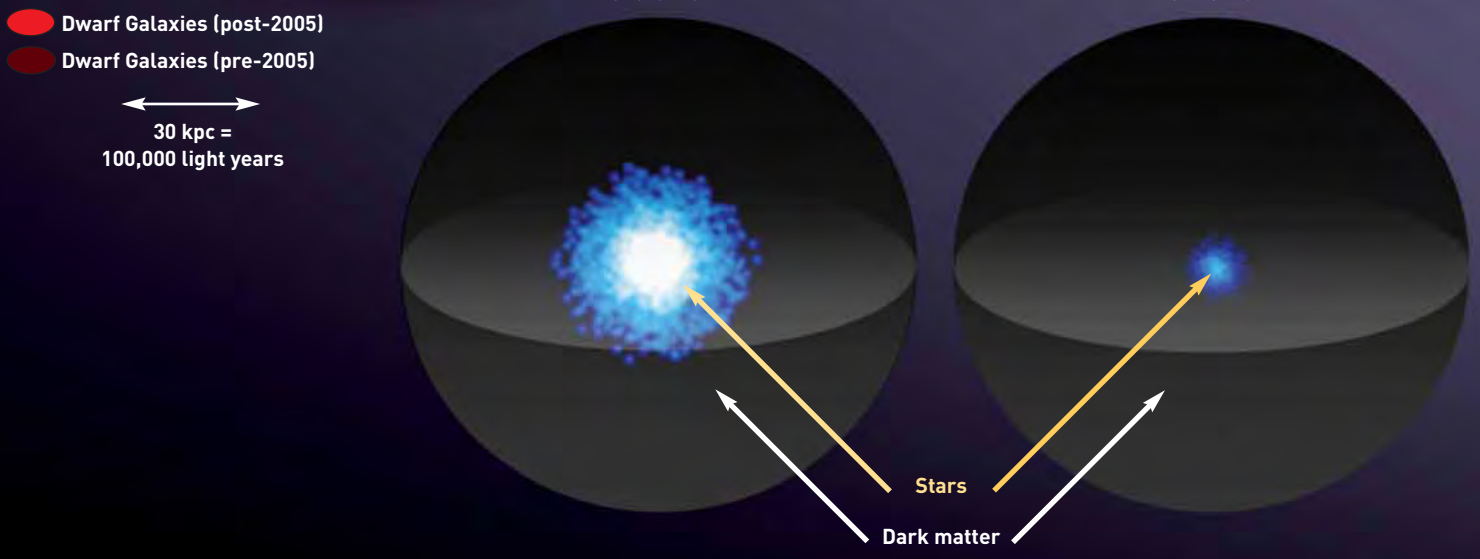
The missing satellite problem sounds like the stuff of a spy novel.

But it's actually about tiny galaxies surrounding the Milky Way. Cosmological models show there should be hundreds of satellite galaxies circling our galaxy. However, even with the 14 galaxies discovered in the last four years, only some two dozen satellites are known. Most of these are incredibly small, round, and very dim dwarfs. These minigalaxies are so small that some contain only a few hundred stars—fewer stars than the better-known stellar groupings in galaxies called globular clusters, which have tens of thousands to millions of stars. These little galaxies are the dimmest objects found in the universe; some glow with the light of just 1,000 Suns.

Postdoctoral fellow Joshua Simon of the Observatories has been at the forefront of discovering some unique features of these peculiar objects. He, along with colleague Marla Geha, a former Carnegie postdoc and now an assistant professor at Yale, may have solved the missing satellite puzzle. They have also shown that these are the lowest-mass galaxies ever observed, that dim dwarfs have more dark matter than any other type of galaxy, and that they contain some of the most primitive stars known.

It all started with the Sloan Digital Sky Survey, operational from 2000 to 2008, which discovered dim groups of stars around the Milky Way in an area covering about a fifth of the sky. Because of their faintness, many astronomers suspected that they were not galaxies at all, but globular clusters. Simon and Geha measured the motions and chemistry of a few dozen to a few hundred stars in 10 of these unusually faint objects. Generally, small amounts of light indicate small amounts of mass. But when the two analyzed their data, they got a big surprise.

"The galaxies are 100 to 1,000 times more massive than they should be based on their brightness," commented Simon. To



astronomers, this mass-to-light ratio is extremely important. High values point to dark matter—the mysterious, invisible material that, with dark energy, makes up most of the universe.

Confirming the presence of dark matter and determining masses depends on measuring the speed at which stars travel at varying distances from the center of a galaxy. According to the law of gravity, stars toward the edge of the galaxy should move at different speeds from stars near the center. So if observed stellar speeds don't obey the law, dark matter is a probable explanation. As it happens, stars in the dim dwarfs move much faster than expected.

The researchers found that the mass to light ratios of dark matter to stars was up to 1,000 for the dim dwarfs. For comparison, the Milky Way has a ratio of about 10. "When we found that these objects were made of 99% dark matter, we knew they had to be galaxies—globular clusters, as far as we can tell, don't have dark matter," Simon continued.

Former Observatories postdoc Marla Geha *(left)* and current fellow Josh Simon are shown at the Magellan telescopes at Carnegie's Las Campanas Observatory.

Image courtesy Wendy Simon

By analyzing the spectrum of starlight, astronomers can also tell the relative abundances of different elements. And that's the key to determining stellar age and how and where the stars in a galaxy formed. Only hydrogen and helium, with a smidgen of lithium, were created during the Big Bang. Everything heavier than beryllium was made later in the nuclear furnaces of subsequent generations of stars. Astronomers dub elements heavier than hydrogen and helium "metals," which makes stars with fewer heavier elements "metal poor." Metal-poor stars were created early in the universe when fewer elements were available. When Simon and Geha analyzed the chemistry of the stars in the dim dwarfs, they found that they were among the most metal poor measured and therefore some of the oldest. They also found that there was a significant spread in chemical composition in each of the dwarfs—providing further evidence that the new dwarfs are not globular clusters, in which all of the stars share the same metal abundance.

Astronomers think that the peculiar nature of most of the dim dwarfs may stem from a period of the universe called the reionization epoch, between about 200 million and 1 billion years after the Big Bang. This is when the first stars, quasars, and galaxies began to form. The ultraviolet radiation from the first stars could have whisked away the hydrogen gas from the galaxies at that time, which would have aborted star formation, leaving many fewer stars and making the galaxies dim or possibly completely dark.

And what about those missing satellites? Now that these dim galaxies have been found, it raises the possibility that there are dimmer or even dark galaxies out there, possibly the hundreds predicted by models. But at the very least, the researchers point out that the Sloan survey only sampled part of the sky, leaving four-fifths untouched, where more dim dwarfs are bound to be found. At the current rate, astronomers think the population of these dwarfs will easily reach 70, with perhaps new populations of other, even darker ones too.

Eventually, astronomers hope that the Giant Magellan Telescope (GMT) and other next-generation facilities will reveal the ultimate secrets these tiny galaxies hold. "Studying the faintest dwarfs with the GMT will help us figure out exactly what dark matter really is and should provide clues about how such unbelievably small galaxies ever managed to form," Simon concluded. □

Dwarf galaxies *(far left)* surrounding the Milky Way that were discovered before the Sloan Digital Sky Survey are brighter and contain relatively smaller amounts of dark matter than the more recently found very dim and very small dwarfs. Simon and Geha found that these minigalaxies are so small that some formed only a few hundred stars. They are the dimmest objects found in the universe, the lowest-mass galaxies ever observed, and they have more dark matter than any other type of galaxy. These objects point to the possibility that dimmer and perhaps even entirely dark galaxies could surround the Milky Way and thus solve the so-called missing satellite problem.

Image courtesy Josh Simon

This Sloan Digital Sky Survey image *(right)* shows the dwarf galaxy Leo II, a satellite of our Milky Way. Despite its rather faint appearance here, Leo II is about 100 times brighter than the two dozen or so tiny dwarfs recently discovered.

Image courtesy Sloan Digital Sky Survey

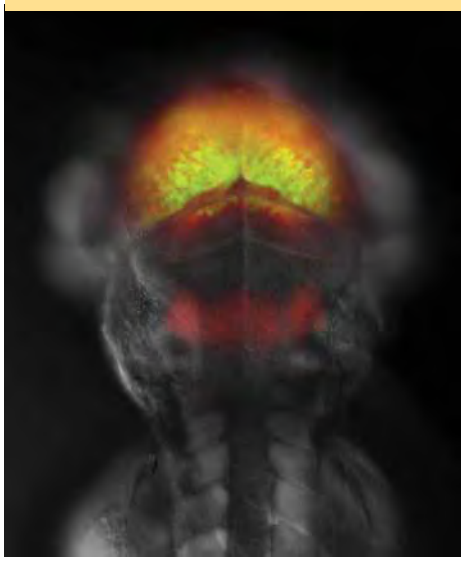
For Collaborative Fellow, Two Labs Are Better than One

When Mary Goll finished her Ph.D. in the life sciences at Columbia University, she knew she wanted to continue her research in epigenetics, the rapidly expanding field that studies the nongenetic factors controlling gene expression. But she also wanted to explore new techniques and expand her expertise so that she could develop a unique research niche in science. In particular, she was excited by the possibilities offered by zebrafish, whose transparent bodies make it possible to track genetic effects during the development of a living embryo. The problem was, no zebrafish labs she could find had active programs in epigenetics and the capacity for the genetic screens she needed.

The solution turned out to be the Department of Embryology's newly minted Carnegie Collaborative Fellowship. The fellowship is designed for students capable of thinking outside the mainstream and pursuing research that exceeds the boundaries of any single laboratory. Goll certainly fit the bill. And at Carnegie she found a strong zebrafish program in Marnie Halpern's laboratory. In Allan Spradling she had a mentor who shared her interest in epigenetics, chromatin, and transposable elements. So in 2006, Goll signed on as the first official Carnegie Collaborative Fellow.

"Because my research is related to but distinct from what both Marnie and Allan are doing, I think I have been especially free to explore my own ideas and to develop a research program that conforms to my interest," says Goll. "Of course, Marnie and Allan are always there to provide perspective on my ideas and to provide their own ideas." The Spradling and Halpern labs are adjacent, and postdocs from both labs share research space. "This has been especially nice because it has kept me feeling like I am a part of both labs as opposed to an outsider—which I hear can be a problem for collaborative postdocs elsewhere."

Collaborative postdoc Mary Goll *(above left)* with mentors Marnie Halpern and Allan Spradling.



Postdoc Mary Goll developed a method of monitoring epigenetic regulation in developing zebrafish embryos using fluorescent reporter genes. In the photo, previously silenced reporter genes glow green where they are reactivated.

Images courtesy Mary Goll

The collaboration has paid off. At Carnegie, Goll has made great strides in using zebrafish to study the role of epigenetics during development. In a developing organism, genes are turned on and off to produce different types of cells and tissues. This is controlled by epigenetic factors, one of which is methylation, in which genes are silenced by methyl groups attached to the DNA strand. But the precise mechanism is not well understood. By inserting fluorescent "reporter" genes into zebrafish DNA, Goll has developed a system that allows her to visually observe the changes in DNA methylation in a transparent embryo as tissues develop. Already, she has seen surprising differences among different tissues. With Halpern and Spradling, Goll published a paper this past spring in *Genetics* that lays the groundwork for further investigation of new mechanisms underlying the epigenetic regulation of development.

"I have been amazed by the variety of new approaches and perspectives to which I have been exposed to through my interactions with the Spradling and Halpern labs," she says. "Being constantly exposed to research outside my area of expertise has absolutely pushed me beyond my comfort zone and influenced my research." Some of these influences have been subtle. "When I presented my work at the international zebrafish meeting, several people asked me if I had previously performed research on flies," she says. "I have not and am certain that people were picking up on the Spradling lab influence in my research."

Goll was recently invited to join the staff of the Sloan-Kettering Department of Developmental Biology as an assistant member. "I cannot imagine having a better opportunity than the past three years," she says. "Not only am I well positioned to initiate my own independent research career, but I feel I have received a unique and broad training experience that will continue to influence me for years to come." □

DTM's Paul Silver and daughter Céline
Image courtesy Nathalie Valette-Silver

Seismologist Paul G. Silver Dies with Daughter in Car Crash

Terrestrial Magnetism seismologist Paul Gordon Silver died in an automobile accident in North Carolina on August 7, 2009, driving with his daughter Céline returning from a research internship in Florida. Céline perished in the crash as well.

A member of the research staff at the Department of Terrestrial Magnetism since 1982, Silver was an international leader in understanding how earthquakes are triggered and how they interact with each other. Born in Los Angeles, Silver obtained a Ph.D. in geophysics from UC San Diego in 1982. Since 1986 he has held a joint appointment as a research associate professor at The Johns Hopkins University Department of Earth and Planetary Sciences.

Silver served as mentor and collaborator to younger scientists throughout his career.

Silver made a series of important contributions to earthquake research by observing the slow redistribution of stress and strain in the Earth. In one study of small earthquakes triggered by a large event in southern California, he and his colleagues discovered an annual cycle: fall had the greatest number of earthquakes, spring the least. The team found that this pattern could be related to barometric pressure changes—less pressure meant reduced stress on the faults, which permitted them to move more frequently.

Just last year, Silver was coauthor of a paper showing there were subtle changes in the speed of seismic waves that preceded two small earthquakes—encouraging results for the field of earthquake prediction.

Silver's research took him all over the world. He developed techniques to determine the direction-dependence of seismic wave speeds in the Earth's upper mantle, now widely used to study the patterns of convective flow in the Earth's interior and the processes for continent formation.

Silver served as the president of the seismology section of the American Geophysical Union from 2004 to 2006, and he chaired the board of directors of both UNAVCO and the Incorporated Research Institutions for Seismology. He was a leader in proposing the concept of the Plate Boundary Observatory in western North America.

Among his honors, Silver was elected a Fellow of the American Academy of Arts and Sciences in 2007, and he was the Royal Astronomical Society Harold Jeffreys Lecturer in 2005. He was also a Fellow of the American Geophysical Union and the Geological Society of America and a member of Phi Beta Kappa.

Silver served as mentor and collaborator to younger scientists throughout his career. A skilled jazz musician, Silver was also a drummer in a jazz trio that played throughout greater Washington, D.C. □

The Paul G. Silver Postdoctoral Fellowship in Seismology has been established at DTM to honor his extraordinary contributions to science. To donate to the fellowship go to http://www.ciw.edu/silver_fellowship.

In Brief

❶ Carnegie president Richard Meserve visited Notre Dame Cathedral while in Paris to speak at a conference assembled by the OECD/Nuclear Energy Agency.
Image courtesy William Travers

Director Emeritus of Embryology Donald D. Brown

received the 2009 Lifetime Achievement Award from the Society for Developmental Biology. It is given to "a senior developmental biologist in recognition of her/his outstanding and sustained contributions in the field . . . [and] for the individual's excellence in research and for being a superb mentor who has helped train the next generation of exceptional scientists." □

Don Brown *(left)* talks with Yun-bo Shi, a former Brown lab postdoctoral fellow *(center)*, and Igor Dawid of NIH after receiving the award.
Image courtesy Marnie Halpern

TRUSTEES AND ADMINISTRATION

❶ Carnegie president **Richard A. Meserve** chaired a meeting of the National Academies' Nuclear and Radiation Studies Board on July 8 and 9. On July 20 he participated in briefings to Congress and DOE on the National Academies' report titled *America's Energy Future*. In Paris on Sept. 11 he spoke at a meeting sponsored by the OECD/Nuclear Energy Agency, and he chaired a forum on nuclear safety at the General Conference of the International Atomic Energy Agency in Vienna on Sept. 14.

EMBRYOLOGY

Director **Allan Spradling** presented lectures at the Columbia Medical School, Yale Medical School, the CNRS-U. of Strasbourg, France, and the Gurdon Inst. of Cambridge, England. He also gave talks at a London Research Inst. Symposium and the International Society for Stem Cell Research Annual Meeting in Barcelona, and attended the Society for Developmental Biology (SDB) meeting in San Francisco.

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❷ In May **Marnie Halpern** gave a seminar at the Skirball Inst. at NYU. In July she was session chair and speaker at the European Zebrafish Meeting in Rome and presented a talk at the 60th annual meeting of the SDB.

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Doug Koshland presented his work at the Weizmann Inst. of Science in Rehovot, Israel. He was an invited speaker at the FASEB Summer Research Conference "Genetic Recombination and Genome Rearrangements" and the Cold Spring Harbor Laboratories meeting "Yeast Cell Biology" in Aug.

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Chen-ming Fan presented a lecture at SDB's Mid-Atlantic Regional meeting.

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Yixian Zheng presented a lecture at U. Ottawa and was an invited speaker at the FASEB meeting in Lucca, Italy.

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Steve Farber gave a keynote talk at the HHMI-funded program Maps in Medicine, which develops innovative curricular materials and improves high school biology learning. He also cochaired an educational symposium at the 2009 SDB meeting and gave a talk at Merck Research Laboratories on June 15.

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Alex Bortvin gave talks at the National Inst. of Child Health and Human Development, the 17th International Chromosome Symposium, and the FASEB Summer Research Conference on Mobile Elements in Mammalian Genomes.

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CASE's Toby Horn to Receive Alberts Science Education Award

Codirector of the Carnegie Academy for Science Education (CASE) Toby Horn will receive the prestigious 2009 Bruce Alberts Award for Excellence in Science Education from the American Society for Cell Biology at their Dec. meeting. Horn a molecular and developmental biologist, is being honored for "her sustained contributions to K-12 science education." □

(Above) Carnegie Academy for Science Education's codirector Toby Horn

Save the Date

First Lighters' 20th Reunion

Tuesday, Dec. 22, 2009
4:00 - 8:00 p.m.
Carnegie Administration Building
1530 P St., NW,
Washington, D.C. 20005

Twenty years ago this year, Carnegie founded First Light, the hands-on Saturday science school for Washington, D.C., elementary school children. What a difference 20 years makes! The Carnegie Academy for Science Education (CASE) and First Light team invite all former First Light students and teachers to the reunion. Rekindle old friendships, learn about what's changed, and catch up on the huge impact the program has had in D.C. over the past two decades. □

Judith Yanowitz will become an assistant professor at the Magee-Womens Research Inst. in Pittsburgh beginning in Nov. She gave a talk at the International *C. elegans* Research Conference in June.

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The department's summer undergraduate seminars were organized by **David MacPherson**. They expose undergraduate and high school students to the various research projects. Carnegie postdocs and graduate students assist and present their work informally to the students.

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Research scientist **Cynthia Wagner** accepted a position as a lecturer at U. Maryland-Baltimore County. The Spradling lab's postdoctoral associate **Tina Tootle** accepted a faculty position at U. Iowa Medical School; postdoctoral associate **Todd Nystul** will serve on the faculty of UC-San Francisco; postdoctoral associate **Vicki Losick** was awarded a three-year fellowship from the Jane Coffin Childs Memorial Fund, and postdoctoral associate **Rebecca Frederick** received a three-year fellowship from the American Cancer Society. **Alexis Marianes** joined the lab as a graduate student.

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Technician **Alison Singer** left the Gall lab to begin graduate work in the School of Public Health, Johns Hopkins U. **Daniel Escobar**, a student assistant in the lab, completed his M.S. degree in biology from Hopkins in May and became a lab technician in mid-Aug.

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Halpern lab postdoctoral associate **Mary Goll** was an invited speaker at the Mount Desert Island Biological Laboratory Stem Cell Symposium Aug. 7-9 and attended the 2009 Gordon Research Conference on Epigenetics, where she won a poster award. **Vanessa Matos-Cruz** was awarded a predoctoral fellowship from NIH for her collaborative research with Samer Hatter's lab, Johns Hopkins U. She was also awarded a three-year fellowship from the Neuroscience Scholars Program of the Society for Neuroscience. Baltimore Polytechnic Inst. biology high school

Director Emeritus Charles Prewitt

received the first International Mineralogical Society medal at the Goldschmidt Conference in Davos, Switzerland, June 24 for his "invaluable lifelong contribution to mineral sciences." President of the society and senior visiting scientist at GL Takamitsu Yamanaka *(left)* presented the medal to Prewitt. □

❷ Embryology's Marnie Halpern

❸ Christoph Lepper

❺ Anat Shahar *(left),* Connie Bertka *(center),* Reinhard Boehler *(right).*

❹ Director Rus Hemley *(front row, second from right)*, son Emerson *(on lap)*, and wife Amanda *(second from left)* attend the Bridgman Award Dinner at the AIRAPT-22 & HPCJ-50 conference in July. Dave Mao *(back row in Hawaiian shirt)*, Alex Goncharov *(standing seventh from left)*, president of the International Mineralogical Society and senior visiting scientist at GL Takamitsu Yamanaka *(front row, right)*, and former GL postdocs and visitors also attended.

teacher **Lissa Rotundo**, Polytechnic high school graduate Victoria Robinson, and Johns Hopkins U. undergraduate **Alexander Yeh** joined the Halpern group for the summer through NIH's ARRA Program to provide summer research experiences for students and science educators. Postdoctoral associate **Tagide DeCarvalho** joined the Halpern lab in June.

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Koshland lab members **Frederick Tan** and **Lamia Wahba** attended the FASEB Summer Research Conference, and lab members **Dean Calahan** and **Vinny Guacci** attended the CSHL Yeast Cell Biology meeting.

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❸ Graduate student **Christoph Lepper**, in the Fan lab, gave a talk at the International Frontiers in Myogenesis meeting. Graduate student **David Martinelli** completed his Ph.D. thesis in May and will begin his postdoctoral studies at Stanford U. in the fall.

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Zheng lab's **Danny Ducat** completed his Ph.D. in May and began his postdoctoral studies at Harvard U.

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Pavol Genzor joined the Bortvin lab as a graduate student and Johns Hopkins U. student **Neil Vranis** spent the summer working with postdoc **Godfried van der Heijden**.

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Undergraduate **Frazer Heinis**, of the Yanowitz lab, completed his studies at Johns Hopkins U. and will begin a Ph.D. program at U. Minnesota.

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The department hosted the Johns Hopkins U. Fifth Lab History Conference in June. The conference was organized by JHU's Dept. of the History of Science. **Pedram Nozari** and **Matthew Atkins** joined the animal facility and **Valerie Butler** joined the fish facility.

GEOPHYSICAL LABORATORY

❹ Director **Russell Hemley** presented two invited talks: at the Joint AIRAPT-22 & HPCJ-50, International Conference on High Pressure Science and Technology in Odaiba, Tokyo, Japan, July 26-31, and at the Diamond and Nano Carbons Conference in Traverse City, MI, June 8.

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❺ The Geophysical Lab welcomed its newest staff member, **Anat Shahar**, on July 1. She is pioneering a field that blends isotope geochemistry with high-pressure experiments to examine planetary cores and the Solar System's formation, and has developed numerous new techniques for the research. **Connie Bertka** was appointed program director of the Sloan Deep Carbon Observatory on Sept. 1 **Reinhard Boehler** joined the lab as senior scientist Aug. 17. He was formerly a director of the Max-Planck-Institut für Chemie in Mainz, Germany, and will work on the EFree initiative.

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Doug Rumble lectured on the asteroid 2008 TC3 and meteorite, Almahata Sitta, at the Smithsonian Institution; at the Laboratoire de Minéralogie et Cosmochimie du Muséum, Muséum National d'Histoire Naturelle, Paris; and at Dartmouth College. He led a field trip in western New Hampshire and attended the Goldschmidt Conference in Davos, Switzerland.

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Nabil Boctor presented a paper at the Meteoritical Society Meeting in Nancy, France.

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❻ **Robert Hazen** was named the 2009 Baldwin Lecturer at U. Miami. He presented lectures at U. Alaska and at the annual meeting of the American Chemical Society on aspects of the origins of life.

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Anat Shahar gave a talk at the Goldschmidt Conference in Davos, Switzerland.

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Postdoctoral fellow **Dominic Papineau** gave a presentation at the Goldschmidt Conference in Davos and an invited seminar at the ETH in Zurich. He was also awarded a grant to do fieldwork in India and China.

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Postdoctoral associate **Subramanian Natarajan** gave a talk at the International Conference on High Pressure Science and Technology in Tokyo July 26-31.

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Postdoctoral fellow **Javier Montoya** was a visiting scientist at the International Centre for Theoretical Physics in Trieste, Italy, May 24-June 23. He gave an invited talk at Symposium 2 of the XVIII International Materials Research Congress in Aug.

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Research scientist **Henderson (Jim) Cleaves** gave a talk in San Sebastian, Spain, in May, at the ETH in Zurich in June, and at Georgia Tech in July. He also hosted Pierre-Alain Monnard of U. Odensee in June and two summer interns, **Mickey Kopstein** and **Karina Marshall-Bowman**.

—

Research scientist **Dionysis Foustoukos** hosted a summer intern, **Niya Grozeva**, who will be presenting at the AGU 2009 Fall Meeting. She is a sophomore at Stony Brook U.

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John Armstrong presented an invited paper at the International Microscopy and Microanalysis 2009 meeting this July in Richmond, VA.

High Pressure Collaborative Access Team (HPCAT)

Stanislav Sinogeikin gave an invited talk at the COMPRES Workshop on Long Range Plan for High Pressure Earth Sciences in Tempe, AZ, in Mar. In May he gave an invited talk at the HPSynC workshop held in conjunction with the APS User Meeting and one at the AGU Joint Assembly, The Meeting of the Americas, held in Toronto. Sinogeikin was a workshop organizer at APS Sept. 23-25. He is currently chairing an APS Proposal Review Panel.

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In Aug. **Yuming Xiao** presented a poster at the Gordon Research Conference X-ray Science in Waterville, ME.

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2009 Carnegie Summer Scholars Research Symposium

The Carnegie Institution held its annual Summer Scholars Research Symposium on Aug. 5. The 12 students presented results to the Broad Branch Road campus community, covering topics from mineral physics, organic geochemistry, astrobiology and petrology to astronomy. □

The class of 2009 summer scholars at the Broad Branch Road campus.

❻ Robert and Margaret Hazen, shown here with paleontologist Jake Skabelund *(left)*, visited several classic fossil sites that were discovered and described by Charles D. Walcott (1850-1927). Walcott was secretary of the Smithsonian Institution, a close confidant of Andrew Carnegie, and one of the founding trustees of the Carnegie Institution. He got his scientific start here at the Walcott-Rust Quarry in Russia, New York, where in his early 20s he found the first trilobite specimens with preserved soft parts. He went on to discover the Burgess Shale Formation in British Columbia and became one of the most influential paleontologists of his generation.
Image and text courtesy Robert Hazen

❼ Malcolm Guthrie

Wenge Yang and **Qiang Mei** gave invited talks at the Advanced Crystallography at High Pressure Conference at the Harbin Institute of Technology, Harbin, China, in July.

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In July **Yue Meng** gave an invited talk at Jilin U. China, and at the 22nd AIRAPT International Conference.

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Arrivals: On June 1 **Chongyang Park**, from ANL's Chemical Sciences and Engineering Division, joined HPCAT as a beamline scientist. **Curtis Kenney-Benson**, from the Dept. of Physics, Allegheny College, joined as a beamline associate Sept. 1. Summer intern **Alaina Beres**, a senior at Elmhurst College, conducted research on public views of future energy needs.

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Several visiting researchers came to the group. Ph.D. student **Raol Lacomba** (U. Valencia, Spain) worked with Yue Meng. High school student **Alex Wang** worked with Paul Chow. High school students **Erik Wang** and **Ruby Zhao** mentored with Guoyin Shen.

High Pressure Synergetic Consortium at the Advanced Photon Source (HPSynC)

Staff scientist **Michael Lerche** gave a talk at the High Pressure Synchrotron Science workshop held at ANL May 6-8.

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Staff scientist **Yang Ding** gave a talk at the Joint AIRAPT-22 & HPCJ-50 conference meeting in Tokyo.

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❼ **Malcolm Guthrie** joined the staff and gave invited talks at the Entropy and Glass II international workshop at Aberystwyth U., UK, Apr. 22-24, and at the International Union of Crystallography High Pressure Commission Meeting in Harbin, China, July 19-23. He attended the AIRAPT meeting in Tokyo July 26-31, and was invited to sit on the international advisory committee for the J-PARC high pressure neutron diffractometer, in Mito, Japan, July 24-25.

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Postdoctoral researcher **Lin Wang** presented a poster at the CDAC Winter Workshop Feb. 27-28. May 4-6 he presented a poster at Users Week 2009 at ANL, and May 6- 8 he gave an invited talk at the High Pressure Synchrotron Science workshop.

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Postdoctoral researcher **Junyue Wang** arrived in July from BSRF, Chinese Academy of Sciences, and visiting scholar **Pei-Lun (Sharon) Lee** came from National Chiayi U. in July.

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Melike Abliz, postdoctoral researcher, left in Aug. for a position at Argonne as an assistant physicist with the Magnetic Devices Group at the APL.

GLOBAL ECOLOGY

Director **Chris Field** chaired the content outline process of the IPCC Working Group 2 Fifth Assessment Report in Venice July 13-17.

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❽ In June **Joe Berry** attended the award ceremony for newly elected Fellows of the American Geophysical Union in Toronto.

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Greg Asner is a chapter author of a book that synthesizes the decade-long study of the Amazon Basin. It covers the socioeconomic drivers and ecological impacts of the timber industry in relation to deforestation.

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Asner and **David Knapp**, with **Guayana Paez-Acosta** and **Aravindh Balaji**, met with key institutions in the Andes Amazon region to use the CLASlite system, their user-friendly forest-monitoring tool. They trained about 85 people from 40 different institutions in five countries. The lab's **Angelica Almeyda** and **Eben Broadbent** spent some of July in the Manuel Antonio region of Costa Rica assessing the impacts of tourism on social, economic, and environmental sustainability. In early June, Broadbent presented invited overviews of remote sensing forest cover and degradation to forestry professionals from throughout Central and South America at the Seminario Latino-americano en Politica y Manejo Forestal in Santa Cruz de la Sierra, Bolivia.

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❾ Asner and **Robin Martin** spent most of July in Peru working with their team on a major spectranomics field campaign. The group collected more than 600 tree species. It was the first of a four-part campaign to be spread over three months. The team collected from 450 rain forest canopy trees and lianas in the northern Peruvian Amazon in Aug.

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Also in Aug., Asner, **Ty Kennedy-Bowdoin**, **James Jacobson**, and **Dave Knapp** took the CAO on its first mission to the Amazon over a 10-million-acre tropical rain forest region to support an international effort to reduce carbon dioxide emissions from deforestation and forest degradation.

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The week of Apr. 20, **Ken Caldeira** participated in a meeting in Lisbon, Portugal, on the governance of intentional intervention in the climate system and gave a talk on ocean acidification at the Lisbon aquarium. On Apr. 25 he participated in a panel discussion at the San Francisco International Film Festival after a screening of *A Sea Change*, in which he appeared. Caldeira attended the 9th Scientific Steering Committee meeting of the Global Carbon Project in Beijing in June. On July 3 he gave a briefing in London on geoengineering to advisors of David Cameron, head of the Conservative Party in the UK. On July 6 he spoke at "The Coral Reef Crisis: Addressing the Challenges of Climate Change and Ocean Acidification," a meeting held at the Royal Society of London. July 25-Aug. 2 he taught classes on ocean acidification and geochemical modeling at the annual summer school at U. Urbino, Italy. In Aug. he traveled to Paramount Studios to participate in the film *Acid Test*, which premiered Aug. 12 on Discovery Planet Green.

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Kyla Dahlin is a recipient of a three-year Stanford Interdisciplinary Graduate Fellowship.

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After 26 years, former business manager **Mary Smith** retired this past June 30. Smith joined Plant Biology in 1983 as the office administrator, which became the business manager position later that year. In 2007 Smith became a part-time employee working on special projects for both Plant Biology and Global Ecology. She organized countless events at the departments over the years. □

Visiting investigator Luis Fernández

was recognized with the EPA's highest award in June. Fernández has been at Global Ecology for the past year as part of the bioenergy team. The award was for work he did before coming to Carnegie, pioneering a program to study and reduce the impacts of mercury contamination from artisanal and small-scale gold mining in developing countries. □

Luis Fernández receives the EPA's Gold Medal from EPA administrator Lisa Jackson.

Image courtesy EPA

❽ Joe Berry

❾ Robin Martin *(top)* collects a branch in Puerto Rico. Spectranomics' team *(bottom)* dines in Costa Rica.

Images courtesy Asner lab

Kris Ebi, the executive director of the Technical Support Unit (TSU) for Working Group II of the IPCC, arrived at Global Ecology in mid-Aug. The report will be completed in 2014. The group will also be working on a special report on managing the risks of extreme events and disasters to advance climate change adaptation, to be released in 2011. Stanford grad **Mike Mastrandrea** is the project scientist for Working Group II.

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Arrivals: Julia Pongratz joined the Caldeira lab in July as a postdoc research associate. Pongratz came from the Max Planck Institute for Meteorology in Hamburg. **Daniel Gorham** and **Michael Spieler** worked at the Caldeira lab as summer interns. The Asner lab hired summer interns **Devon Arscott** and **Elliot Brenner**.

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Departures: Field lab postdoc **Eve-Lyn Hinckley** left in Aug. for a postdoc position in Colorado. **Claire Lunch** successfully defended her dissertation in May and left for a postdoc position at Woods Hole, MA. **Jack Silverman**, a postdoc in the Caldeira lab, left Carnegie Aug. 31 for a position in Israel.

OBSERVATORIES

On June 1 director **Wendy Freedman** gave a GMT talk to a group in Santa Barbara. On June 8 she spoke on the Carnegie Hubble Project at the AAS meeting in Pasadena as part of the Spitzer Exploration Science Meeting. She was an invited speaker at the Windows on the Universe conference in Blois, France, where she gave the plenary talk on June 23. Freedman attended the TeV Particle Astrophysics Conference at KIPAC, Stanford, and gave the plenary talk on July 14.

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Staff astronomer **Alan Dressler** attended The Lyman Alpha Universe conference at the Institut d'Astrophysique de Paris July 6-10.

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❿ In Aug. staff astronomer **Andrew McWilliam** gave an invited talk at the IAU General Assembly in Rio de Janeiro. He was awarded the Beatrice M. Tinsley Research Scholarship by U. Texas-Austin in Apr. 2009, where he visited for a week and gave a talk.

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Staff astronomer **Luis Ho** attended the 5th UC-Irvine Center for Cosmology Workshop, "Intermediate-Mass Black Holes: From First Light to Galactic Nuclei," and the conference "Millimeter and Submillimeter Astronomy at High Angular Resolution" in Taipei, Taiwan. He gave invited lectures at U. Science and Technology in Hefei, China, at the Inst. of High Energy Physics of the Chinese Academy of Sciences in Beijing, and at Tianjin Normal U. He also visited Tsinghua U. and Peking U.

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Staff astronomer **Michael Rauch** gave an invited review at the The Lyman Alpha Universe conference held at the Institut d'Astrophysique de Paris in July.

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Spitzer Fellow **Jane Rigby** gave a public lecture on May 4 titled "Seeing Black Holes and New Stars in All Possible Colors" at the Huntington Library in San Marino, CA. A video of the talk is at http://users.ociw.edu/jrigby/Teach-port). She also gave talks at the Spitzer Fellowship Symposium in May, and in June at the Space Telescope Science Inst., Goddard Space Flight Center, and at The Johns Hopkins U.

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Carnegie Fellow **Josh Simon** gave a talk at the AAS meeting in Pasadena June 8-11. He attended the workshop "Shedding Light on the Nature of Dark Matter" in Pasadena July 13-24, and gave a talk at the Extreme Star Formation in Dwarf Galaxies workshop in Ann Arbor, MI, July 27-29.

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NSF Fellow **Karín Menéndez-Delmestre** organized a College Night at the Griffith Observatory in Apr. and led a panel discussion featuring astronomers from UCLA, Caltech, Griffith Observatory, and Hubble Fellow Janice Lee. This event was part of the worldwide event 100 Hours of Astronomy, a cornerstone project of the International Year of Astronomy 2009. In June she was a Career Day guest speaker at the Sandburg Middle School in Glendora, CA. She attended two European conferences in July, the "Harvesting the Desert: The Universe between Redshift 1 and 3" meeting in Marseille, France, and the "SFR@50: Filling the Cosmos with Stars" meeting in Spineto, Italy. She also gave oral presentations at a symposium at the IAU 2009 General Assembly held in Rio de Janeiro, and at the joint discussion "FIR2009: The ISM of Galaxies in the Far-Infrared and Sub-Millimetre."

PLANT BIOLOGY

Director **Wolf Frommer** received a dissertation award from the German Society for Biochemistry and Molecular Biology. On June 11 he visited ETH Zurich. On July 13 he gave two talks at

Director Wendy Freedman is corecipient of the 2009 Gruber Cosmology Prize, and participated in the IAU XXVII General Assembly Inaugural Ceremony on Aug. 4 and on Aug. 5. She gave a talk with corecipients Jeremy Mould and Robert Kennicutt. □

Carnegie's Wendy Freedman *(second from left)* is flanked by corecipients Robert Kennicutt *(left)* and Jeremy Mould. At far right Patricia Gruber holds the award certificate.

Image courtesy Barry Madore

Winslow Briggs, director emeritus, was awarded the 2009 International Prize for Biology given by the Japan Society for the Promotion of Science to be presented at a ceremony in the presence of the emperor and empress of Japan in Tokyo on Nov. 30. He is being honored for his work on light sensing by plants. □

Director Emeritus Winslow Briggs

At the Observatories' 8th Annual Open House on September 20, director Wendy Freedman thanked local firefighters, including Captain A. C. Brown, who represented the Pasadena Fire Department, for their valiant efforts in protecting the Mount Wilson Observatory during L.A. County's recent Station fire.
Image courtesy Scott Rubel

the Plant Metabolic Engineering Gordon Research Conference in Waterville Valley, NH, and on Aug. 10 he gave a talk, "BioMedical Transporters 2009," at BioParadigms in Thun, Switzerland.

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Winslow Briggs gave the leadoff symposium talk for the American Society of Plant Biologists in Honolulu, HI, on July 18. **Bill Eisinger**, a visiting investigator in that lab, presented a poster and gave a talk.

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Arthur Grossman received an appointment at Hebrew U. as a visiting professor. June 8-9 he gave a talk at the French Society of Photosynthesis meeting at École Normale Supérieure in Paris. June 14-15 he gave a talk at the Advancing Marine Science IUI conference in Eilat, Israel. July 18-22 he attended the Joint Annual Meetings of the American Society of Plant Biologists and Phycological Society of America in HI, and presented two talks. Aug. 9-14 he spoke at the 13th Annual International Symposium on Phototrophic Prokaryotes in Montreal.

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David Ehrhardt gave a talk at the Gatsby Cambridge Laboratory Advisory Group Meeting in Telluride, CO, June 23-25. July 26-30 he attended the Microscopy Society of America Annual Meeting in Richmond.

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⓫ **Zhi-Yong Wang** gave a talk at the 20th International Conference on Arabidopsis Research in Edinburgh on July 2. He also gave a talk at the EU-COST Workshop Systems Biology for Plant Design on July 9 at Wageningen U., Netherlands.

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⓬ In May 2009 **Kathryn Barton** was an invited speaker at the Genetics Society UK meeting in Oxford. She was a session chair and speaker at the American Society of Plant Biologists Meeting in Honolulu in July.

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⓭ **Devaki Bhaya** was invited to advise five freshmen in the Sophomore Mentoring Program at Stanford U. She contributed movies of cyanobacterial motility to the World Science Festival June 10-14 at Lincoln Center, NYC, for the opening talk. On June 18-23 she spoke at the 15th International Congress on Photobiology in Düsseldorf. In July she was an invited speaker at the annual Microbiology Microbial Diversity course at the Hopkins Marine Station, Stanford U., and in Aug. she spoke at the annual NSF-FIBR workshop.

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On July 2 **Eva Huala**, director of TAIR, along with **David Swarbreck** and **Kate Dreher**, TAIR curators, presented a workshop at the International Conference on Arabidopsis Research in Edinburgh.

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TAIR curator **Tanya Berardini** gave a talk at the 3rd International Biocuration Conference in Berlin on Apr. 19. On July 23 she gave a talk at the Plant Development in a Changing World Satellite Symposium of the Society for Developmental Biology meeting in San Francisco. She also attended the society's meeting.

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On July 20 **Philippe Lamesch**, **Donghui Li**, and **A. S. Karthikeyan**, TAIR curators, gave a workshop at the American Society of Plant Biologists Annual Meeting in Honolulu.

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On June 24-25 **Kate Dreher** gave a talk at Cornell U., Ithaca, NY. In July she gave presentations and helped with a course at CIGRAS, U. Costa Rica, San Pedro.

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On June 18 **Philippe Lamesch** gave a workshop in St. Louis. On Apr. 17 he spoke at the International Biocuration Conference in Berlin. On July 20 he gave a talk at the American Society of Plant Biologists meeting in HI and presented a workshop. On July 13 he gave an invited talk at the Translational Genomics Research Inst. in Phoenix.

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Frommer lab's **Viviane Lanquar** was awarded a Marie Curie Fellowship in Feb. Postdoc **Clara Bermejo** gave a talk on July 20 at the Yeast Genetics 2009 Conference.

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Ryan Gutierrez, a Ph.D. student in the Ehrhardt lab, attended the EU-COST Workshop Systems Biology for Plant Design at Wageningen U., Netherlands, July 9-11.

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Tae-Wuk Kim, a postdoctoral fellow in the Wang lab, gave a talk at the Annual Meeting of the American Society of Plant Biologists in HI July 18-21.

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Barton lab postdoctoral fellow **Enrico Magnani** was awarded an LSRF postdoctoral fellowship sponsored by the Howard Hughes Medical Institute.

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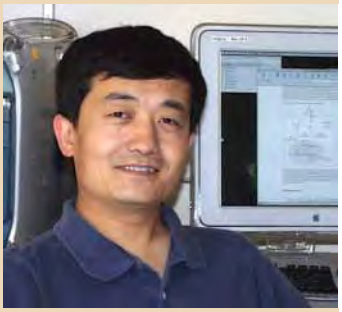
Arrivals: The department had a successful summer intern program with 21 participants. The Frommer lab welcomed **Angela Lam** and **Richard Lee**, local students, and **Heng-Cheng "Alvin" Hu** (U. Md). Grossman's lab welcomed **Matthew Blain-Hartung** (Colorado Coll.), **Matthew Prior** (UCLA), also from last year, **Amanda Rees** (Princeton U.), and **N. Raman**, a senior at Lynbrook High School in San Jose. **Danielle DeCosta** and **Tiffany Shih** (Stanford U.), joined the Evans lab. **Laura Rose** (Castilleja School) returned for another year, and **Brandon Araki** (Harker High School) joined the Barton lab. The Rhee lab welcomed **Cherise Lau** and **Purva Karia**, and returning intern **Michael Ahn** (Swarthmore Coll.) Former graduate

A celebration of Vera Rubin's career, "Unveiling the Mass: Extracting and Interpreting Galaxy Masses," was held at Queen's U., Kingston, ON, in June. Over 130 astronomers from all over the world, including many friends and former colleagues, and Rubin postdocs attended the gathering. □

⓾ Andrew McWilliam



⓫ Zhi-Yong Wang

⓬ Kathryn Barton

⓭ Devaki Bhaya

student and postdoc **Margaret Olney** (St. Martins U., Lacey) brought her students **Amy Campanelli** and **Rachel Golda** to work in the Briggs lab. **Richard Fu** joined the Wang lab, as did returning intern **Daniel Li** (UC-San Diego) and **Andrew Ma** (Lynbrook High School). **Tony Zhang** joined the TAIR group for one month.

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Tina Kubitzki joined the Frommer lab for a month on July 23. Arriving at the Grossman/Bhaya labs were postdocs **David Dewez** (UC-Berkeley) on Mar. 1 and **Mark Heinnickel** (Penn State) on May 1. Postdoc **Susanne Wisen** (U. Mich.) arrived June 1. Postdoc **Antony Chettoor** (Iowa State) joined the Evans lab May 1. Two summer field assistants joined the lab: **Duncan Oja** (Bard Coll.) on July 6, and **Graham Newell** on July 1. **Pinar Mutluoglu** joined the administrative staff as administrative assistant to director Wolf Frommer on June 1.

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Departures: Postdoc **Christine Chang** left the Frommer lab for the EU project NANOMMUNE at the Karolinska Institutet in Stockholm. Postdoc **Guillaume Pilot** left on July 31 to start an assistant professorship at Virginia Tech. **Fariba Fazelli**, a lab technician in the Grossman/Bhaya lab, left on July 17 to work at BioTech in Alameda, CA. Ehrhardt postdoc **Viktor Kirik** joined the faculty at Illinois State U.-Normal on Aug. 15. TAIR curator **Debbie Alexander** left on Apr. 18 for the UCSF Patent Office. Postdoc **Stephan Wenkel** left the Barton lab for Tübingen U. in Germany. **Yu Sun** left the Wang lab on July 31, and **Azam Noorani Vatani**, lab assistant for the Rhee lab, left on Aug. 31 for the biotech industry.

TERRESTRIAL MAGNETISM

Sean Solomon co-organized and delivered papers at a workshop on spectroscopic observations of the planet Mercury held in Parma, Italy, in June, and at a special session on Mercury at the European Planetary Science Congress held in Potsdam, Germany, in Sept. He also gave an invited presentation on the exploration of Mercury to the 1st Annual Symposium on Planetary Exploration held in May at the Chiba Institute of Technology, Chiba, Japan. In June he served on the visiting committee to the MIT-Woods Hole Oceanographic Institution Joint Program in Oceanography and Applied Ocean Science and Engineering. In late Sept. he chaired meetings of the MESSENGER Science Team timed to coincide with data playback from the spacecraft's third flyby of Mercury.

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In May, June, and Sept. **Alan Boss** participated in the Astro2010 Decadal Survey on Astronomy and Astrophysics, in meetings held in Irvine and Pasadena, CA, and in Washington, DC. In Aug. Boss spoke at a NASA televised press conference for the Kepler mission and presented opening remarks for the special session at the International Astronomical Union (IAU) General Assembly in Rio de Janeiro. He later spoke about former director **George Wetherill**'s life and gave an invited review at an IAU Symposium. During the General Assembly, Boss stepped down as president of IAU Commission 51 on Bioastronomy and began his tenure as president of IAU Commission 53 on Extrasolar Planets. In Sept. Boss and Hubble Fellow **Mercedes López-Morales** gave colloquia on search efforts for extrasolar planets at the Pathways towards Habitable Planets conference in Barcelona.

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In Sept. **Paul Butler** participated in an operations meeting for the Keck Observatory at NASA and was featured on the Australian science television program *Catalyst* for his extrasolar planet research at the Anglo-Australian Observatory.

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In Aug. **Rick Carlson** gave an invited talk at the Joint Statistical Meeting of the American Statistical Association in Washington, DC, and worked with postdoctoral fellow **Jonathan O'Neil**, collecting samples from the 4.28-billion-year-old Nuvvuagittuq terrane on the shores of Hudson Bay. Carlson hosted **Christy Till**, a Ph.D. candidate at MIT, and in Sept. **Diana de Leeuw** of the Scottish U. Environmental Research Centre arrived to work with him.

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John Chambers gave a talk at a meeting of the National Capital Astronomers held at U. Maryland in Sept.

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In Sept. **Larry Nittler** spoke at a European Space Agency workshop in Noordwijk, the Netherlands.

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Steve Shirey carried out fieldwork in July, with son Clayton as a field assistant, on the world's oldest diamond-bearing volcanic rocks in Wawa, ON. Also in July, Shirey hosted **Anrian Van Rythoven** of U. Toronto.

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Alycia Weinberger gave a colloquium on circumstellar disks at Lowell Observatory in July.

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Hubble Fellow **Mercedes López-Morales** gave an invited talk at the NASA Exoplanet Science Institute's 2009 Sagan Summer Workshop on Exoplanetary Atmospheres in Pasadena in July. In Sept. López-Morales hosted graduate student **Sergio Hoyer** of U. Chile to complete analyses of observations on transiting exoplanet systems.

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In Aug. postdoctoral fellow **Nick Schmerr** was an invited researcher at the Institute for Geophysics of Westfälische Wihlms-Universität in Münster, Germany. In Sept. Schmerr joined **David James** and field seismologist **Steven Golden** to retrieve seismometers deployed as part of the High Lava Plains Seismic Experiment in Oregon.

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Postdoctoral fellow **Jessica Warren** spoke at the Deformation, Rheology, and Tectonics Conference held in Liverpool, UK, in Sept.

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Several DTM staff and postdoctoral fellows presented papers at the 2009 Meteoritical Society meeting held in Nancy, France, in June, including **Conel Alexander**, **Alan Boss**, **Larry Nittler**, **Jianhua Wang**, postdoctoral associate **Ming-Chang Liu**, and postdoctoral fellow **Liping Qin**.

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Larry Nittler and geochemistry laboratory manager **Mary Horan** gave colloquia at the 2009 Goldschmidt conference held in Davos, Switzerland, in June.

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Sean Solomon, **Rick Carlson**, and postdoctoral fellows **Nick Schmerr** and **Wen-che Yu** presented papers at the 2009 Gordon Research Conference on the "Interior of the Earth" held in June at Mount Holyoke College in South Hadley, MA.

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The 2009 Gordon Research Conference on "Origins of Solar Systems" was held at Mount Holyoke College in South Hadley, MA, in July. DTM presenters included **John Chambers**, **Alycia Weinberger** and postdoctoral associate **Ming-Chang Liu**.

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In July **Rick Carlson**, **Steve Shirey**, and **Tim Mock** instructed primary school teachers at DTM in the separation of minerals and the laser-ablation analysis of uranium and lead to determine the age of rock as part of the Smithsonian Institution's Science Education Academy for Teachers.

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In July **Paul Silver**, field seismologist **Steven Golden**, and postdoctoral fellow **Wen-che Yu** participated in fieldwork in the Cascade Mountains of Washington State.

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Postdoctoral fellow **Nick Moskovitz** arrived in Sept. following the receipt of his Ph.D. at U. Hawaii.

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Administrative assistant **Robin Seidel** departed DTM in Aug. to begin graduate school in archaeology at California State U., Los Angeles.

DTM/GL

Shaun Hardy attended the Special Libraries Association annual conference in June in Washington, DC. □

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MOODY'S AFFIRMS Carnegie's Aaa/VMIG1 Rating HIGHEST AWARDED

On August 24, Moody's Investors Service affirmed its highest rating—Aaa/VMIG1—on the Carnegie Institution's Series 1993, 2002, and 2006 bonds. Only 37 other higher-education institutions and not-for-profit organizations are currently rated in this category, the highest ranking awarded to this group. The rating is based on Carnegie's financial strength and reflects Moody's expectation that "the Institution's balance sheet and liquidity will continue to provide a solid cushion for debt and operations and that the Institution will successfully manage the impact of lower investment values on its operations." Moody's outlook for the rating is stable.

Moody's cited numerous strengths that led to the rating, including a large balance sheet, a strong market position as an advanced research institution with diversified funding sources, and "improved operating performance in recent years." Moody's also believes that the institution has a sufficient "cushion of liquidity" for any short-term needs, if they arise.

"In these challenging economic times, it is particularly gratifying to be given this commendable rating," remarked Carnegie president Richard A. Meserve. "A strong financial footing is essential for the institution to fulfill its mission of advancing basic scientific research."

The Series 1993B and Series 2006 bonds are issued through California Educational Facilities Authority, while the Series 2002 bond is issued through Maryland Health and Higher Education Facilities Authority. □