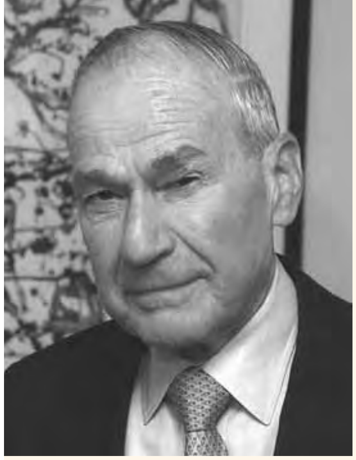
CarnegieScience

The Newsletter of the Carnegie Institution

SUMMER 2010

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

On the Inside



If anything typifies science at Carnegie, it is a boldness of vision. Our scientists are true explorers, taking calculated risks to answer difficult questions and discover new scientific vistas. That pioneering spirit is certainly alive in the ambitious Giant Magellan Telescope (GMT) project, led by Observatories director Wendy Freedman. Slated for completion in 2018, the GMT will be far larger than any ground-based telescope ever built and promises images 10 times sharper than those from the Hubble Space Telescope.

At the annual May meeting, Carnegie's board of trustees took the courageous step of authorizing our president to commit $59.2 million for the design, construction, and commissioning of the GMT. This is on top of the $19.9 million that Carnegie has already committed to the project. With the commitment from the GMT's other partners,* Carnegie's pledge puts the funding at more than 40% of the telescope's total $700 million price tag. We expect that our partners will soon follow our lead and thereby enable the project to proceed.

The technical and financial challenges of a project of this magnitude are daunting. The telescope's novel design calls for six off-axis mirrors arranged like the petals of a flower around a central on-axis mirror. The first of the off-axis mirrors was cast in 2005 and is now being polished at the University of Arizona Mirror Lab. When it is finished later this year, it will be the first mirror produced for the next generation of extremely large telescopes.

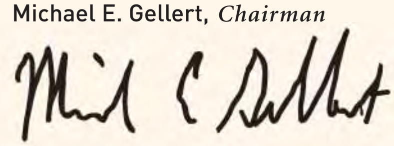
Carnegie has been down this road before, however. In 1904, when the institution was barely two years old, it took a gamble on George Ellery Hale's vision for an observatory atop Mount Wilson. The 100-inch (2.5-meter) Hooker telescope built by Hale with Carnegie's support was unprecedented. It reigned as the world's largest telescope for more than 30 years and ushered in a new generation of large telescopes.

The GMT will be 10 times bigger than the Hooker. And its innovative adaptive optics will remove distortion from atmospheric turbulence to produce images of unsurpassed clarity. The Hooker telescope opened a new window on the universe. Carnegie astronomer Edwin Hubble used it to discover that there are galaxies beyond the Milky Way, and that the universe is expanding. Other astronomers mapped our galaxy's star clusters and chronicled the life cycles of stars. Astronomy was never the same as a result of the discoveries the Hooker telescope made possible.

What will the GMT reveal to us? We don't know, of course, but it is certain to be exciting. Astronomers will be able to look farther back in time than ever before, and at fainter and more distant objects. It may provide direct images of planets around other stars, giving us a better look at these alien worlds as we hunt for signs of life. It could help scientists crack the mysteries of dark matter and dark energy. And, based on past experience, it will enable us to answer questions no one has even thought of asking.

The Carnegie Institution has a legacy of leadership in astronomy that spans more than a century. We are proud that Carnegie is on course to continue that leadership into the next century.

Michael E. Gellert, *Chairman*



*The GMT partner institutions are the Carnegie Institution for Science, the University of Texas at Austin, Harvard University, the Australian National University, the Smithsonian Astrophysical Observatory, the University of Arizona, Texas A&M University, Astronomy Australia Limited, and the Korea Astronomy and Space Science Institute.

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Board Meets, Commits to Giant Magellan Telescope Construction

THE CARNEGIE BOARD OF TRUSTEES met at the administration building in Washington, D.C., on May 6 and 7. On Thursday, May 6, the Employee Affairs, Finance, and Development committees met, after which the full board held its first session. The day's business was followed by the annual dinner honoring donors and friends of the institution. Trustee, physicist, and congressman from New Jersey Rush Holt was the evening's speaker. He talked about science in the current political climate and emphasized that the "scientific way of thinking is fundamental to our liberty." After dinner, Nicholas Biniaz-Harris, a student at the Levine School of Music, played the piano for guests.

On Friday, May 7, the Audit and Nominating committees met. They were followed by the second session of the board, where President Richard A. Meserve reviewed the business plan for the Giant Magellan Telescope (GMT). The GMT will be the first in the next generation of astronomical observatories that will drive new scientific discoveries. The Carnegie board authorized President Meserve to commit $59.2 million for the design, construction, and commissioning of the telescope to supplement the $19.9 million that Carnegie has already committed to the project. At this time more that 40% of the total funding required to construct the GMT has been committed by the founding institutions. It is the board's hope and expectation that the other partners in the project will soon commit the remainder of the funds and thereby allow the telescope to be brought into service.

In the United States the participating institutions are the Carnegie Institution for Science, Harvard University, the Smithsonian Institution, Texas A&M University, the University of Arizona, and the University of Texas at Austin. The two Australian members of the founders group are the Australian National University and Astronomy Australia Limited. The South Korean government approved participation in the GMT project, with the Korea Astronomy and Space Science Institute as the representative of the Korean astronomical community. □

Trustee, physicist, and New Jersey congressman Rush Holt spoke at the annual dinner honoring Carnegie friends.

Erik Hauri Finds Water in the Moon at Carnegie Evening

THE MOON IS A LONG WAY TO GO for a little bit of water, especially if, like Terrestrial Magnetism's Erik Hauri, you are used to collecting your geological samples from the South Pacific. But as Hauri explained to his audience at this year's Carnegie Evening lecture, the minute traces of water he and colleagues discovered in volcanic glass collected by Apollo astronauts have planet-rocking consequences.

Hauri's discovery made the news when it was published in 2008, reflecting our eternal fascination with the Moon. In this year's talk, he explained how he used Carnegie's NanoSIMS ion microprobe to obtain ultraprecise analyses of minute glass beads in the Moon samples.

But first he outlined the role of water in the evolution of planets. Water within a planet lowers the melting temperature of rocks and reduces their strength. It is the lubricant that makes plate tectonics possible on Earth. But water is not common in the rocky planets because of intense solar radiation and condensation of ice in the outer Solar System. And the giant impact that created the Moon would have boiled off volatile compounds such as water. Hauri showed animations of the collision and the intense heat in the Earth and the debris disk that became the Moon.

Since its violent birth, the Moon has had periods of volcanic activity. The volcanic glass beads studied by Hauri were formed during pyroclastic eruptions between 3 and 4 billion years ago. On Earth, pyroclastic eruptions are driven by volatiles within the magma. Previous studies of lunar volcanic glasses had failed to find evidence of water, but using the NanoSIMS Hauri and his colleagues found concentrations of up to about 100 parts per million. Accounting for water lost by degassing from the beads, these results imply that the original magmas contained water in concentrations similar to those of the Earth's interior.

How could water have survived the giant impact? Hauri suggested that the molten Earth and the debris disk may have been surrounded by an envelope of silicon vapor, which kept the water from dissipating. Alternatively, as he showed in a computer simulation, some parts of the debris disk may have escaped total melting. And some of the water on Earth and the Moon may have come from accretion that occurred after the impact.

Hauri finished by giving the audience a glimpse of work in progress. He is using the NanoSIMS to analyze the carbon content in lunar glasses. He plans similar studies on tiny melt inclusions, which have preserved the volatiles from the magmas prior to eruption. He noted that if samples could be retrieved from other bodies in the Solar System, such as Mercury, Venus, and Saturn's moon Io, studies of volatiles held in volcanic glasses could offer a wealth of information about the distribution of water in the Solar System during planet formation. □

(Above left) Terrestrial Magnetism's Erik Hauri was this year's Carnegie Evening speaker.

Frank Perez (left), Carnegie president Richard Meserve (middle), and Dianne Williams (right) attend a reception in the administration building library before Carnegie Evening.

Two Receive Carnegie's Service to Science Award

The Carnegie Service to Science award was created to recognize outstanding or unique contributions to science by employees who work in administrative, support, and technical positions at Carnegie. This year, two recipients received awards at the May 5 Carnegie Evening at the administration building.

Dianne Williams

DEPARTMENT OF EMBRYOLOGY

More than 25 years ago, Dianne Williams of Embryology was hired by the department to wash lab dishes as part of a city job program for inner-city youth. Now, as head technician and manager of a *Drosophila* research lab, and with two degrees from The Johns Hopkins University, she has authored four scientific papers published in prestigious journals and has been acknowledged for technical assistance on countless others.

Within a year of joining Embryology, Williams volunteered to take over the unpopular task of preparing the thousands of vials of fly food needed by Director Allan Spradling's lab. The model fruit fly *Drosophila melanogaster* is used for genetics studies, including stem cell research and research into the development of egg and sperm. Williams wanted to know about the food problems the researchers encountered so she could find ways to improve the fly diet. She soon designed a much preferred diet.

Much of the fly food is used by the lab's stock technician, who maintains the collection of mutant strains. This person must understand genetics and be able to recognize dozens of mutant appearances and behaviors in the tiny fruit fly. Williams was a quick learner and within a few years had moved into this position.

Taking advantage of Carnegie's educational benefits, Williams attended Johns Hopkins at night for eight years, ultimately earning a B.A. She began to undertake molecular biology experiments at the lab that allowed her to become a research technician. Soon she was acknowledged in scientific papers. She then entered graduate school, also at night. Her research was on effects of so-called jumping genes when they enter and leave the repetitive DNA sequences that make up much of animal genomes. Williams's research suggested that transposons play a role in this evolution, and her work resulted in publication as lead author of an article in the *Proceedings of the National Academy of Sciences* as well as a master's degree.

Genetics researchers around the world have also benefited greatly from reagents she has produced. A few years ago, the Spradling lab began to run low on a critical antibody that recognizes a protein called Vasa. The lab studies germ cells and used this antibody extensively to identify developmental processes. Williams generated two new Vasa antibodies of exceptional quality, including a "monoclonal" antibody that now provides an unlimited supply. Williams's reagent was submitted to a public repository, where it is distributed to researchers around the world.

Frank Perez

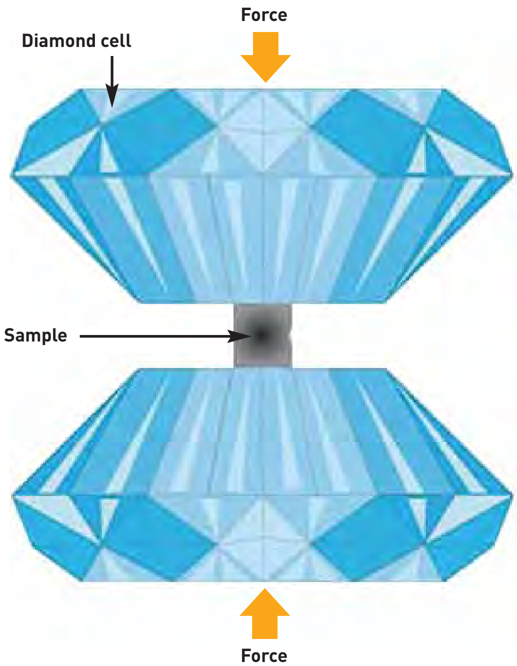
CARNEGIE OBSERVATORIES

President Richard Meserve announced in March that Frank Perez, telescope engineer at the Observatories, would receive one of the two Service to Science awards. Perez, who has been with Carnegie for over 32 years, played a crucial role in the design, construction, and maintenance of the Magellan telescopes and other structures at Carnegie's Las Campanas Observatory in Chile. In the late-1990s, Perez and his wife, Terrie, moved to Chile to prepare for the on-site assembly of the Magellan telescopes. As site manager, he was responsible for directing the technical crew during the commissioning activities. Thanks in great measure to Perez's management, the enclosure for the first telescope was erected in only two months. The first telescope began science operations in February 2001, and the second followed only 19 months later, in September 2002.

Among his many other contributions, Perez was responsible for the specification, design, and procurement of the coating plant that would be used for the periodic aluminizing of the surfaces of the 6.5-meter primary mirrors. The result was a coating system that is reliable and low cost and that has preserved the telescopes' remarkable capabilities.

In anticipation of increased demand for power with the coming of the twin Magellan telescopes, Perez led the effort to connect the observatory's power source to the Chilean commercial power grid for higher reliability and significantly reduced costs. Perez's skill and perseverance have contributed heavily to a pair of extraordinary instruments that have remarkably low downtime for repairs, significantly increasing their scientific productivity. □

How Deep Is Deep?



Scientists subject samples to extreme pressures between two diamonds in a diamond anvil cell to mimic pressure conditions in the deep Earth. In this research, they heated the material to Earth-interior temperatures with an improved laser-heating technique.

Image courtesy U.S. Department of Energy

THE OIL AND GAS THAT FUEL OUR LIVES have come from the Earth's crust. It is currently understood that hydrocarbons started out as living organisms, which died, were compressed, and were heated under heavy layers of sediments in the topmost layer. Scientists have debated for years whether some of these hydrocarbons could also have been created deeper and been formed without organic matter. Now, for the first time, researchers have found that ethane and heavier hydrocarbons can be synthesized under the pressure-temperature conditions of the upper mantle—the layer of Earth under the crust and on top of the core. The research, by scientists at the Geophysical Laboratory with colleagues from Russia and Sweden, was published in an advanced online issue of *Nature Geoscience*.

Methane (CH_4) is the main constituent of natural gas, while ethane (C_2H_6) is used as a petrochemical feedstock. These hydrocarbons, and others associated with fuel, are called saturated hydrocarbons because they have simple, single bonds and are saturated with hydrogen. Using a diamond anvil cell and a laser heat source, the scientists first subjected methane to pressures exceeding 20 thousand times the atmospheric pressure at sea level and temperatures ranging from 1300 F° to over 2240 F°. These conditions mimic those found 40 to 95 miles deep inside the Earth. The methane reacted and formed ethane, propane, butane, molecular hydrogen, and graphite. The scientists then subjected ethane to the same conditions, and it produced methane. The transformations suggest heavier hydrocarbons could exist deep down. The reversibility implies that the synthesis of saturated hydrocarbons is thermodynamically controlled and does not require organic matter. But the formation processes for these results will require further investigation.

"We were intrigued by previous experiments and theoretical predictions," said staff member Alexander Goncharov, a coauthor. "Experiments reported some years ago subjected methane to high pressures and temperatures and found that heavier hydrocarbons formed from methane under very similar pressure and temperature conditions. However, the molecules could not be identified, and a distribution was likely. We overcame this problem with our improved laser-heating technique where we could cook larger volumes more uniformly. And we found that methane can be produced from ethane." The hydrocarbon products did not change for many hours, but the telltale chemical signatures began to fade after a few days. □

This research was supported by the U.S. Department of Energy, the National Nuclear Security Agency through the Carnegie/DOE Alliance Center, the National Science Foundation, the W. M. Keck Foundation, and the Carnegie Institution.

Carbon Emissions "Outsourced"
to Developing Countries

A STUDY BY SCIENTISTS AT GLOBAL ECOLOGY finds that over a third of carbon dioxide emissions associated with the consumption of goods and services in many developed countries are emitted outside their borders. Some countries, such as Switzerland, "outsource" over half of their carbon dioxide emissions. In the United States, about 2.5 tons of carbon dioxide consumed per person are produced elsewhere. In Europe, the figure can exceed 4 tons per person. Most of these emissions are outsourced to developing countries, especially China. The report was published in the March 8, 2010, early online edition of the *Proceedings of the National Academy of Sciences USA*.

"Instead of looking at carbon dioxide emissions only in terms of what is released inside our borders, we also looked at the amount of carbon dioxide released during the production of the things that we consume," said Global Ecology's Ken Caldeira, coauthor of the study. Caldeira and lead author Steven Davis, also at Carnegie, used published trade data from 2004 to create a global model of the flow of products across 57 industry sectors and 113 countries or regions. By allocating carbon emissions to particular products and sources, the researchers calculated the net emissions "imported" or "exported" by specific countries.

"Just as the electricity that you use in your home probably causes CO_2 emissions at a coal-burning power plant somewhere else, we found that the products imported by the developed countries of western Europe, Japan, and the United States cause substantial emissions in

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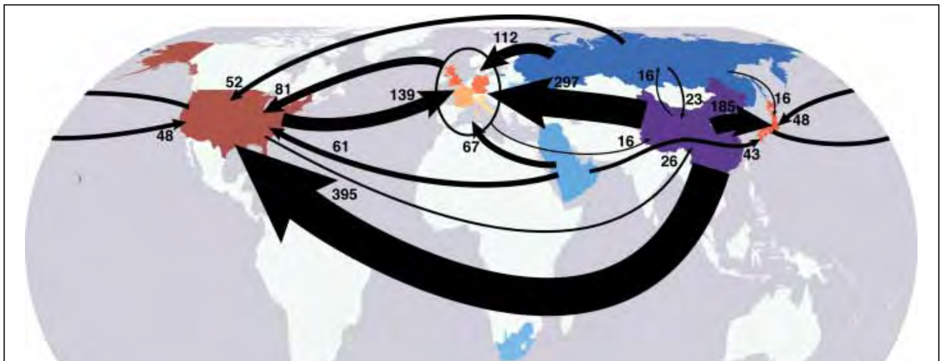
Carbon Emissions "Outsourced" to Developing Countries

other countries, especially China," said Davis. "On the flip side, nearly a quarter of the emissions produced in China are ultimately exported."

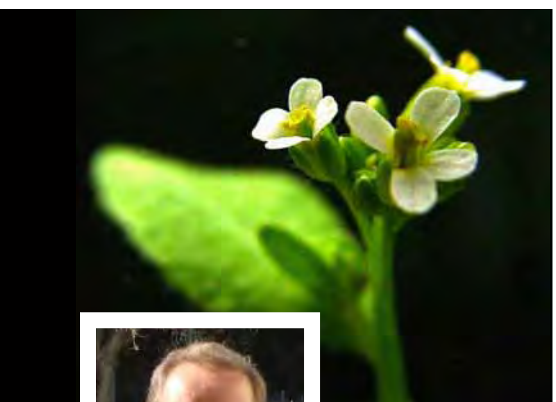
Over a third of the carbon dioxide emissions linked to goods and services consumed in many European countries occurred elsewhere. In Switzerland and several other small countries, outsourced emissions exceeded the amount of carbon dioxide emitted within national borders.

The United States is both a major importer and a major exporter of emissions. On a net basis, the U.S. outsources about 11% of total consumption-based emissions, primarily to the developing world. The researchers point out that regional climate policy needs to take into account emissions embodied in trade, not just domestic emissions. "Where CO_2 emissions occur doesn't matter to the climate system," said Davis. "Effective policy must have global scope. To the extent that constraints on developing countries' emissions are the major impediment to effective international climate policy, allocating responsibility for some portion of these emissions to final consumers elsewhere may represent an opportunity for compromise." □



This map shows the flow of "outsourced" carbon emissions.
Image courtesy Steven Davis and Ken Caldeira

Cracking the Plant-Cell Membrane Code



(Top) The experimental *Arabidopsis thaliana* plant shares many of its genes with other organisms, including humans.

(Bottom) Wolf Frommer, director of Carnegie's Department of Plant Biology

TO ENGINEER BETTER, MORE PRODUCTIVE CROPS and develop new drugs to combat disease, scientists look at how the sensor-laden membranes surrounding cells control nutrient and water uptake, secrete toxins, and interact with the environment and neighboring cells to affect growth and development. Remarkably little is known about how proteins interact with these protective structures. With National Science Foundation funding, researchers at the Carnegie Institution's Department of Plant Biology are using the first high-throughput screen for any multicellular organism to pinpoint these interactions using the experimental plant *Arabidopsis*. They have analyzed some 3.4 million potential protein/membrane interactions and have found 65,000 unique relationships. They made the preliminary data available to the biological community by way of the Web site www.associomics.org/search.php. The work applies to fields from farming to medicine, since proteins are similar in all organisms.

"This is just the beginning," said Wolf Frommer, director of Carnegie's Department of Plant Biology. "*Arabidopsis* shares many of its genes with other organisms, including humans. As the library of interacting proteins grows, scientists around the world will be able to study the details of protein interactions to understand how they are affected by forces such as climate change and disease and how they can be harnessed to produce better crops and medicines more effectively."

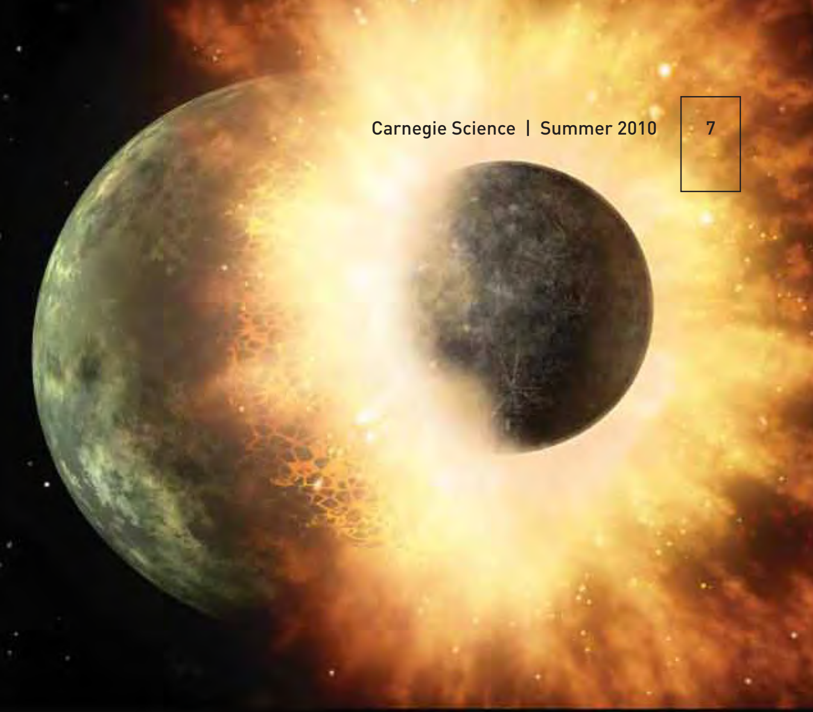
All of a cell's internal machinery relies on the binding of proteins. Complementary-shaped proteins dock with one another to start processes, such as turning on a gene or letting in the proper nutrient. These membrane proteins make up some 20% to 30% of the proteins in *Arabidopsis*, a relative of the mustard plant.

The team uses a screen called the mating-based protein complementation assay, or split ubiquitin system. Ubiquitin is a small protein. The scientists fuse candidate proteins onto a version of ubiquitin that is split in half. When the two candidates interact, the two halves of the ubiquitin reassemble, triggering a process that liberates a transcription factor—a protein that tells a gene to produce a protein. When the protein is turned on in the nucleus, the researchers are alerted to the successful interaction. The ultimate goal is to test the 36 million potential interactions as well as the sensitivity of the interactions to small molecules with a high-throughput robotics system.

The group has started a second round of screening to test another 3.4 million interactions. □

This work was made possible by grants from www.arabidopsis.org/portals/masc/FG_projects.jsp NSF 2010 : Towards a comprehensive *Arabidopsis* protein interactome map: Systems biology of the membrane proteins and signalosomes (grant MCB-0618402) in addition to support from Carnegie. Other participants on the NSF 2010 project include UCSD, Penn State, and the University of Maryland. The group previously donated 2,010 clones to the Arabidopsis Biological Resource Center (ABRC) at Ohio State University, and more recently donated another 1,010 for other scientists to use to help advance fields from medicine to farming.

Silver Tells *of* Earth's Origin



The Earth may have first accreted volatile-depleted material until it reached most of its final mass and then accreted volatile-rich material in the late stages of formation. The addition of volatile-rich material could have occurred in the giant collision between the proto-Earth and a Mars-sized object believed to have ejected enough material into Earth orbit to form the Moon.

Image courtesy NASA

Tiny variations in the composition of silver isotopes in meteorites and Earth rocks are helping scientists construct a timetable of how the Earth assembled beginning 4.568 billion years ago. Isotopes of silver are silver atoms with the same number of protons but a different number of neutrons. The study, published in *Science*, indicates that water and other key volatiles may have been present in at least some of Earth's original building blocks rather than having been acquired later from comets, as some have suggested.

Compared with the Solar System as a whole, Earth is depleted in volatile elements, such as hydrogen, carbon, and nitrogen, which likely never condensed on planets formed in the inner, hotter, part of the Solar System. Earth is also depleted in moderately volatile elements, such as silver. "A big question in the formation of the Earth is when this depletion occurred," says coauthor Richard Carlson of the Department of Terrestrial Magnetism. "That's where silver isotopes can really help."

Silver has two stable isotopes. One of them, silver-107, was produced in the early Solar System by the rapid radioactive decay of palladium-107. Palladium-107 is so unstable that virtually all of it decayed within the first 30 million years of the Solar System's history.

Silver and palladium differ in their chemical properties. Silver is the more volatile of the two, whereas palladium is more likely to bond with iron. These differences allowed the Carnegie researchers* to use the isotopic ratios in primitive meteorites and mantle rocks to determine the history of Earth's volatiles relative to the formation of Earth's iron core. Other evidence from hafnium and tungsten isotopes indicates that the core formed between 30 to 100 million years after the origin of the Solar System.

It is widely believed that the Solar System formed when a giant molecular cloud collapsed. Most of the material was in the center and formed the Sun. The matter farther out became a protoplanetary disk that eventually coalesced into the planets and moons.

Image courtesy NASA/JPL-Caltech/T. Pyle (SSC)

"We found that the silver isotope ratios in mantle rocks from the Earth exactly matched those in primitive meteorites," says Carlson. "But these meteorites have compositions that are very volatile rich, unlike the Earth, which is volatile depleted." The silver isotopes presented another riddle, suggesting that the Earth's core formed about 5 to 10 million years after the origin of the Solar System, much earlier than the date from the hafnium-tungsten results.

The group concludes that these contradictory observations can be reconciled if Earth first accreted volatile-depleted material until it reached about 85% of its final mass and then accreted volatile-rich material in the late stages of its formation, about 26 million years after the origin of the Solar System. The addition of volatile-rich material could have occurred in a single event, perhaps the giant collision between the proto-Earth and a Mars-sized object thought to have ejected enough material into Earth orbit to form the Moon.

The results of the study support a 30-year-old model of planetary growth called heterogeneous accretion, which proposes that the Earth's building blocks changed in composition as the planet accreted. Carlson adds that it would have taken just a small amount of volatile-rich material similar to primitive meteorites added during the late stages of Earth's accretion to account for all the volatiles, including water, on the Earth today. □

This work was supported by National Science Foundation grant EAR-0229417 and the Carnegie Institution for Science. *Researchers were Carnegie's Rick Carlson; lead author Maria Schönbächler (formerly at Carnegie, now at the University of Manchester); and Carnegie's Erik Hauri, Mary Horan, and Tim Mock.

Bald Eagles:

Isotope Analysis Meets Conservation

AN UNPRECEDENTED STUDY OF BALD EAGLE DIET from about 20,000 to 30,000 years ago to the present will provide wildlife managers with unique information for reintroducing bald eagles to the Channel Islands off California. The results of the study were published in the early online edition of *Proceedings of the National Academy of Sciences USA*, on May 3.

The scientists, who included researchers from Carnegie's Geophysical Laboratory, found that eagles fed mainly on seabirds from about 20,000 to 30,000 years ago until the 1840s and 1850s, when humans introduced sheep. The seabirds provided carrion for the eagle population until DDT wiped the eagles out in the 1960s.

"Reintroducing bald eagles to the Channel Islands has had mixed results," remarked lead author Seth Newsome, a postdoctoral researcher at Carnegie at the time of the study. "An understanding of their diet is critical to successful reintroduction, so we looked for chemical traces of the foods the eagles consumed over many millennia. Since bald eagles are extremely opportunistic, they can quickly adapt to changes in the prey of the diverse ecosystems. Because there are no sheep on the islands today and the seabird populations are diminished, we think that the reintroduced eagles could scavenge seal or sea lion carrion, exert predation pressure on a threatened but recovering local seabird population, or even prey on the endangered island fox. Each of these sources has its challenges for wildlife managers. Several studies have shown that seals and sea lions are contaminated with pollutants, and a growing bald eagle population could potentially exert pressure on the fragile fox and seabird populations."

The scientists used a technique called stable isotope analysis to examine eagle bone and feather remains, gathered primarily from a now-abandoned historic nest on San Miguel Island. They also examined prehistoric material from the late Pleistocene from paleontological sites on the island and material collected during the historic period (1850-1950) from other Channel Islands and the Southern California mainland.

Atoms of elements such as carbon and nitrogen, which cycle through the food chain, come in different forms, or isotopes, which have the same number of protons but different numbers of neutrons. Scientists can distinguish the isotopes by the tiny differences in their masses. As it turns out, marine and terrestrial prey have different amounts of the isotopes carbon-13 (^{13}C) and nitrogen-15 (^{15}N). The coastal marine ecosystems in California have higher amounts of ^{13}C and ^{15}N than adjacent terrestrial ecosystems. The marine ecosystems also have more steps in the food chain, resulting in even higher amounts of ^{15}N. Since the isotope ratios in sheep and foxes are different from those in seabirds and fish, the researchers could determine the diets of bald eagles by analyzing the isotopes found in their remains. □

❶ This photograph of a bald eagle was taken on the west end of Santa Catalina Island in 2008.

❷ This bald eagle chick, tagged A-49, hatched in the Pelican Harbor nest on Santa Cruz Island in 2006 and was the first chick to hatch naturally on the Channel Islands since 1950.

❸ Two bald eagle chicks on the west end of Catalina Island, 2008.

❹ The researchers measure and sample the historic nest on San Miguel Island, which they excavated for the study.

Image courtesy Jim Spickler, Eco-Ascension Research and Consulting

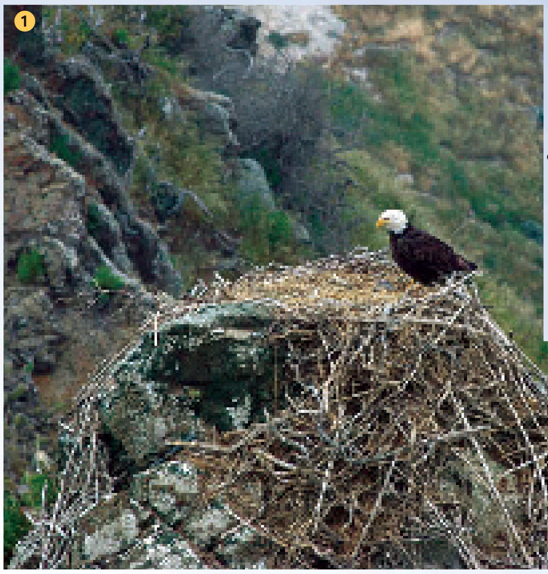


Image courtesy Peter Sharpe, Institute for Wildlife Studies

Image courtesy Peter Sharpe, Institute for Wildlife Studies

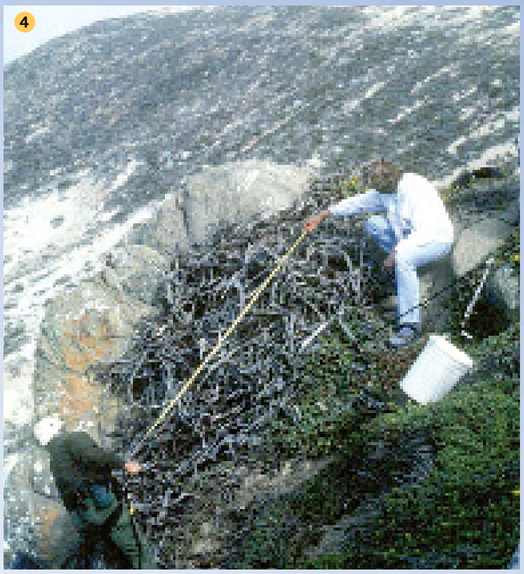
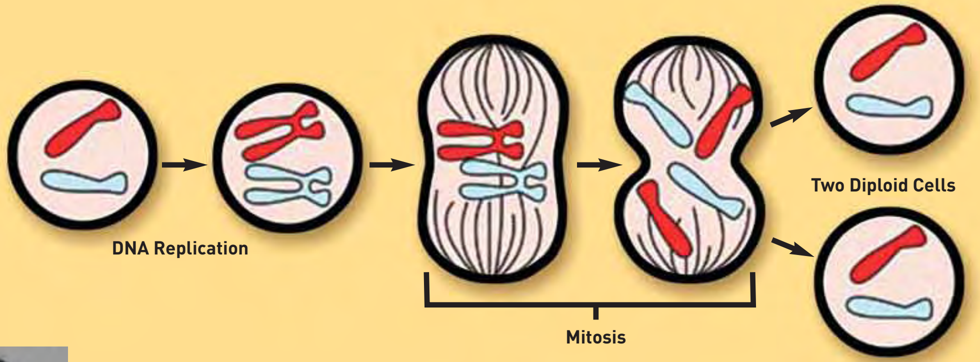


Image courtesy Paul Collins, Santa Barbara Museum of Natural History

This research was supported by the National Park Service, the National Science Foundation, the W. M. Keck Foundation, and the Carnegie Institution for Science.

Chromosome "Glue" Surprises Scientists



Jill Heidinger-Pauli was a predoctoral fellow at the time of the study.

Image courtesy Christine Pratt

In every cell of your body, proteins called cohesins ensure that newly copied chromosomes bind together, separate correctly during cell division, and are repaired after DNA damage.

Scientists at the Department of Embryology have discovered that cohesins are needed in different concentrations for their different functions. This finding helps to explain how certain developmental disorders arise without affecting cell division essential to development. The research was made possible by a new technique that the scientists developed for membrane-bound cells (called eukaryotes). It enabled them to gradually reduce the concentration of a protein in living cells. The paper, published in the May 6 online edition of *Current Biology*, opens the door to a better understanding of developmental disorders and to the study of other proteins with multiple functions.

"One of the biggest surprises is that only a small amount of cohesin, the protein 'glue' that keeps replicated chromosomes bound together, is needed for the cell division process, and that's what we think cohesin's primary role is," said lead author Jill Heidinger-Pauli, a predoctoral fellow at the time of the study.

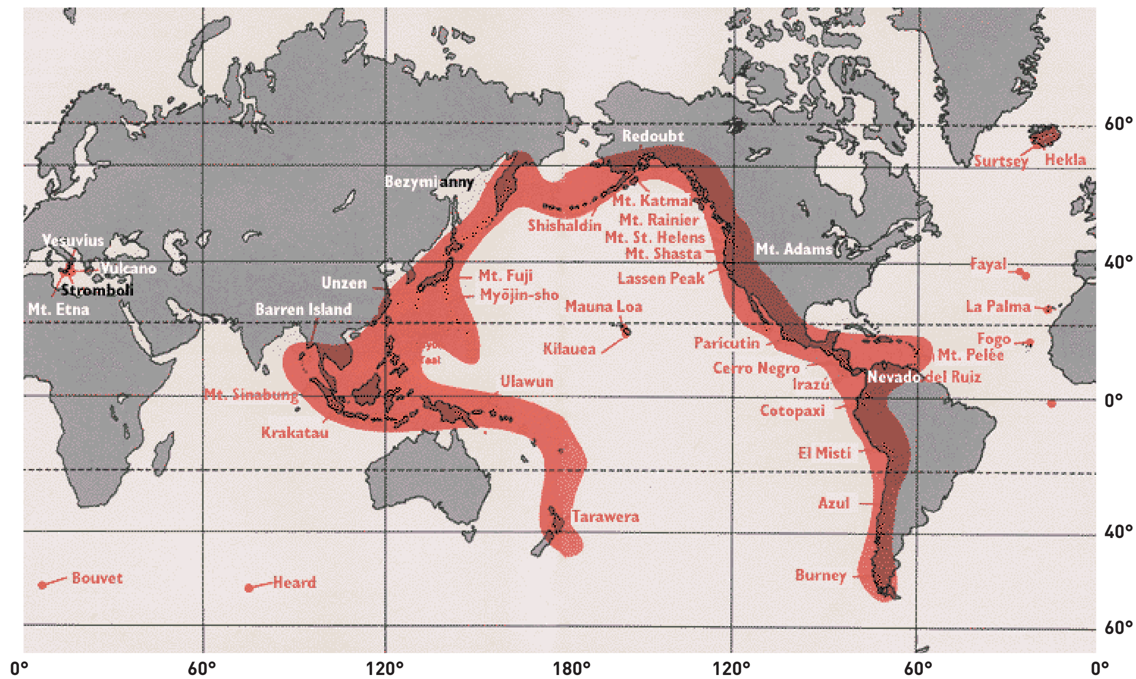
A cell has a four-phase life cycle: growth, synthesis, growth, and mitosis. During the synthesis phase, DNA inside the cell's nucleus is duplicated, and two identical daughter chromosomes called sister chromatids result. These twins must remain connected until the cell is ready to divide. This moment occurs in the last step of the cell cycle, the mitosis phase, where chromosomes condense and fibrous structures called spindles form. Cohesin keeps the sisters properly glued together until it is time for the spindles to pull the sisters to opposite sides of the cell. The cell then separates into two, resulting in two genetically identical cells.

Cohesin is also critical in DNA condensation and in the repair of DNA damage. To monitor how much cohesin is needed for these different processes, the researchers exploited a genetic trick that lets a so-called stop codon occasionally code for an amino acid. A codon is a set of three DNA bases that codes either for a particular amino acid or stops the translation (the reading) of the DNA sequence. If the translation process is halted, a fully functional protein can't be formed. The researchers inserted stop codons early into a DNA sequence that codes for a cohesin protein. Normally this would result in the death of the cell, but the researchers had inserted another mutation, called *SUP53*,which resulted in reduced cohesin protein, but did not change the timing of when cohesin was made or its amino acid sequence.

"We found that DNA repair, chromosome condensation, and the stability of repeat sequences of DNA were all compromised by decreasing cohesion to 30% of normal levels," remarked Heidinger-Pauli. "Interestingly, sister-chromatid cohesion and chromosome segregation were not affected even with levels at only 13% of normal. We also looked at how reducing the amount of cohesin changes how it interacts with chromosomes. Normally cohesin bind to regions throughout chromosomes, but we found that when cells only had a small amount of cohesin, cohesin prefers to bind to the center of chromosomes. We didn't know that this existed before." □

(Above) This simplified diagram shows the process of cell division. Chromosomes (red and blue) inside a cell nucleus duplicate and produce daughters called sister chromatids. They then separate with the help of ropelike structures called spindles into two cells that have a complete copy of the genetic information.

Image courtesy NIH



This map shows the distribution of some of the Earth's 500 active volcanoes. Image courtesy USGS

The Hunt for Deep Carbon

Carbon not only fuels our daily lives, it is also the basis of all known life. Given this lofty status, it is remarkable how little we know about carbon systems that are any more than a few hundred feet deep in the Earth. For example, we have no idea how much carbon is stored in Earth's interior, or of the nature of deep reservoirs. We do not know how carbon moves from one deep repository to another, or the extent to which carbon moves to and from Earth's surface. And there are only vague hints of any extensive deep microbial ecosystem.

With support from the Alfred P. Sloan Foundation, in September 2009 Carnegie's Geophysical Laboratory (GL) launched the Deep Carbon Observatory (DCO) to explore these questions. This international, multidisciplinary, decade-long effort, headquartered at GL, plans to gain a transformational understanding of carbon's chemical and biological roles in Earth's deep interior. Several GL staff members are coordinating the efforts: Bob Hazen, principal investigator; Russell Hemley, GL director; Connie Bertka, program director; and Lauren Cryan, program assistant.

The DCO, supported by a 10-year financial effort from private, government, and corporate sources, has broad implications for major scientific and societal issues and may ultimately coordinate the activities of more than 1,000 scientists in 50 countries.

The first meeting of the Founders Committee, including Carnegie staff and senior representatives from seven countries, met in September. The committee agreed that the research would be organized around three science directorates: Deep Carbon Reservoirs and Fluxes; Deep Life; and Energy, Environment, and Climate. Challenges and goals were set for each directorate.

The goal of the Deep Carbon Reservoirs and Fluxes directorate is to advance our understanding of the deep-Earth cycling of nonbiological carbon from the atomic to the global scale. A major ambition is to develop a global, real-time, Web-based monitoring system of CO_2 emissions from all of Earth's 500 or so active volcanoes.

The Deep Life directorate is commissioned to advance our understanding of the inner limits of our planet's life process and the role of deep life in controlling biogeochemical processes and climate on Earth's surface. It plans to conduct a global census of deep microbial life, based primarily on a new program of targeted continental and oceanic drilling.

The Energy, Environment, and Climate directorate will focus on carbon chemistry and physics under extreme conditions.

In addition to these meetings, a number of other scientific groups have held sessions on deep carbon at their meetings. The DCO has also made numerous contacts with other foreign institutions. Carnegie trustee John Crawford facilitated key meetings with French science and industry leaders, and discussions have begun with former Carnegie postdoctoral researchers to organize outreach efforts in India and Brazil. A third Deep Carbon Cycle International Conference has been proposed for Brazil in August 2011.

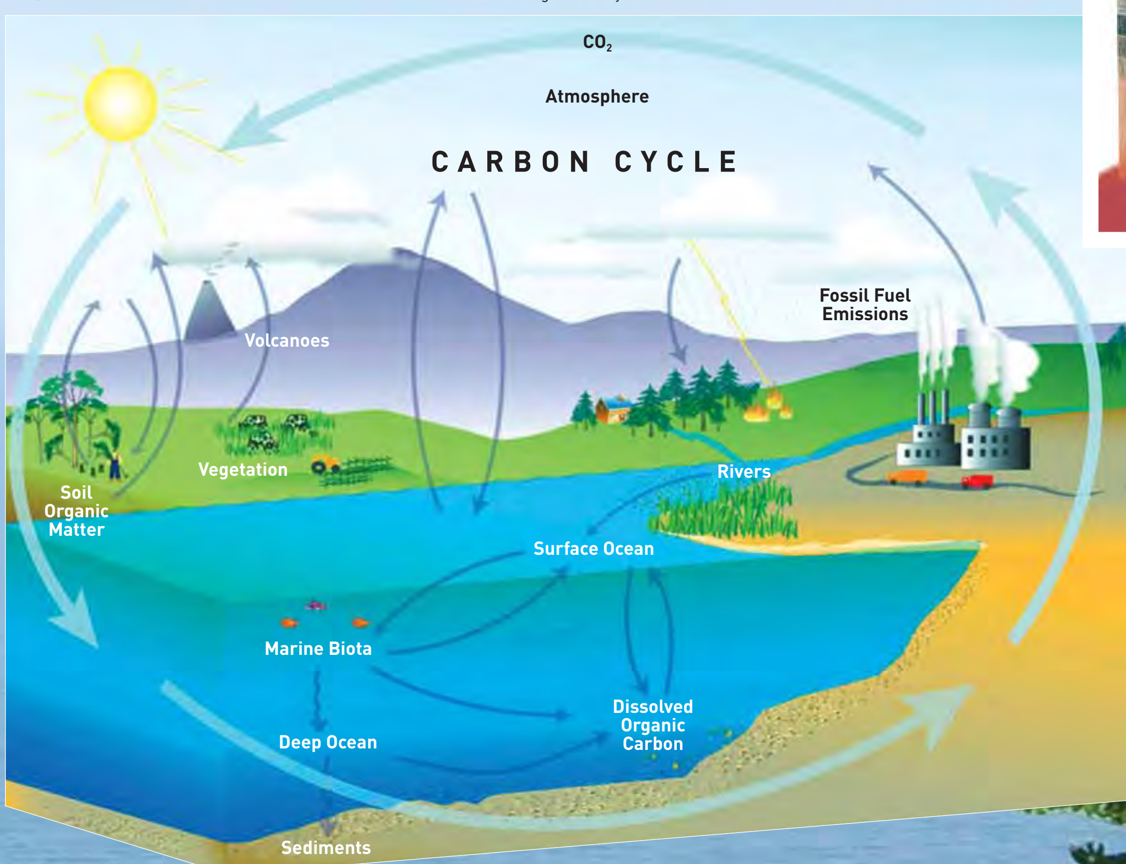
The group has also developed important ties with the Integrated Ocean Drilling Program (IODP) and the Japanese scientific leadership to spearhead a project to drill to Earth's mantle using the new drilling ship *Chikyu*. On September 9-11, 2010, Carnegie will host an international meeting, "Reaching the Mantle Frontier: Moho and Beyond," to develop a technical and scientific strategy for this ambitious effort.

At home, the group is promoting deep carbon science with the Department of Energy leadership. Numerous other activities include outreach to the National Science Foundation to establish new programs in its Earth Sciences and Biosciences directorate; visits to discuss deep carbon activities with key academic institutions; engaging with Shell Oil in a new research effort; continued expansion of the DCO Web site (http://dco.ciw.edu); and administering new Sloan Foundation–sponsored funding opportunities in deep carbon instrumentation and a Deep Carbon Fellowship program. □

Carbon not only fuels our daily lives, it is also the basis of all known life.

(Below) At present, almost everything scientists know about the carbon cycle is confined to how the element circulates near the surface and in the atmosphere.
Image courtesy NOAA

(Right) The Japanese drill ship *Chikyu* is two-thirds the length of the *Titanic*. It will be able to drill through about 23,000 feet of crust (7,000 meters) in 8,200 feet (2,500 meters) of water.
Image courtesy Det Norske Veritas



INAMORI MAGELLAN Areal Camera and Spectrograph

Reveals Earliest Known Galaxy Cluster

A team of astronomers including Observatories postdoc Ivelina Momcheva has discovered the most distant cluster of galaxies ever found. In a surprising twist, the young cluster born just 2.8 billion years after the Big Bang appears remarkably similar to the present-day galaxy clusters.

"We were looking for clusters of galaxies when the universe was still very young," said Momcheva, who did the spectroscopic analysis on the Inamori Magellan Areal Camera and Spectrograph (IMACS) that led to the discovery of the cluster. "One might think that the clusters we find would look young as well. However, in this cluster we found a number of surprisingly ancient-looking galaxies. This cluster resembles modern-day clusters, which are nearly 10 billion years older."

CLG J02182-05102, as the cluster is called, contains approximately 60 galaxies. Several enormous red galaxies at its center hold 10 times as many stars as the Milky Way. Such huge galaxies were thought to be rare in the universe at this early stage. Similar galaxy clusters today have had billions of more years to develop and grow.

The cluster was first detected using NASA's Spitzer Space Telescope, which is sensitive to the infrared light emitted by the galaxies. The researchers observed a high density of galaxies, but could not determine from the Spitzer data whether they are indeed gravitationally bound, as is the case with true galaxy clusters. For these measurements, the team, which also included Carnegie astronomer Patrick McCarthy, used the IMACS on the Magellan Baade 6.5-meter telescope at the Las Campanas Observatory in Chile. The IMACS instrument, built by a team led by Alan Dressler, is uniquely sensitive at the light wavelengths needed for the study. "I was myself astonished that IMACS was able to do this," said Dressler. "The detection of the oxygen emission was almost at the limit of its wavelength range. This team was bold enough to try, and it succeeded."

Analyzing the faint light from seven galaxies near the center of the cluster, the researchers found that the galaxies had an average redshift of 1.62. "This means that we are seeing it the way it looked 9.6 billion years ago," said Momcheva. "Since then it has moved away from us as the universe has expanded. Today the distance to the cluster is 15 billion light-years."

"We are witnessing the youth of a truly massive cluster of galaxies," said Momcheva. "CLG J02182-05102 will continue growing, accreting more galaxies and slowly aging. By the present day it has probably grown to be a large metropolis of a cluster like our neighbor, the Coma cluster." □

The composite image below combining infrared and visible-light observations shows a distant galaxy cluster with surprisingly large collections of galaxies (red dots in center).

Image courtesy NASA/JPL-Caltech/Subaru

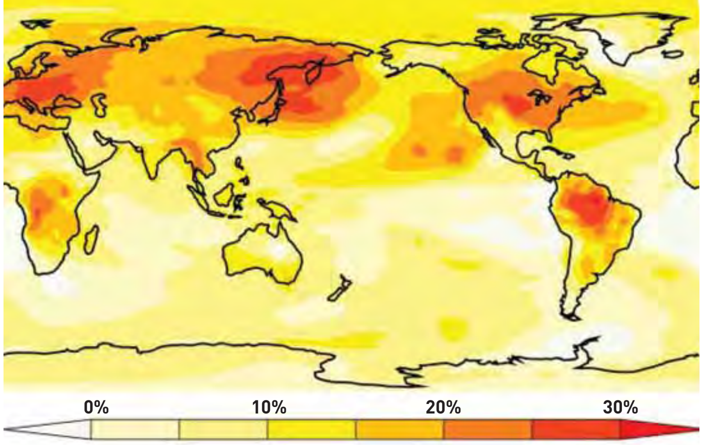
(Above) Engineer Tyson Hare inserts a slit mask into the front end of the IMACS, Carnegie's highly versatile wide-field imager and multiobject spectrograph. Its sensitivity at key wavelengths was essential to the discovery of the galaxy cluster.

Image courtesy Alan Dressler

(Left) Ivelina Momcheva

Image courtesy Ivelina Momcheva

CO_2 Makes Plants Increase Global Warming



TREES AND OTHER PLANTS help keep the planet cool, but rising levels of carbon dioxide in the atmosphere are turning down this global air conditioner. According to a new study by researchers at the Department of Global Ecology, in some regions more than a quarter of the warming from increased carbon dioxide is due to its direct impact on vegetation. This warming is in addition to carbon dioxide's better-known effect as a heat-trapping greenhouse gas. For scientists trying to predict global climate change, the study underscores the importance of including plants in climate models.

"Plants have a very complex and diverse influence on the climate system," said study coauthor Ken Caldeira. "Plants take carbon dioxide out of the atmosphere, but they also have other effects, such as changing the amount of evaporation from the land surface. It's impossible to make good climate predictions without taking all of these factors into account."

Plants give off water through tiny pores in their leaves, a process called evapotranspiration that cools the plant, just as perspiration cools our bodies. On a hot day, a tree can release tens of gallons of water into the air, acting as a natural air conditioner for its surroundings. The plants absorb carbon dioxide for photosynthesis through the same pores. But when carbon dioxide levels are high, the leaf pores shrink, causing less water to be released and diminishing the tree's cooling power.

Caldeira and fellow Carnegie scientist Long Cao were concerned that it is not widely recognized that carbon dioxide warms the planet by its direct effects on plants. Previous work by Carnegie's Chris Field and Joe Berry had indicated that the effects were important. "There is no longer any doubt that carbon dioxide decreases evaporative cooling by plants and that this decreased cooling adds to global warming," remarked Cao. "This effect would cause significant warming even if carbon dioxide were not a greenhouse gas."

In their model, the researchers doubled the concentration of atmospheric carbon dioxide and recorded the magnitude and geographic pattern of warming from different factors. They found that, averaged over the entire globe, the evapotranspiration effects of plants account for 16% of warming of the land surface, with greenhouse effects accounting for the rest. In some regions, such as parts of North America and eastern Asia, evapotranspiration can account for more than 25% of the total warming.

The researchers also found that their model predicted that high carbon dioxide will increase the runoff from the land surface in most areas, because more water from precipitation bypasses the plant cooling system and flows directly to rivers and streams. Earlier models based on greenhouse effects of carbon dioxide had also predicted higher runoff, but the new research predicts that changes in evapotranspiration due to high carbon dioxide could have an even stronger impact on water resources than those models predict. The study was published in the May 3-7 online edition of the *Proceedings of the National Academy of Sciences*. □

This map shows the percentage of predicted warming due to the direct effect of carbon dioxide on plants. In addition to warming the Earth from the greenhouse effect, carbon dioxide causes plants to provide less evaporative cooling. A study by Long Cao and Ken Caldeira of Global Ecology finds that in some places (darkest orange) over 25% of the warming from increased atmospheric carbon dioxide is a result of decreased evaporative cooling by plants.

For Stem Cells, Practice Makes Perfect

MULTIPOTENT STEM CELLS develop into different types of cells by reprogramming their DNA to turn on different combinations of genes, a process called differentiation. In a new study, researchers at the Department of Embryology found that reprogramming is imperfect in the early stages of differentiation; some genes turn on and off at random. As cell divisions continue, the stability of the differentiation process increases by a factor of 100. The finding will help scientists understand how stem cells reprogram their genes and why fully differentiated cells are very hard to reprogram—knowledge that could impact the study of aging, regenerative medicine, and cancer research.

Allan Spradling and Andrew Skora studied stem cells in the ovaries of the fruit fly *Drosophila*. The stem cells develop into specialized follicle cells over nine generations of cell divisions. In the study, the researchers kept track of genes located at different sites on the chromosomes as the

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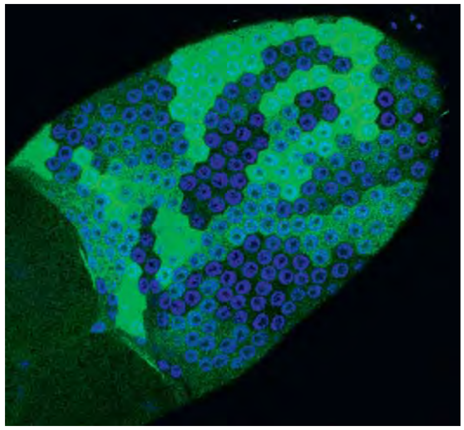
For Stem Cells, Practice Makes Perfect

follicle cells developed. They reasoned that if the programming were perfectly transmitted from parent to daughter cell, the follicle cells would express the gene at the same level after each division. But, surprisingly, they found that in the first division random changes occurred 41% of the time. By the fifth division changes took place about 8% of the time, and by the ninth division only 0.37% of the time.

The scientists speculate that stem cells may be deficient in epigenetic inheritance machinery to prevent them from differentiating prematurely, and that this deficiency helps maintain the flexibility to give rise to many different cell types. Changes in chromosome structure, as opposed to changes in the genes themselves, which are passed on to the next generation are called epigenetic changes. "Stem cells appear unable to faithfully pass on a particular genetic program to their daughter cells," said Spradling. "Apparently, before one particular kind of cell can differentiate from a stem cell, its progenitors have to learn how to maintain and transmit programming information."



Genetic programming is unstable downstream from follicle stem cells. The follicle cells in this image developed from the same stem cells, but their gene expression varies, as seen by different colors expressed by reporter genes. (Scale bar, 25 m.)

Image courtesy *Proceedings of the National Academy of Sciences.*

Spradling explained that their research confirmed the expectation that at least some of the critical changes take place in the gene-bearing chromosomes themselves, rather than in external factors such as the cell's environment or signals from other cells. Most likely the reprogramming alters proteins on the chromosome, which package the DNA and control which genes are expressed. The researchers hope that the research will provide a way to learn more about the methods cells use to transmit epigenetic information faithfully during cell division. The results were published in the *Proceedings of the National Academy of Sciences.* □

(Top) Scientists, postdocs, and support staff worked for weeks packing journals and staging the boxes.

(Center) Next stop, China!

(Left) Merri Wolf oversaw the frenzy of activity at the loading dock.

Images courtesy Shaun Hardy

Journals Bound for China

BY SHAUN J. HARDY

A 20-FOOT SEA CONTAINER left snowy Washington this winter, bound for China. Its cargo—750 boxes of scientific journals, donated by the Broad Branch Road campus library to Xiamen University in Fujian Province.

More than 30 volunteers from the Department of Terrestrial Magnetism and the Geophysical Laboratory pitched in to help library staff members Merri Wolf and Shaun Hardy with boxing, labeling, and loading the huge shipment. Carnegie scientists now access most physics, chemistry, and astronomy periodicals online, so the time had come to find a new home for many of the library's print volumes. That search led to Bridge to Asia, a San Francisco–based foundation that supports research and education in developing Asian countries, primarily China. Bridge to Asia facilitated the arrangement with Xiamen and covered all of the shipping expenses.

Washington's back-to-back blizzards (dubbed Snowmaggedon in the local media) delayed the project a couple of weeks, but on February 25, a truck carrying an empty container finally arrived at our loading dock. In less than two hours it was filled and on its way—a symbol of international goodwill and Carnegie's ongoing commitment "to encourage investigation, research, and discovery." □

InBrief

❶ Trustee and astronomer Sandra Faber

❷ Carnegie president Richard A. Meserve received an honorary doctorate of science at Washington College.
Image courtesy Washington College

❸ Embryology director Allan Spradling

❹ Masatoshi Takeichi

❺ Mario Izaguirre-Sierra

TRUSTEES AND ADMINISTRATION

❶ Trustee **Sandra Faber** was selected as the principal investigator of the largest Hubble proposal in history. Her team will study distant galaxy evolution using the newly installed Wide Field Camera 3 (see www.ucsc.edu/news_events/ text.asp?pid=3619). Faber, with Wendy Freedman and Alan Dressler, had feature roles in the recent Hubble telescope 20th anniversary video. The video can be seen at http://hubblesite.org/newscenter/archive/releases/2010/13/video/a/.

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❷ Carnegie president **Richard A. Meserve** moderated a session on human resources for nuclear safety at an IAEA conference in Abu Dhabi Mar. 15. He attended a meeting of the Blue Ribbon Commission on America's Nuclear Future Mar. 24-26, and participated in meetings of the Harvard board of overseers Apr. 10-11 and May 25-26. He chaired a meeting of IAEA's International Nuclear Safety Group in Vienna, Austria, on Apr. 14-16, and a meeting of the National Academies' Nuclear and Radiation Studies Board on Apr. 26-27. He spoke at the Washington College Commencement in Chestertown, MD, on May 16, and received an honorary degree. Meserve served as cochair of a meeting of the National Academies' Committee on Science,Technology, and Law May 17-18 in Washington, DC, and attended the Nuclear Power Plant Export Code of Conduct Meeting, sponsored by the Carnegie Endowment for International Peace, on May 19-21 in Toronto. On June 21 he gave a lecture on national energy policy at the Nuclear Plant Safety Summer Course at MIT.

Carnegie is a partner in the Inaugural USA Science & Engineering Festival

Carnegie is an official partner in the Inaugural USA Science & Engineering Festival to be held Oct. 10-24 in Washington, DC. It will be the first national, multicultural, multigenerational, multidisciplinary celebration of science in the U.S. and will feature a two-day expo on the DC mall, which will host 500 exhibitors. □

EMBRYOLOGY

❸ Director **Allan Spradling** presented seminars at Baylor U., UC-Davis, U. Nebraska-Omaha, and U. Kentucky in Lexington. He also spoke at the NIH Chromatin Symposium and was a member of the Janelia Project Teams Symposium held at HHMI, Janelia Campus, in Ashburn, VA. Spradling attended the 51st Annual *Drosophila* Research Conference in Washington, DC, with several lab members.

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Four Gall lab members, **Joseph Gall**, **Zehra Nizami**, **Sveta Deryusheva**, and **Dan Escobar**—attended the 51st Annual *Drosophila* Research Conference Apr. 7-11.

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Yixian Zheng is coteaching a stem cell course in the Biology Dept. at Johns Hopkins as part of the core curriculum for the Cell, Molecular, Developmental Biology, and Biophysics Program. **Alex Bortvin**, **Marnie Halpern**, and **Allan Spradling** are also coteaching a Hopkins course, "Genomes and Development," which will also be part of the core curriculum.

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Marnie Halpern was the keynote speaker at the 2nd Israeli Meeting on Zebrafish as a Model Organism for Biomedical Studies, Tel Aviv U., Feb. 15 and gave a seminar at The Weizmann Inst. of Science in Rehovot, Israel, Feb. 16.

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Doug Koshland gave seminars at U. Massachusetts Medical School in Worcester, U. Montreal, and the Salk Research Inst.

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Steve Farber gave the seminar "Visualizing Intestinal Lipid Metabolism in Live Animals: Studies with Guts" at U. Nebraska-Lincoln.

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❹ Former Embryology postdoctoral fellow **Masatoshi Takeichi** visited the department on Apr. 20 and presented a lecture. He is director of the RIKEN Center for Developmental Biology in Kobe, Japan.

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Spradling lab postdoc **Andrew Skora** received third-place honors at the annual *Drosophila* meeting for his poster "Epigenetic stability increases in the *Drosophila* follicle stem cell lineage." **Ming-Chia Lee** joined the Spradling lab as a postdoc in Mar. working on the molecular mechanisms underlying lineage-dependent epigenetic stability.

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❺ Postdoc **Mario Izaguirre-Sierra** joined the Gall lab May 1 to study nuclear bodies in *Drosophila*.

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DCBiotech Member & Former Carnegie Intern Wins Full Scholarship to College

Isaiah West, a resident of southeast Washington, D.C., is a former Carnegie intern in the communications office and member of the Ballou High School DCBiotech program. He is the 2010 Ballou valedictorian and was awarded the prestigious Gates Millennium Scholarship, which covers all costs at any university for any major. West is interested in studying medicine. The Carnegie Academy for Science Education (CASE) is the lead organization for DCBiotech, which assists the District of Columbia Public Schools' Office of Career and Technical Education to establish rigorous, productive biotechnology academies at two Washington D.C., high schools.

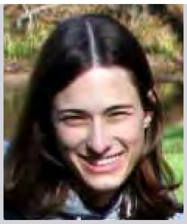
Codirector of CASE Toby Horn was introduced to West his sophomore year through the DCBiotech partnership. She recommended him for an internship in the communications office to assist with multimedia content, where he worked for two summers. West was not only one of seven D.C. students awarded the Gates scholarship, he was among nine D.C. high school seniors given a full scholarship to the George Washington University. He has decided to attend Emory University in Atlanta in the fall. Congratulations Isaiah! □

Isaiah West, member of the Ballou High School DCBiotech program, former Carnegie intern, and the 2010 Ballou valedictorian, will go to Emory University on a full scholarship based on his academic achievements.

The 29th Annual Minisymposium on Apr. 29-30, "Journey of the Germ Cell,"

was organized by postdoctoral fellows Joshua Bembenek, Vicki Losick, and Jianjun Sun. It highlighted several discoveries that have allowed us to appreciate how an undifferentiated cell becomes a gamete. □

From the left, symposium organizers Joshua Bembenek, Jianjun Sun, and Vicki Losick



❻ Jill Heidinger-Pauli (left), Margaret Hoang (right).

Doug Koshland Elected to National Academy of Sciences

Douglas E. Koshland, staff scientist at the Department of Embryology, was elected one of 72 new members of the National Academy of Sciences for his excellence in original scientific research. Koshland will be inducted into the academy next April during its 148th annual meeting in Washington, DC.

Using the simple, single-celled yeast *Saccharomyces cerevisiae*, Koshland has become a leader in studying the molecular processes that control the dynamics of chromosome structure and evolution—the foundations for understanding developmental problems and diseases such as cancer. □

❻ Two Koshland lab graduate students successfully defended their Ph.D. theses: **Jill Heidinger-Pauli** in Feb. and **Margaret Hoang** in Apr.

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Halpern lab graduate student **Courtney Akitake** spoke at the Mid-Atlantic Zebrafish Meeting in Philadelphia Apr. 16.

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In Mar. Farber lab graduate student **Tim Mulligan** successfully defended his Ph.D. thesis.

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The department hosted the alumni meeting of the HHMI-NIH Research Scholars Program on Mar. 30.

GEOPHYSICAL LABORATORY

❼ Director **Russell Hemley** has been appointed to the Science Advisory Committee for Brookhaven National Laboratory's Light Sources Directorate, which is building the world's brightest X-ray source, the National Synchrotron Light Source II. For more information on the committee see www.nsls.bnl.gov/organization/committees/sac. Hemley presented talks at Penn State's Pennergy Colloquium on Feb. 19; Rensselaer Polytechnic Institute's Dept. of Materials Science and Engineering Seminar on Mar. 24; the Advanced Photon Source on Apr. 2; Indiana U.'s Joseph and Sophia Konopinski Colloquium on Apr. 14; the State Key Laboratory of Superhard Materials at Jilin U. on Apr. 19; and the Chinese Institute of Physics' Zhongguancun Forum on Apr. 21. During a trip to Beijing for the 2nd International Conference on the Deep Carbon Cycle in Apr., Hemley, with **Robert Hazen** and **Connie Bertka**, met with leaders from key Chinese science foundations to encourage their support and participation. This meeting, as well as the conference organization, benefited from the efforts of staff member **Yingwei Fei**. With the help of Carnegie trustee **John Crawford**, Hemley, Bertka, and Hazen also took part in meetings with French science and industry leaders.

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Robert Hazen presented lectures on mineral evolution at CalTech, U. Arizona, U. Chicago, Loyola Marymount U., Scripps Research Inst., and the AAAS, and was the Bradley Lecturer at the Geological Society of Washington. He also presented lectures on deep carbon research at the U.S. Dept. of Energy, Institute de Physique du Globe, Paris, and was keynote speaker at the Second Deep Carbon Cycle Workshop in Beijing.

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Marilyn Fogel hosted two visiting scientists. **Ana Liberoff**, from the Consejo Nacional de Investigaciones Científicas y Técnicas in Argentina, visited Jan. 13-Feb. 15. She analyzed samples for isotopic compositions related to her doctoral research. **Valery Terwilliger**, from U. Kansas, visited the lab Feb. 2-Apr. 21 to conduct a paleoclimate study of Ethiopia.

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Doug Rumble presented a paper at the Lunar and Planetary Sciences Conference Mar.1-5 in Houston. He also attended the board of directors meeting of GeoScience World in New Orleans Apr.15-16.

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Bjørn Mysen gave an invited talk at the first Global Network Symposium in Sendai, Japan, Mar. 2-4.

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On Mar. 15-19 **Muhetaer Aihaiti** gave a talk at the APS March Meeting in Portland, OR.

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On Mar. 9 **Henderson James (Jim) Cleaves** gave a talk at Georgia Tech and attended an editorial meeting for the Springer Encyclopedia of Astrobiology Mar. 15-19 in Madrid. He hosted graduate student **Ed Greiner** from U. Wisconsin Mar. 28- Apr. 9 and taught a class at George Mason U. on Apr. 5. On Apr. 18-23 he worked on developing high-resolution chromatographic and mass spectrometry techniques at Spelman Coll. and Georgia Tech in Atlanta. He chaired a session and spoke at AbSciCon in Houston Apr. 27.

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HPCAT

HPCAT project manager **Guoyin Shen** is a member of the advisory committee for the Materials Science Beamline at MAX-I, Sweden, and a member of the advisory committee for the XOR Beamline, Sector 3, at APS.

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Arrivals: Beamline scientist **Dmitry Popov** (Paul Scherrer Inst., Switzerland) arrived on Apr. 15.

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HPSynC

Lin Wang was promoted from postdoctoral scientist to research scientist on Apr. 15. He has had several recent publications in journals such as the *PNAS*.

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The 2010 APS Users Meeting was held May 3-5.

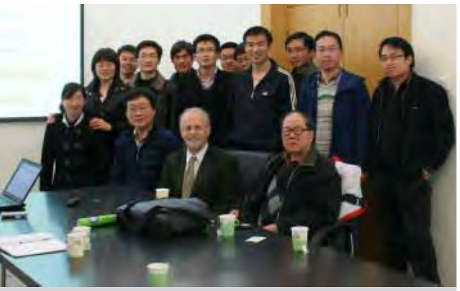
The Jewish Community Services (JCS), a nonprofit human services agency, honored Carnegie with an Employer Partnership Award at their annual meeting June 7 for bringing jobs to the community and working with JCS to get people back to work. Sue Kerns accepted the award. JCS, launched July 1, 2008, consolidated four existing social service agencies. □

GLOBAL ECOLOGY

❽ Director **Chris Field** attended a USGS Global Change workshop in Denver Mar. 9-11. Field and Peter Darbee, CEO of Pacific Gas & Electric, released a white paper on climate change for policymakers and business.

Former GL staff member Gordon Leslie Davis died on Feb. 15 at the age of 97. He joined the lab in 1941 to look at radium in ultrabasic rocks and became a physicist in 1942. His work became an integral part of the Carnegie program to determine rock and mineral ages. A memorial service was held for him Mar. 26 at the Unitarian Universalist Church of Rockville, MD. □

Gordon Leslie Davis in the Geophysical Lab



❼ Director Rus Hemley poses with colleagues from the Chinese Institute of Physics.

❽ Global Ecology director Chris Field (second from right) testified May 6 before the Select Committee on Energy Independence and Global Warming about the foundation of climate science.

Image courtesy U.S. Congress

The paper summarizes the best scientific evidence for climate change and addresses a number of the recent questions raised about the climate and the responses to it. In Apr. Field was elected to the American Academy of Arts and Sciences. The academy cited Field for his research in global ecology and contributions to the assessment and understanding of climate change.

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Greg Asner and **Robin Martin** conducted field research in Osa, Costa Rica, Jan. 4-13; Huampal, Peru, Jan. 31-Feb. 9; Lambir, Malaysia, Feb. 27-Mar. 8; and Madagascar, Mar. 17-Apr. 12. They collaborated with several institutions, including the Lambir Forestry Service, the World Wildlife Fund, and the Missouri Botanical Gardens.

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The Asner lab's **Guayana Paez-Acosta** and **John Clark** are advancing the CLASlite program. In Feb. they partnered with Red Amazónica de Información Socioambiental Georreferenciada and Fundación Gaia Colombia, Bogota. In Mar. they partnered with the Instituto de Conservação e Desenvolvimento Sustentável do Amazonas, Manaus, Brazil; the Instituto de Pesquisa Ambiental da Amazônia, Brasilia, Brazil; and the Viceministerio de Medio Ambiente, Biodiversidad, Cambios Climáticos y Gestión y Desarrollo Forestal, La Paz, Bolivia.

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❾ The Carnegie Airborne Observatory (CAO) traveled to Madagascar and South Africa in Mar. and Apr. In Madagascar, **Ty Kennedy-Bowdoin** and **James Jacobson** collected data to assess carbon storage in that country's dwindling native forests as a continuation of their REDD research in Hawaii, Peru, and Panama. They created a baseline for native forests to assess changes, particularly hardwood logging. The trip to South Africa was made to survey the savanna in Kruger National Park. Carnegie scientists and their collaborators will be using these datasets to explore how key drivers of changes, such as fire, elephants, and humans, influence the structure and function of the savanna.

—

Greg Asner, **Shaun Levick**, **Scott Loarie** and **Matt Colgan** attended the 8th Annual Savanna Science Network Meeting Mar. 8-12 in Skukuza, Kruger National Park, South Africa, where they presented some publications from the 2008 CAO flight campaign. Asner and Levick met with numerous local and international scientists and park managers to build on collaborations by using CAO data to address key issues in savanna ecology and conservation. Colgan embarked on a two-month field campaign to correlate direct biomass measurements of trees with airborne LiDAR—the first study of its kind in savannas.

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From Hawaii, the Asner lab's **Eben Broadbent** and **Angelica Almeyda** published their study on tourism and forest conservation in the Osa Peninsula, Costa Rica. It is the first in a three-part series.

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Marion O'Leary organized a Carnegie briefing on climate change, highlighting the Asner team's work on tropical deforestation. Carnegie president **Richard Meserve** and Carnegie trustee **Will Hearst** were the hosts.

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On Mar. 22 **Ken Caldeira** was on NPR (KQED) to discuss ways to cool our planet via geoengineering. On Mar. 31 he spoke at UCLA. On Apr. 14 he spoke on "Intentional and Unintentional Climate Change: Using Global Models to Inform Public Policy" at the Dept. of Environmental Earth System Science at Stanford, and on Apr. 16 he again appeared on NPR.

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Members of the IPCC Working Group 2 Technical Support Unit attended an authors' meeting in Hanoi Mar. 17-19. Attendees were **Chris Field**, **Kris Ebi**, **Michael Mastrandrea**, and **Yuka Estrada**.

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On Apr. 10 Field lab graduate student **Kyla Dahlin** gave a talk at a Washington, DC, conference on science and technology in society. In Apr. graduate students **Bill Anderegg** and **Jennifer Johnson** were awarded NSF Graduate Research Fellowships for their "outstanding abilities and accomplishments . . . and potential to contribute to strengthening the vitality of the U.S. science and engineering enterprise."

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❿ The Caldeira lab's **Julia Pongratz** presented a poster at the Berkeley Atmospheric Sciences Center symposium in Feb. and gave two invited talks, one at Woods Hole Research Center on Mar. 23 and one at UCLA on Apr. 29. She was awarded the Otto Hahn Medal of the Max Planck Society for her Ph.D. work on the human impact on climate in Germany in June.

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The Berry lab's **Adam Wolf** defended his Ph.D. dissertation at Stanford and will leave in Nov. for Princeton U.

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Arrivals: Jean Baptiste Feret joined the Asner group in Feb. from the Geophysics Institute of Paris, where he completed his Ph.D. in remote sensing. In Mar. **Eric Kissel** joined the Technical Support Unit of Working Group 2 at the IPCC to support Chris Field and Working Group 2 for Assessment Report 5. **Stephanie May** began working part time on the Caldeira lab Web page in Mar.

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Departures: Graduate student **Carolyn Snyder** accepted a position in July as director for clean energy and climate policy for Delaware.

OBSERVATORIES

⓫ In Jan. **Wendy Freedman** served on a tenure review committee for the Harvard U. Dept. of Astronomy. She attended the Canadian Inst. for Advanced Research (CIFAR) Cosmology conference at Lake Louise in Feb. As a member of the NRC Division of Engineering and Physical Sciences Committee, Freedman participated in the Mar. 3-4 meeting in Washington, DC. As chair of the Astronomy and Astrophysics Advisory Committee, Freedman completed the annual report to NASA, NSF, DOE, OMB, and Congress about the status of programs in astronomy and astrophysics. She gave an invited colloquium at Argonne National Laboratory on the GMT.

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Director Emeritus **George Preston** delivered the Henry Norris Russell Lecture Jan. 4 at the AAS in Washington, DC. On Jan. 14 he presented a salutatory address at U. Washington for

❾ **This series of images show the Asner team in Madagascar.** Image courtesy Greg Asner and team

❿ Julia Pongratz

⓫ Observatories director Wendy Freedman

⓬ Alan Dressler

⓭ Alan Uomoto

⓮ Jane Rigby is shown volunteering at the Webster Elementary School in Pasadena.

⓯ Janice Lee (left), Mark Seibert (right)

astronomer George Wallerstein's 80th birthday.

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⓬ On Mar. 17 staff member **Alan Dressler** gave a public lecture, "The Living History of the Universe," as part of the NOAO 40th anniversary celebration.

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Ian Thompson will serve as the Observatories' associate director for technical affairs, and staff member **John Mulchaey** will serve as associate director for academic affairs. **Alan Uomoto** has been appointed Magellan technical manager. **Jeff Crane**, formerly a Carnegie Fellow in instrumentation, is now a staff associate.

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In Feb. senior research associate **Barry Madore** gave a talk at the conference "Infrared Emission, the Interstellar Medium and Star Formation" at the Max Planck Institute for Astronomy in Heidelberg. In late Mar. he attended the first meeting of the Virtual Astronomical Observatory (VAO) at the Goddard Space Flight Center as a founding member of the VAO Science Council. That same week he gave a seminar at Boston U. On Apr. 8, as part of a collaborative teaching project with Pomona Coll., he gave an undergraduate seminar.

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Staff member **Juna Kollmeier** gave colloquia at the National Radio Astronomy Observatory in New Mexico; at U. Wisconsin, Madison Dept. of Astronomy; and at the Kavli Inst. for Cosmological Physics there. She also gave a galaxy seminar at U. Wisconsin.

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⓭ Magellan technical manager **Alan Uomoto** announced that the Magellan telescopes have two new infrared spectrographs. MMIRS, built by a team at the Smithsonian Astrophysical Observatory led by Brian McLeod, is a multiobject infrared spectrograph that enables stellar composition studies of high redshift galaxy clusters. The FIRE spectrograph, built by a team at MIT led by Rob Simcoe, is a medium-resolution instrument designed for detailed studies of faint brown dwarf stars and high redshift quasars.

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Carnegie Fellow **Josh Simon** gave colloquia at Johns Hopkins on Feb. 23 and at U. Arizona on Mar. 4, and a lunch talk at the Observatories on Mar. 25.

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Carnegie Fellow **Masami Ouchi** gave an invited talk at the conference "Cosmological Reionization" at Harish-Chandra Research Inst., India, Feb. 16-20. He observed at the W. M. Keck Observatory in Hawaii in Feb. and at Las Campanas Observatory in Chile in Feb./Mar.

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⓮ Carnegie Fellow **Jane Rigby** attended the AAS meeting in Washington, DC, in early Jan. She gave a colloquium at Tufts U. in Feb. and a seminar at Arizona State U. in Mar.

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⓯ Carnegie Fellow **Janice Lee** organized and spoke at a special session at the AAS meeting. She lectured at U. Michigan, at U. Wisconsin-Madison, and at the STSI. Lee and postdoc **Mark Seibert** were the principal organizers and cochairs of the conference "UP: Have Observations Revealed a Variable Upper End of the Initial Mass Function?" June 20-25 in Sedona, AZ.

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NSF Fellow **Karín Menéndez-Delmestre** attended the Astronomy & Astrophysics NSF Postdoctoral Fellows Symposium Jan. 2-3 in Washington, DC, where she discussed her work on the internal dynamics of distant submillimeter-selected galaxies. On Feb. 8 she coordinated a lunch discussion on women in science led by Columbia astronomer Kathryn Johnston. The event was attended by women astronomers from Carnegie, Caltech, the Spitzer Science Center, and the Infrared Processing and Analysis Center.

PLANT BIOLOGY

Director **Wolf Frommer** was the cochair of the "Genetics & Genomics, Molecular Biology, Plant Biology" sessions at the Keystone Symposia on Molecular and Cellular Biology held at Silverthorne, CO, Jan. 19-24. He was an invited speaker at Monsanto Co., St. Louis, Mar. 23-24. On Apr. 16 he was an invited speaker at UC-San Diego and spoke on "Dynamic Imaging of Metabolite Flux Impedance as a Discovery Tool: Identification of Novel Transporters and Signaling Networks."

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Director Emeritus **Winslow Briggs** participated in the department's Autobiographical Perspectives Seminar series on Jan. 15. On Feb. 9 he gave a talk at U. Ulsan, Ulsan, Korea. He spoke about LOV domains on Feb. 15 at Seoul National U., and on Feb. 16 at Sookmyung Women's U., Seoul. On Apr. 9 he spoke at Santa Clara U. on wildfire in Henry W. Coe State Park, and on Apr. 19 he presented a talk at UCLA on phototropins.

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On Apr. 11 and 12 **Arthur Grossman** gave two seminars at the Hebrew U. in Jerusalem, one on sulfur deprivation of photosynthetic organisms and another on oil production by algae. On Apr. 22 he attended the inaugural SD-CAP Biofuels Symposium 2010 and presented a talk. On Apr. 30 he gave a seminar at UC-Davis.

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Zhiyong Wang gave a seminar on Mar. 23 at the Swiss Federal Inst. of Technology, ETH Zurich. On Mar. 25 he gave an invited seminar at the annual meeting of BRAVISSIMO, an EU-sponsored network on brassinosteroid research, held in Lausanne, Switzerland. He gave a similar seminar at U. Geneva on Mar. 26.

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On Feb. 7 **Devaki Bhaya** was the invited speaker at Darwin Day Celebrations at Stanford U., and on Apr. 19 she attended the Advisory Meeting of the Metacyc/Ecocyc databases at SRI, Menlo Park, CA. On Apr. 26 and 27 she attended the 2010 Conference on Frontiers in Mathematical Biology at U. Maryland.

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Matt Evans attended the 52nd Annual Maize Genetics Conference in Riva del Garda, Italy, Mar. 18-21.

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Martin Jonikas attended the 19th Western Photosynthesis Conference & Arnon Centennial Symposium in Asilomar, CA, Mar. 18-21. He presented a talk on Apr. 13 at the BioEngineering Dept., Stanford U.

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⓰ **Arrivals:** On Feb. 22 postdoc **Alexander Jones** (UC-Berkeley) joined the Frommer lab. Postdoc **Ankit Walia** joined the Ehrhardt lab May 1. On Feb. 16 the Rhee group welcomed fellow **Flavia Bossi** and research assistant **Hye-In Nam**. The Jonikas lab welcomed **William Stork** (Stanford U.) on Apr. 29 and postdoc **Ru Zhang** (U. Wisconsin-Madison) on Apr. 1. Two volunteers joined the department, **Kaitlyn Baab** (Castilleja High School) and **Jisoo Kim** (UC-Davis).

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Departures: Postdoc **Hitomi Takanaga** left the Frommer lab on Mar. 26 for a position at Santen, Inc., in Napa, CA. Software engineer **Raymond Chetty** left the TAIR group on Apr. 16 for RIKEN in Japan; **Tom Meyer** also left. On Apr. 22 lab assistant **Bindu Ambaru** left the Rhee lab to return to India.

TERRESTRIAL MAGNETISM

Director **Sean Solomon** delivered a Geodynamics Seminar about crustal formation on Mercury at the Woods Hole Oceanographic Institution in Feb. In Mar. he chaired and spoke at a special session on MESSENGER's third flyby of Mercury at the 41st Lunar and Planetary Science Conference in Houston, and he served on a panel that reviewed the facilities in NSF's EarthScope Program. In Apr. he gave a NASA Space Grant lecture on exploring Mercury to an undergraduate class at U. Washington, spoke on the MESSENGER mission to a NASA workshop at the National Afterschool Association, and presented lessons learned from MESSENGER to a NASA forum for spacecraft mission principal investigators.

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In Mar. **Vera Rubin** visited Skidmore Coll. to meet with students and give a colloquium on dark matter. The National Space Grant Foundation awarded her their 2010 Distinguished Service Award at their annual meeting, where Rubin answered questions on astronomy after receiving the award. Also in Mar. she opened the Kitt Peak National

Shown here (left to right) are host Hongfu Zhang, Jianhua Wang, and Steve Shirey in front of a now-inactive diamond mine in the Pipe 50 kimberlite.
Image courtesy Steve Shirey

Steve Shirey and ion microprobe research specialist Jianhua Wang participated in the 2nd Deep Carbon Cycle International Conference in Beijing, and followed the conference with fieldwork in the Fuxian kimberlite field in Lioaning Province.

⓰ Alexander Jones

⓱ Alan Boss and his wife, Catherine, stand in front of the Western Wall in Jerusalem. Boss is the 2010 Yuval Ne'eman Distinguished Lecturer in Geophysics, Atmosphere, and Space Sciences at Tel Aviv U. He lectured on extrasolar planets, gas giant planet formation, and supernova triggering of the formation of the Solar System. The lectureship is supported by the Raymond and Beverly Sackler endowment at TAU.

⓲ Elizabeth (Liz) Anne Myhill

⓳ Douglas Orson ReVelle

⓴ Archivist student David Black worked with Shaun Hardy.

Observatory's 50th anniversary celebration in Tucson. In Apr. Rubin visited the Carnegie Observatories and delivered two talks, including one at the Huntington Library.

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⓱ **Alan Boss** gave an invited talk about the search for habitable worlds at the American Physical Society/American Association of Physics Teachers Joint Meeting in Washington, DC, in Feb. He became the chair of the astronomy section at the AAAS's annual meeting, held in San Diego in Feb. In Mar. Boss gave a lecture on his book *The Crowded Universe* at the annual Teachers Conference at the Kavli Inst. for Theoretical Physics at UC-Santa Barbara. Boss became the chair of the Astrophysics Subcommittee of the NASA Advisory Council (NAC), as well as a member of NAC's Science Committee, and attended a meeting of the latter committee at NASA's Goddard Space Flight Center in Apr. He chaired a session and spoke on astrometric constraints on habitable planets at the NASA Astrobiology Science Conference in Houston in Apr.

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In Jan. **Paul Butler** gave colloquia on the search for extrasolar planets as part of the Space Telescope Science Institute's Star and Planet Formation Seminar Series and at the National Institute of Standards and Technology. In Apr. he spoke at California State U.-Northridge and delivered the Philosophical Society of Washington's Public Lecture.

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Rick Carlson hosted several visitors in Apr.: **Lars Borg** of Lawrence Livermore National Laboratory and former postdoctoral fellow **Maud Boyet**, now at U. Blaise Pascal, Clermont-Ferrand, France, who spent two weeks working on the analysis of ancient anorthosites from the lunar crust. **Ashley Bromley**, a student at Oregon State U., worked with Carlson on isotopic analyses of mantle and crustal xenoliths from China.

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John Chambers gave an invited talk on terrestrial planet formation models at the Exoplanets Rising Conference organized by the Kavli Inst. for Theoretical Physics in Santa Barbara in Mar.

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In Mar. **Larry Nittler** hosted former postdoctoral fellow **Henner Busemann** of U. Manchester and his graduate student **Nicole Spring** to work with the NanoSIMS ion microprobe. Nittler presented a lecture on presolar stardust at the Triangle Universities Nuclear Laboratory at Duke U. in Apr.

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Hubble Fellow **Mercedes López-Morales** participated in the first meeting of the Near-infrAred High-resolUtion spectrogrAph for pLanet hunting (NAHUAL) science working group held at the Center for Astrobiology, Madrid, in Jan. She gave colloquia on extrasolar planet searches at U. Central Florida and at the Hubble Fellows 20th Anniversary Symposium at the STSI in Feb. and Mar., respectively. Also in Mar. López-Morales hosted graduate student **Jeff Coughlin** of New Mexico State U. to work on Kepler mission data. She gave colloquia on extrasolar planets in Apr. and May at the American Museum of Natural History, at the Spanish National Research Council's Institute for Space Sciences, Barcelona, at the 2nd NAHUAL Science Team Meeting, at the U. Complutense de Madrid, at New Mexico State U., and at Vanderbilt U.

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Postdoctoral fellow **Wendy Nelson** and colleagues from U. College London participated in fieldwork in Tanzania in May, sampling carbonatite lavas and entrained xenoliths from volcanoes.

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Sean Solomon, **Conel Alexander**, **Alan Boss**, **Rick Carlson**, **Larry Nittler**, postdoctoral fellows **Frank Gyngard** and **Ming-Chang Liu**, and former postdoctoral fellow **Liping Qin** were among the DTM participants at the 41st Lunar and Planetary Science Conference held in Houston in Mar.

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Alan Linde, IT systems engineer **Michael Acierno**, and electronic design engineer **Brian Schleigh** serviced strainmeter and seismic stations in Montserrat in Apr. as part of the Caribbean Andesitic Lava Island Precision Seismo-geodetic Observatory project.

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Arrivals: Neng Jiang of the Inst. of Geology and Geophysics, Chinese Academy of Sciences, arrived for a yearlong visit in Apr. to work with Rick Carlson on isotopic analyses of mantle and crustal xenoliths from China.

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Former postdoctoral fellow **Teh-Ru (Alex) Song**, now at the Japan Agency for Marine-Earth Science and Technology, returned in Apr. for a six-month visit to conduct research on topics including the seismic structure and nature of slow slip and episodic tremor in the subduction zones of southwestern Japan and Sumatra.

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In Apr. **Ernst Zinner**, research professor at Washington U., arrived for a month-long visit as a Merle A. Tuve Fellow. An expert on the ion microprobe in the study of presolar grains and other problems in astrophysics and cosmochemistry, Zinner was a mentor to both Conel Alexander and Larry Nittler during their time at Washington U. Zinner presented a Tuve lecture on Apr. 14, "Stardust in the Laboratory: Where Do We Stand?"

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Machinist and instrument maker **Richard Bartholomew** died on Nov. 21, 2009, after a long battle with leukemia.

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⓲ **Elizabeth (Liz) Anne Myhill**, a research associate at DTM from 1993 to 1996, died of cancer on May 5. She was 49. Mayhill worked with Alan Boss testing their two independent radiative hydrodynamic codes for modeling the collapse of protostellar clouds.

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⓳ **Douglas Orson ReVelle** of Los Alamos, a postdoctoral fellow at DTM from 1977 to 1978, died on May 2 in Albuquerque. ReVelle worked at Los Alamos National Laboratory for 16 years before his retirement in Feb. He was recovering from lymphoma but experienced liver failure due to complications of chemotherapy treatment.

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Departures: Postdoctoral associate **Thomas Ruedas** departed in Apr. to return to Germany.

DTM/GL

Shaun Hardy hosted a meeting of the DC Science Librarians group at Broad Branch Road in Jan. to explore the status of e-books in science libraries.

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⓴ **David Black**, a graduate student in the School of Library and Information Science at Catholic U., completed a three-month internship in the DTM/GL library in Apr.

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2010

October 21 — **KAVLI LECTURE**
cohosted with the Royal Norwegian Embassy and the Norwegian Academy of Science and Letters
Speaker: **Dr. Roger Angel**, *Steward Observatory Mirror Lab, The University of Arizona*

November 3 — **BALZAN LECTURE**
cohosted with the embassies of Italy and Switzerland
Speaker: **Dr. Michael Grätzel**, *École Polytechnique Fédérale de Lausanne*

2011

January 20 — **NATIONAL SCIENCE & TECHNOLOGY MEDALS LECTURE**
cohosted with the National Science & Technology Medals Foundation and Biotechnology Institute
Speaker: **Dr. Elaine Fuchs**, *The Rockefeller University*

March 10 — **WASHINGTON, D.C., FILM PREMIERE**
The Office of Science & Technology at the Embassy of Austria, the Austrian Cultural Forum Washington and the American Chemical Society Film, *Carl Djerassi—My Life*
Speakers: **Dr. Carl Djerassi**, *inventor of the first oral contraceptive pill*
Madeleine Jacobs, *Executive Director and CEO of the American Chemical Society*

April 21 — **CARNEGIE LECTURE**
Speaker: **Dr. Alejandro Sánchez Alvarado**
Howard Hughes Medical Institute Investigator, University of Utah