CarnegieScience

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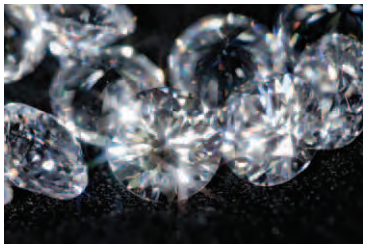
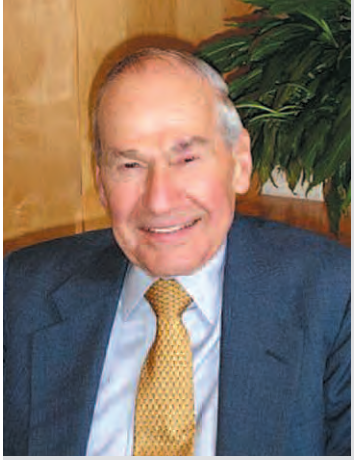
FALL 2008

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



On the Inside



Concerns over the supply, demand, and environmental consequences of energy use pervade daily headlines and crowd government agendas. Ideas abound for solving the maze of problems, including some surprising innovations from Carnegie researchers.

Chris Field and team at Global Ecology recently looked at the sustainability of using biomass energy—energy from agricultural waste or crops. They found that biofuels could be an important contributor to the world's energy equation, but the contribution is less than some have claimed if we are to avoid competition with food crops and limit environmental impacts.

Ken Caldeira, also at Global Ecology, is looking at some futuristic solutions to generate energy or to control the planet's climate. He is part of a group investigating ideas as revolutionary as installing enormous wind generators high in the stratosphere and suspending particulates in the atmosphere to reflect heat-generating sunlight.

Fundamental research at Plant Biology (PB) is the foundation for developing new crops, including those used for biofuels. David Ehrhardt and colleagues recently devised a marker to trace the formation of cellulose—the fibrous material found in all plants and the favored feedstock for biofuels. Sue Rhee and Eva Huala lead the newly launched Plant Metabolic Network (PMN) database. It consolidates research from around the world on plant metabolic processes, which is necessary information to accelerate both food and biofuels development.

Scientists at the Geophysical Lab (GL) are engaged in an array of energy-related research. Piezoelectrics are materials that translate mechanical energy into electricity and vice versa. Ron Cohen, Rus Hemley, and their group recently found the piezoelectric promise of lead titanate. Under pressure it behaves the same as more complex materials, and theory suggests that with pressure it has the largest piezoelectric response of any known substance. This research could cut costs and boost performance in technologies ranging from medical diagnostics to green energy.

Superconductors promise the loss-free transmission of electricity. Most superconductors have to be cooled to very low temperatures—temperatures that are impractical for transmission lines. Now GL's Viktor Struzhkin, Alexander Goncharov, and their team have found for the first time that the superconducting state can be induced by high pressure in a class of so-called high-temperature superconductors. This research opens a path to understanding superconductivity in these materials, with the eventual promise of uses that could totally change our energy system.

Carbon is key to life and is the currency of our energy structure. The Broad Branch Road campus shared by GL and the Department of Terrestrial Magnetism was the site for the three-day Deep Carbon Workshop in May. The event explored questions ranging from the potential carbon content of the Earth's interior to the search for living microbes deep in the Earth's crust. Over 100 participants attended. The meeting marked the birth of a new, Carnegie-led interdisciplinary field that will bring fresh eyes to the understanding of carbon.

The institution's contribution does not stop with the science of energy. Carnegie president Dick Meserve is deeply engaged in national and international energy policy. He is a member of the National Commission on Energy Policy and chairman of the National Academies' Nuclear and Radiation Studies Board. He is also a member of the Academies' America's Energy Future committee and deals with nuclear power safety issues in his work with the International Atomic Energy Agency.

The world confronts very serious energy problems and must harness the best, most innovative minds to find solutions. I am very pleased to see so many Carnegie researchers, from very different disciplines, using their ingenuity and dedication to tackle these problems—the biggest challenge confronting humanity today.

Michael E. Gellert, *Chairman*

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Trustee Emeritus Robert Seamans, Jr., Dies

Robert C. Seamans, Jr., trustee emeritus, died on June 28, 2008, at his home in Beverly Farms, Massachusetts. He was 89. Seamans was elected to the Carnegie board in 1974 and became a trustee emeritus in 1994. He was a longtime vice chairman of the board, chairman of the Executive Committee, and a member of the Magellan and Capital Campaign Committees and the Department of Terrestrial Magnetism Visiting Committee. He gave the Carnegie Evening lecture in 1977, in the midst of an energy crisis, and discussed the importance of research on alternative energy sources.

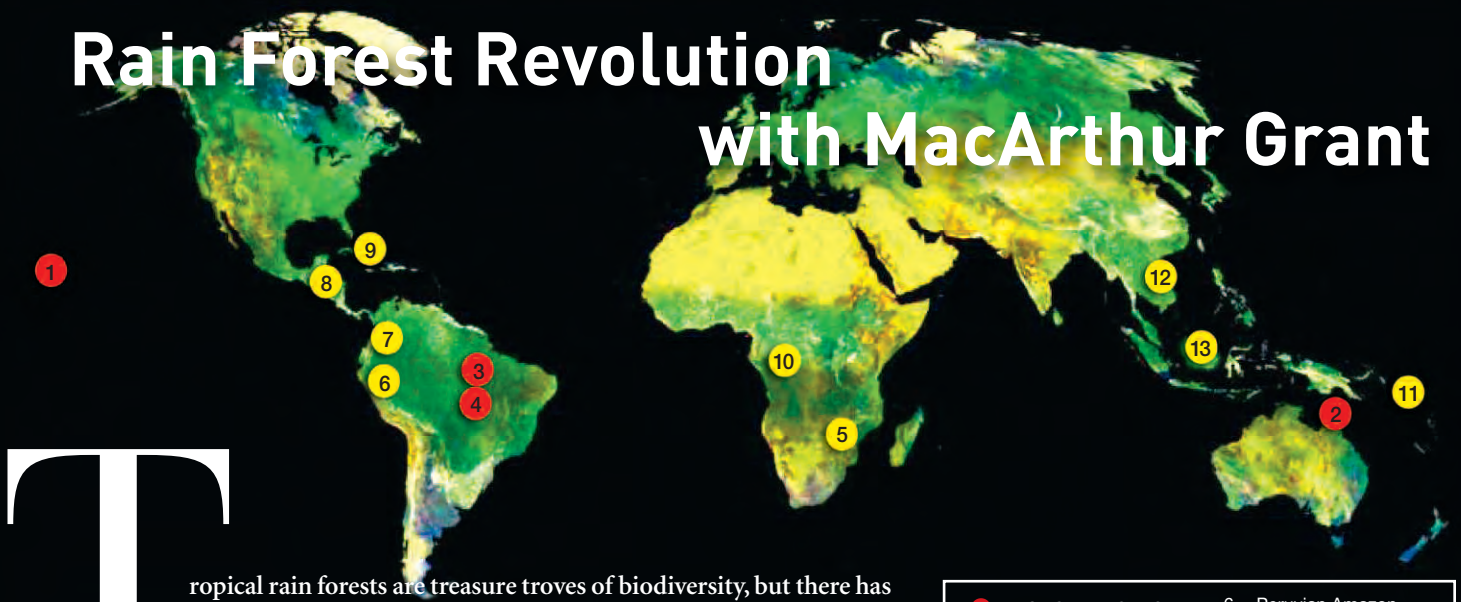
As a top decision maker at NASA from 1960 to 1968, Seamans was instrumental in putting the first man on the Moon. He was deputy administrator during his last three years at the agency. After NASA, Seamans served as secretary of the Air Force and then as president of the National Academy of Engineering. In 1974 he was appointed by President Ford as administrator of the new Energy Research and Development Administration, which was the precursor to the Department of Energy.

When Ford left the White House, Seamans returned to the Massachusetts Institute of Technology as a professor. He had received his master's in aeronautics and his doctorate in instrumentation there decades earlier. For three years he served as dean of the School of Engineering. Seamans officially retired from MIT in 1984 but continued to lecture. After becoming a Carnegie trustee emeritus in 1994, he remained active in the institution-wide Capital Campaign. Seamans helped Carnegie raise $3 million to endow the Vannevar Bush chair for the institution's president. □

In his Carnegie Evening Lecture in 1977, Robert C. Seamans said the energy crisis at that time was "an extremely difficult but solvable problem."

Caitlyn Kennedy

Rain Forest Revolution with MacArthur Grant



Tropical rain forests are treasure troves of biodiversity, but there has been no effective way to inventory and monitor their plant species over large areas. As a result, we have limited understanding of how climate change, clearing, invasive plants, and other threats are affecting these delicate ecosystems. A major advance in improving this situation is in the works, however. Gregory Asner of Carnegie's Department of Global Ecology was awarded a $1.8 million grant from the John D. and Catherine T. MacArthur Foundation to create a database of plant chemical and remote sensing signatures for tropical forest species. This large ground-based "Spectranomics Project" will expand Carnegie's unique aerial mapping and remote sensing capabilities to inventory and track rain forest vegetation around the globe.

PILOT STUDY SITES
PLANNED SITES

1. Hawaiian Islands
2. Queensland, Australia
3. Central Brazilian Amazon
4. Brazilian Cerrado
5. South African woodlands
6. Peruvian Amazon
7. Ecuadorian Amazon
8. Costa Rica
9. Caribbean
10. Congo
11. South Pacific
12. SE Asia
13. Borneo

The Asner team is going global with its spectranomics database, with the help of the John D. and Catherine T. MacArthur Foundation. This map shows pilot sites and planned sites.
Image courtesy Greg Asner

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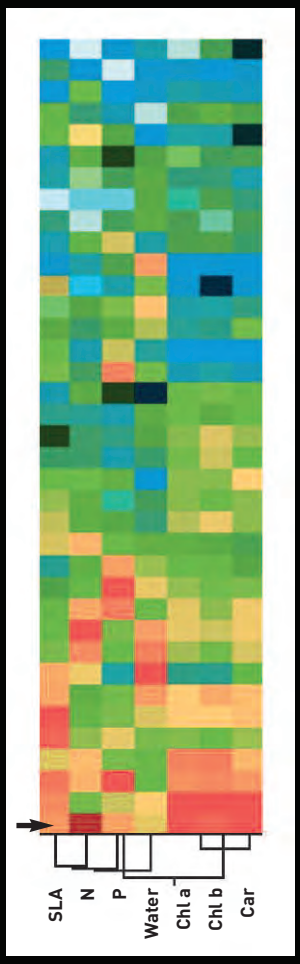
Tested and proven in the rain forests of Hawaii, the Carnegie Airborne Observatory (CAO), designed and operated by Asner and Global Ecology, is uniquely positioned to undertake large-area ecological studies. With its instrumentation, techniques, and algorithms, the CAO can map forest canopy chemistry over nearly 40,000 acres per day. The system is highly portable and flies aboard a fixed-wing aircraft. The CAO uses a waveform LiDAR (light detection and ranging) system that maps the three-dimensional structure of vegetation and combines it with advanced spectroscopic imaging. By analyzing different wavelengths of reflected light, this imaging reveals an area's biochemistry in stunningly beautiful 3-D maps from the treetops to the forest floors. However, like most airborne or space-based instrumentation, the CAO is hampered by a lack of on-the-ground data about the chemical properties of rain forest vegetation. The MacArthur grant provides funding for Asner's team to collect this much-needed information.



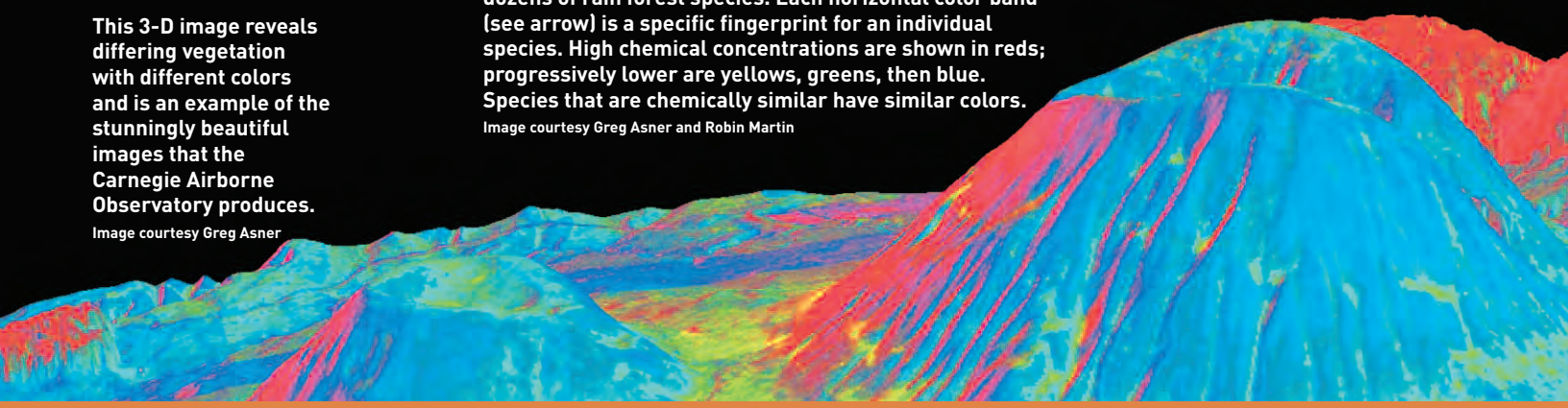
"This grant will allow our team to accomplish something that's never been done before," said Asner. "The Spectranomics Project will help us to build a species database in different tropical forests of Africa, Southeast Asia, Amazonia, the Caribbean, and the western Pacific. Information derived from the project will be a huge boost for rain forest mapping, and thus for conservation and management around the world."

Asner's team strategically collects plant samples on foot and analyzes their properties to establish a library with chemical fingerprints of thousands of individual species. Spectroscopic measurements will link the chemistry to light-reflecting spectra obtained from the air.

The database will be available on the Web for researchers to use, and there will be video and other educational materials for public outreach. For more information about the spectranomics database and the Carnegie Airborne Observatory see http://spectranomics.stanford.edu/. □

This image is an example of plant chemical fingerprints from Kauai Island. It is a chemical cluster analysis of dozens of rain forest species. Each horizontal color band (see arrow) is a specific fingerprint for an individual species. High chemical concentrations are shown in reds; progressively lower are yellows, greens, then blue. Species that are chemically similar have similar colors.
Image courtesy Greg Asner and Robin Martin

This 3-D image reveals differing vegetation with different colors and is an example of the stunningly beautiful images that the Carnegie Airborne Observatory produces.
Image courtesy Greg Asner



IN THE FIELD

In July, the Asner team completed its first 3-week spectranomics field campaign in the Tambopata River basin of Peru. They processed more than 65,000 specimens from canopy trees. The team included 23 Peruvians, plus several people from Carnegie and the World Wildlife Fund.

Getting to and from collecting areas in the remote region requires age-old transportation infrastructure—logs and rope.

Asner (left) and team sort and pack plant samples for shipment back to the United States.
Images courtesy Greg Asner

Maelstrom Quashes Jumping Genes

Scientists have known for decades that certain genes called transposons can jump around the genome in an individual cell. This activity can be dangerous, however, particularly when it arises in cells that produce eggs and sperm. The changes can threaten the offspring and the success of a species. To ensure the integrity of these cells, nature developed a mechanism to quash this genetic scrambling, but how it works has remained a mystery. Now a team of scientists, including researchers at Carnegie's Department of Embryology, has identified a key protein that suppresses jumping genes in mouse sperm and found that the protein is vital to sperm formation.

Carnegie's Alex Bortvin, a senior author of the study, explained: "There is a tiny cell component that is unique to germ cells—the precursors to egg and sperm—called nuage, which other researchers recently suspected was involved in keeping genes from jumping around in germ cells of the female fruit fly. But until this mouse study, no one knew for sure if it was involved in mammalian germ cells. To test if the mouse nuage played a similar role in mammals, we focused on a mouse protein called Maelstrom, whose distant relative, a protein in the fruit fly, was implicated in the other study."

The scientists first looked at where the protein Maelstrom resides during the formation of sperm. By marking the protein with a fluorescent antibody, they found that it was predominantly located in the cytoplasm, near the nucleus of the germ cell, at the nuage. To understand what Maelstrom does during the formation of sperm, the scientists created mutant mice that did not have the gene to produce the Maelstrom protein.

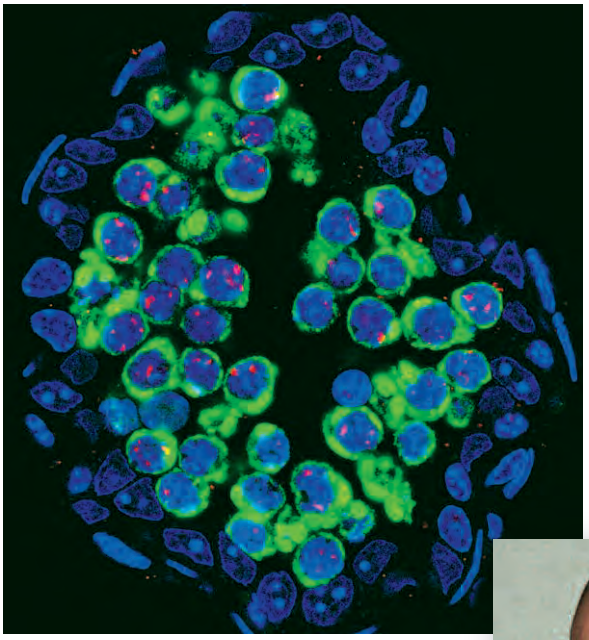
"We found that without the gene the process of meiosis—cell division—was severely impaired," said Bortvin. "There was a profound defect in interactions of parental chromosomes, leading to the death of germ cells. This was clear evidence that the protein is vital to the formation of sperm."

The researchers found the cause of the defect when they looked at the behavior of transposons. "We observed massive flooding of the cytoplasm and nuclei of germ cells by transposons in the mutant mice," said Godfried Van der Heijden, a Carnegie postdoctoral fellow and coauthor of the study. "This was the first time such a phenomenon was observed in germ cells of any species. Moreover, we found that the more transposons present in the nucleus, the more likely parental chromosomes would fail to locate each other. Clearly, uncontrolled activity of jumping genes causes chromosomal mayhem in germ cells. Our results, coupled with work by Toshie Kai, a former Carnegie researcher studying the role of nuage in egg development in the fruit fly, suggest that nuage plays a central role in transposon silencing during the development of egg and sperm of many species from insects to mammals. "

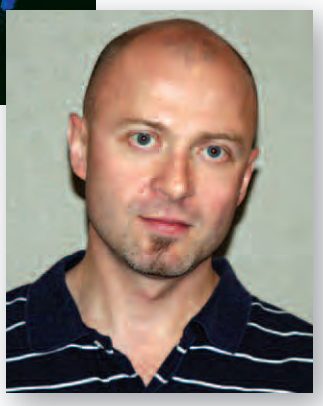
The last surprise for the scientists was the observation that, contrary to the current view in the field, the silencing of jumping genes does not occur one time only in male germ cells during mouse fetal development. Instead, every time a germline stem cell divides by meiosis to make sperm in adults the jumping genes are activated, only to be silenced soon thereafter.

"This was a very puzzling finding," commented Bortvin. "Since the jumping genes are not silenced just once during the development of the fetus, but every time new sperm are produced during a mouse's life, it's possible that germ cells may employ transposons in some fundamental way in male germline meiosis. This research is the first such clue of that possibility. We will be very busy over the next few years trying to crack this and other puzzles of Maelstrom's role in controlling meiosis and sperm production."

The research was published in the August 12 issue of *Developmental Cell.* □



In the absence of the protein Maelstrom to keep them at bay, jumping genes, called transposons (green), flood germ cells (DNA-blue)—the precursor cells of sperm in the male mouse.



Alex Bortvin (right)

Images courtesy Alex Bortvin

This work was supported by the National Institutes of Health and the Carnegie Institution. Other authors of the study are Sarah Soper at The Johns Hopkins University, Tara Hardiman at Carnegie, Mary Goodheart at the Howard Hughes Medical Institute, the Whitehead Institute, and MIT; Sandra Martin at the University of Colorado, School of Medicine; and Peter de Boer at Radboud University Nijmegen Medical Centre, The Netherlands.

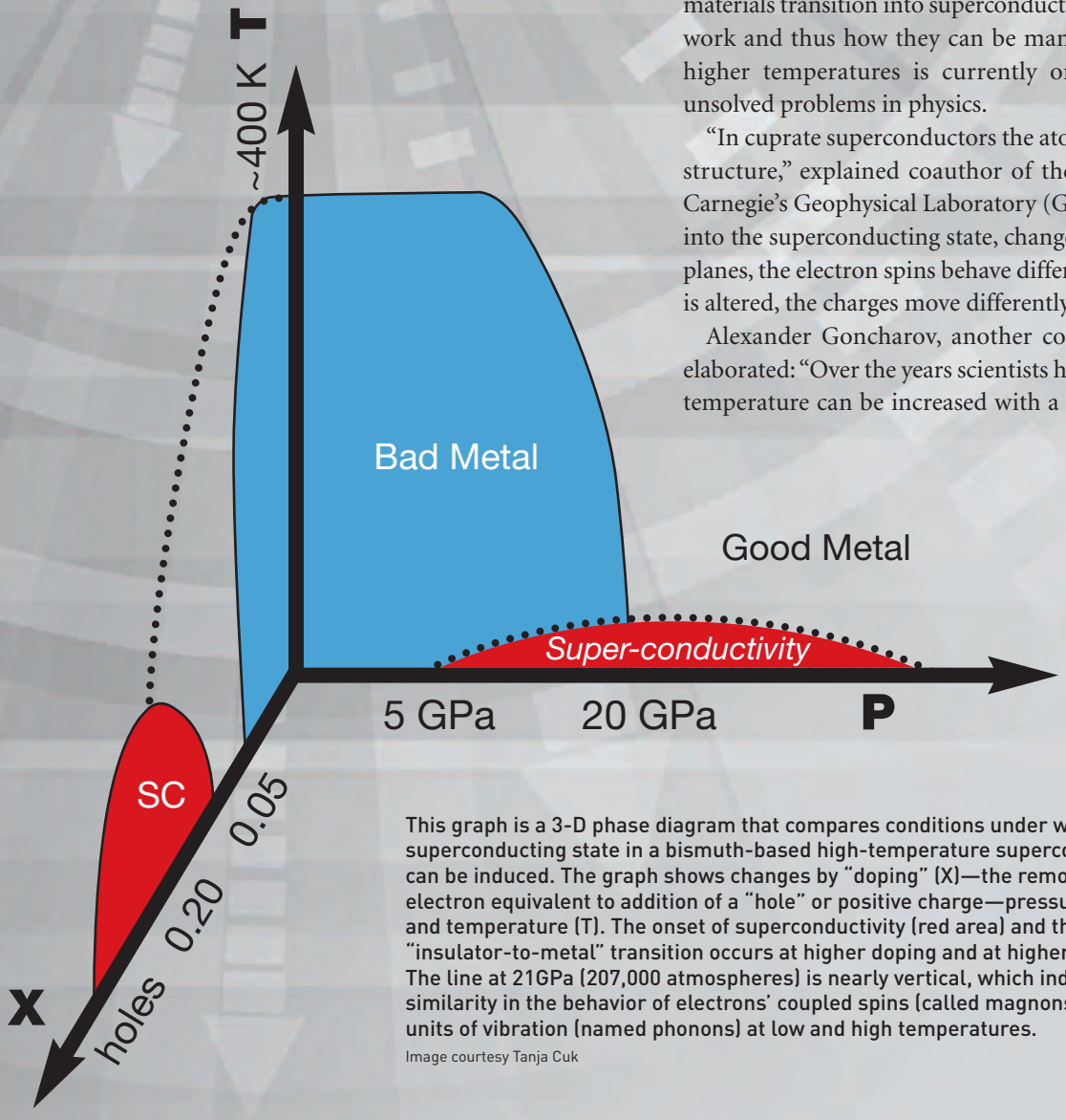
SUPERCONDUCTORS
Get Pumped under Pressure

With skyrocketing energy costs, people are scrambling for all kinds of energy-saving solutions. Superconductors have long been looked at as one such possibility. They can convey more than 150 times more electricity than copper wires because they don't restrict electron movement—the essence of electricity. But there's a catch. To do this, the materials have to be cooled below a very low, so-called transition temperature, which often makes them impractical for widespread use. Now, for the first time, scientists have found that in addition to chemical manipulation, the superconducting state can be induced by high pressure in high-temperature superconductors. The discovery, published in the May 30, 2008, issue of *Physical Review Letters,* opens a new window on understanding and harnessing these miracle materials.

The early superconductors had to be cooled to extremely low (below 20 K, or -423°F) temperatures. But in the 1980s scientists discovered a class of what they call high-temperature superconductors made of ceramic copper oxides called cuprates. They found that at temperatures as high as about 135 K, or -216°F, these materials transition into superconductors. Understanding how they work and thus how they can be manipulated to operate at even higher temperatures is currently one of the most important unsolved problems in physics.

"In cuprate superconductors the atoms are arranged in a layered structure," explained coauthor of the study Viktor Struzhkin at Carnegie's Geophysical Laboratory (GL). "When the material goes into the superconducting state, changes occur in the copper-oxide planes, the electron spins behave differently, the vibrational energy is altered, the charges move differently, and more."

Alexander Goncharov, another coauthor of the study at GL, elaborated: "Over the years scientists have found that the transition temperature can be increased with a specific amount of 'doping,'



This graph is a 3-D phase diagram that compares conditions under which the superconducting state in a bismuth-based high-temperature superconductor can be induced. The graph shows changes by "doping" (X)—the removal of an electron equivalent to addition of a "hole" or positive charge—pressure (P), and temperature (T). The onset of superconductivity (red area) and the "insulator-to-metal" transition occurs at higher doping and at higher pressure. The line at 21GPa (207,000 atmospheres) is nearly vertical, which indicates a similarity in the behavior of electrons' coupled spins (called magnons) and units of vibration (named phonons) at low and high temperatures.

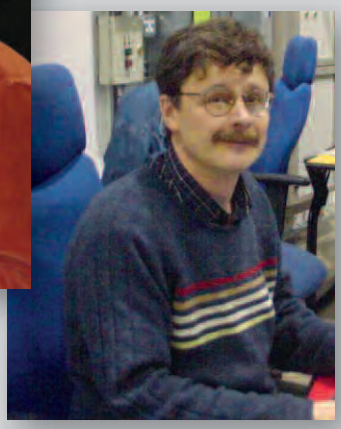
Image courtesy Tanja Cuk

which is the addition of charged particles—either negatively charged electrons or positively charged "holes." We wanted to see the effects of high pressure on one bismuth-based high-temperature cuprate ($Bi_{1.98}.Sr_{2.06}Y_{0.68}Cu_2O_{8+\delta}$). Pressure has the added bonus that it can be applied gradually, like tuning a radio. We gradually tuned in to the superconductivity and could watch what happened over a broad range of pressures."

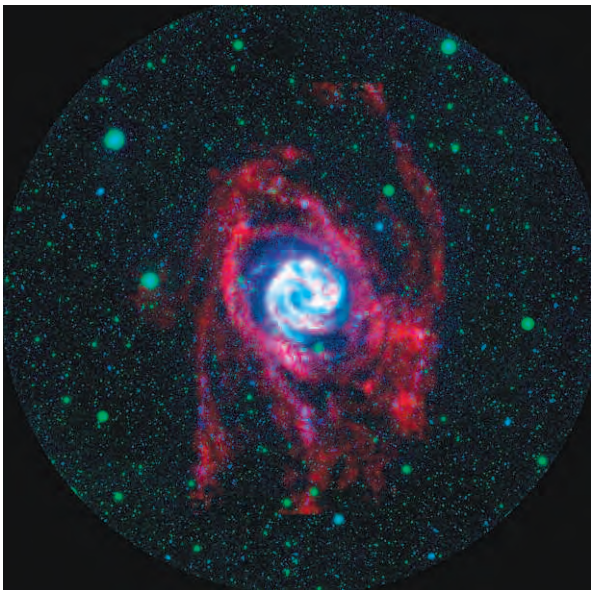
The scientists observed the subatomic effects on the material of pressures close to 350,000 times the atmospheric pressure at sea level (35 GPa) using a diamond anvil cell to squeeze the sample and specialized techniques—Raman spectroscopy, and X-ray diffraction—to measure the changes.

"The magic number, or critical pressure, was 21 GPa," said Tanja Cuk, the lead author and a student at Stanford University, who conducted the work as part of her Ph.D. thesis research. "By compressing the structure, we were able to observe changes in six different physical properties. But even more exciting, the changes were similar to those observed when the material has been doped to its optimal level. This means that the critical pressure is likely related to doping. Plus, by finding that pressure can be used instead of temperature and doping, we've found an entirely new approach to studying what's behind superconducting properties of high-temperature superconductors."

"This study brings us one step closer to understanding the mechanism of high-temperature superconductivity by giving a completely new perspective of the superconducting state driven by a continuous variable—pressure," Struzhkin said. "It appears that superconductivity is favored on the borderline between insulating and metallic states. By applying these high pressures, we may be able to discover the missing clues to the mechanism of high-temperature superconductivity and move a few steps closer to using superconductors in daily life. This could change our whole energy system." □



Viktor Struzhkin(above)
Alexander Goncharov (right)



Baby Stars Born in Galactic Outback

Coauthors Mark Seibert and Barry Madore of the Observatories are part of a team that produced a stunning new image showing infant stars growing in a remote area of galaxy M83, also known as the Southern Pinwheel galaxy. The researchers were surprised by the find because the outer areas of galaxies were thought to lack sufficient star-forming ingredients. The image is a composite produced from ultraviolet data collected by NASA's Galaxy Evolution Explorer (GALEX) and radio data from the National Science Foundation's Very Large Array. "Before these observations we had a strong indication that M83 was unusual in its star-formation history; we just didn't realize how strange it was going to turn out to be," said Madore, who is also a coprincipal investigator on the main GALEX mission. □

In this composite image, far-ultraviolet light is blue, near-ultraviolet light is green, and radio emissions are red. The pink and blue in the center of the Southern Pinwheel galaxy is the main stellar disk, which is surrounded by extended arms. Blue and green in the outlying areas are the farthest clusters of young stars, some 140,000 light-years from the center. Red areas are radio emissions from the Very Large Array, which indicate gaseous hydrogen, an ingredient for producing new stars.

Image courtesy NASA/JPL-Caltech/VLA/MPIA

Engineering Better Crops Online

Carnegie's Department of Plant Biology launched a new Web-based resource in June that promises to help researchers around the world meet increasing demands for food production, animal feed, biofuels, industrial materials, and new medicines. It is the Plant Metabolic Network (PMN) at http://www.plantcyc.org/.

"To use plants to their full potential, it is crucial to understand the chemical reactions that happen in metabolic processes, such as converting carbon dioxide to biomolecules, transporting nutrients, responding to the environment, and otherwise maintaining life," said principal investigator Sue Rhee. The collection of databases is the first of its kind to be dedicated exclusively to plant metabolism. The project brings together varied databases and biochemists, creating a broad network of information about plant metabolic pathways.

A central feature of the system is PlantCyc, a comprehensive plant biochemical pathway database with information from the literature about the genes, enzymes, chemical reactions, and pathways involved in plant metabolism. The database currently contains over 500 biochemical pathways consolidated from over 290 plant species, including more than 2,000 reactions, 3,000 enzymes, and 4,000 literature citations.

In addition to PlantCyc, PMN will develop and host a collection of single-species databases such as AraCyc (*Arabidopsis*). These single-species pathway databases place the sequenced and annotated plant genomes in a biochemical context to facilitate the discovery of enzymes and the engineering of metabolic pathways. The databases provide access to functional genomics data, such as those generated from microarray and metabolomic experiments. PMN is currently developing similar databases for important crop plants including poplar, soybean, wheat, and maize.

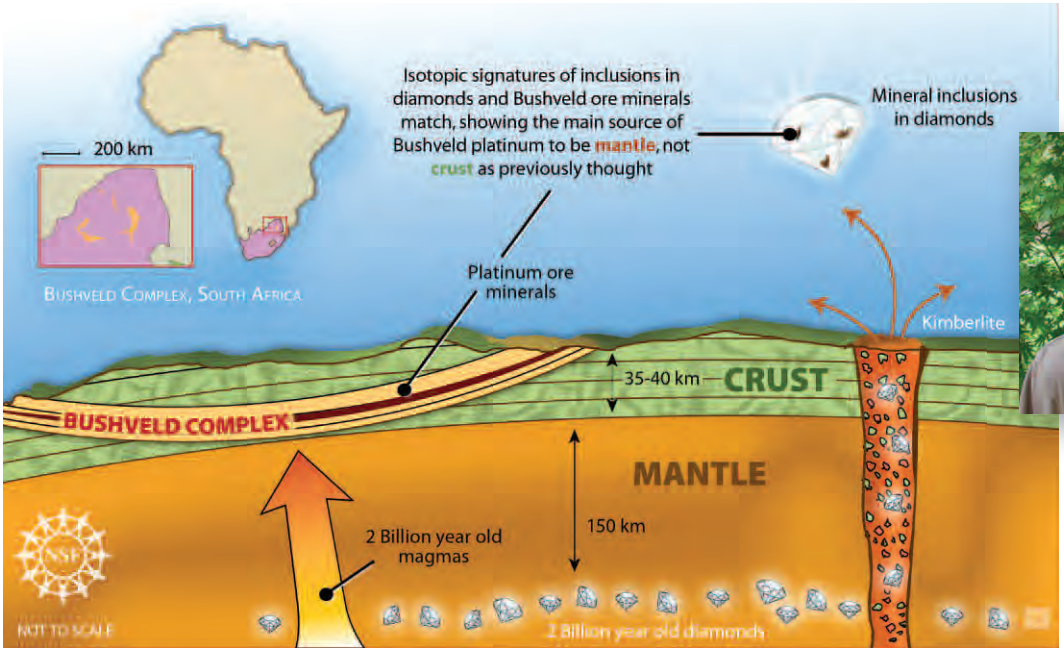
The network draws from many individuals with expertise in annotating genomes, generating metabolic pathway databases, curating biochemical information from the literature, and forming extensive networks with biological databases and biochemistry researchers.

PMN is expected to grow quickly as more plant genomes are sequenced and annotated and new biochemical data are published. Semiannual releases will be used to incorporate the most up-to-date information. □

PMN
Plant Metabolic Network

Plant Biology's Sue Rhee is principal investigator of the Plant Metabolic Network.
Image courtesy Sue Rhee

The Plant Metabolic Network is funded by the National Science Foundation (grant number 0640769), governed by an editorial board composed of internationally renowned scientists, and executed at the Carnegie Institution's Department of Plant Biology.



This graphic representation (left) indicates how the main source of platinum in the region is the mantle, not the crust.
Image courtesy National Science Foundation

Department of Terrestrial Magnetism's Steve Shirey (above)

Diamonds Point to Platinum

The world's richest source of platinum and related metals is an enigmatic geological structure in South Africa known as the Bushveld Complex. These ancient magmas formed some 2 billion years ago, but the source of their metallic riches has been a matter of scientific dispute. Now researchers from the Carnegie Institution and the University of Cape Town have traced the origin of the unique ore deposits by using another of South Africa's treasures—diamonds. The study, published in the June 12 issue of *Nature*, suggests that the source of these valuable ores may be ancient parts of the mantle beneath the African continent.

Platinum group elements (PGEs), which include platinum, palladium, rhodium, ruthenium, osmium, and iridium, are extremely rare in the Earth's crust. Platinum, the most abundant, is 30 times rarer than gold. Mined in only a few places in the world, these elements are becoming increasingly important in applications ranging from pollution control (they are key components of catalytic converters in automobiles) to microelectronics.

Previous isotopic studies of rocks from the Bushveld Complex suggested that a significant fraction of the magma that formed the complex and deposited the ores came from shallow parts of the crust, despite the rarity of PGEs there compared with the Earth's mantle. "But the ore layers are extremely homogeneous over hundreds of kilometers," said Steven Shirey of the Department of Terrestrial Magnetism. "The crust is very heterogeneous. That suggests a deeper source for the platinum."

To test this idea, Shirey and Stephen H. Richardson of the University of Cape Town studied minute mineral inclusions, or impurities, in about 20 diamonds mined from areas surrounding the Bushveld Complex. The diamonds formed at depths of about 90 to 125 miles (150 to 200 kilometers) within the Earth's mantle. By measuring the ratios of certain isotopes—variations of an atom with the same number of protons, but a different number of neutrons—of strontium, osmium, and neodymium in the mineral inclusions, the researchers were able to determine the isotopic "signatures" of the different regions where the diamonds grew. They then compared these signatures with those of ore rocks in the Bushveld Complex.

Richardson and Shirey found that the isotopic signatures of the ores could be matched by varying mixtures of source rocks in the mantle beneath the continental crust. That these parts of the mantle were involved in producing the magmas is also suggested by seismic studies, which reveal anomalies beneath the complex. The anomalies were likely the result of magmas rising through these parts of the mantle. "This helps explain the richness of these deposits," said Richardson. "The old subcontinental mantle has a higher PGE content than the crust and there is more of it for the Bushveld magmas to traverse and pick up the PGEs found in the ores."

The results of this study may be applicable to similar ore deposits elsewhere, such as the Stillwater Complex in Montana. "Knowing how these processes work can lead to better exploration models and strategies," said Shirey. □

This work was supported by the Carnegie Institution and the National Science Foundation.

Deep Carbon Workshop Breaks New Ground

Vents at the Lost City hydrothermal field on the floor of the mid-Atlantic Ocean release fluids that contain abiotic hydrocarbons. Workshop participants debated the significance of abiotic hydrocarbon production in the deep Earth. The "chimneys" shown in the photo are deposits of calcium carbonate.
Image courtesy University of Washington

All eyes are on the carbon cycle these days. Carbon is the key element of life. Plants draw it out of the atmosphere through photosynthesis, and humans pump it back into the atmosphere by burning fossil fuels. Human-induced changes in the carbon cycle are now affecting the atmosphere, the oceans, and the biosphere.

But what about the Earth as a whole—not just the near surface, but the planet's deep interior as well? How much carbon is down there? What form is it in? Is the surface carbon cycle linked to deeper processes within the Earth?

The Deep Carbon Cycle Workshop, funded by the Alfred P. Sloan Foundation, convened in May at the Geophysical Laboratory (GL) to ponder these and other questions. Among the approximately 100 participants were geochemists, petroleum geologists, mineral physicists, organic chemists, microbial biologists, astrobiologists, and other scientists from GL, the Department of Terrestrial Magnetism, and other institutions around the world. Topics of the discipline-crossing talks over the three-day program ranged from the potential carbon content of the Earth's core to the search for living microbes deep in the Earth's crust.

"We're catching a glimpse of a new, unexplored scientific territory," said conference organizer Robert Hazen in his introductory remarks. "The deep carbon cycle has always been there, but it has been an elusive field. Observations, theory, experiments all point to the existence of very deep carbon reservoirs, as well as dynamic fluxes amongst those reservoirs, but the details have been fuzzy. The science is often controversial because the Earth's deep interior is relatively inaccessible."

Many fundamental questions about the deep carbon cycle remain unanswered. For example, what are the major reservoirs of carbon in the deep Earth? "We do not know if carbon is in its own carbonate phase, dissolved in minerals, as diamond, or in a fluid phase," said GL's Ron Cohen, who gave the opening session's keynote talk. "And we do not have any idea about the bulk carbon composition of the Earth. What we see suggests that the Earth is greatly depleted in carbon compared with the Sun and meteorites. Perhaps the missing carbon is in the deep mantle or the core."

Workshop participants also considered the processes driving the deep carbon cycle. Again, basic data are lacking for many fundamental questions. At what rates is carbon exchanged among the different reservoirs and between the deep and surface carbon cycles? Carbon from the surface can be carried downward by plate tectonics, but estimates of the percentage that makes it into the mantle range from 2% to 75%.

By far the most controversial topic at the meeting was the question of deep abiogenic production of petroleum and other hydrocarbons—hydrocarbons not produced by organisms. The standard geologic model for the production of hydrocarbons is that they are generated in sediments from buried organic matter. But other scientists, primarily in the former Soviet Union, have long argued that large amounts of hydrocarbons are generated abiotically by high-pressure reactions in the mantle. The workshop participants generally agreed that some hydrocarbons could be produced in this way. Some questions now are: How prevalent are abiogenic hydrocarbons? Can they be transported in significant amounts toward the surface and thus contribute to global petroleum reserves?

In another session, speakers reviewed recent discoveries of subsurface microbial ecosystems. Little is known about the microbes living in deep crustal environments at depths of up to a few kilometers. What is their source of energy? Do different geological environments support different communities of deep-dwelling microbes? How are these communities linked to the larger carbon cycle? The deep biosphere remains virtually unexplored.

In the workshop's final session, speakers tackled the potential implications of the deep carbon cycle for energy and climate change. Topics included the impact of volcanic carbon dioxide on climate, the possibility of sequestering human-generated carbon dioxide in deep reservoirs, and the existence of methane clathrates, icy deposits in deep sediments containing large reserves of natural gas (mostly methane). Methane clathrates constitute a potential energy resource, but if suddenly released to the atmosphere the gas could dramatically accelerate global warming, as may have happened during earlier periods of geologic history.

Hazen noted that on a number of earlier occasions Carnegie's Broad Branch Road campus had hosted interdisciplinary gatherings of scientists that had led to transformational discoveries. After World War II, nuclear physicists and biochemists came together to deduce the metabolic pathways of *E. coli* using the then-revolutionary process of studying isotopic tracers. In the 1990s, scientists from a wide range of disciplines joined to study the new field of astrobiology—the search for the origin and distribution of life in the universe. In a similar way, the Deep Carbon Cycle Workshop may mark the beginning of an exciting new interdisciplinary research venture. □

1 Workshop organizer Bob Hazen (right) chats with Jesse Ausubel (left) of the Sloan Foundation. The Sloan Foundation funded the workshop.

2 GL's Yingwei Fei (left) poses with fellow workshop participant Amos Nur (Stanford University). Fei gave a talk on carbon in the Earth's core.

3 Carbon exists in several phases in the deep Earth, including diamond (shown in photo). Which phases represent the most significant reservoir in the mantle remains unknown, however.

The image shows jet streams blowing from west to east over the continental United States. The Archer and Caldeira study shows that the jet streams are shifting in both hemispheres; they have risen in altitude and shifted toward the poles.
Image courtesy NASA

CHANGING JET STREAMS

MAY ALTER STORM AND HURRICANE PATHS

Earth's jet streams are shifting—possibly in response to global warming. Cristina Archer and Ken Caldeira at Global Ecology found that from 1979 to 2001 these high-altitude bands of fast winds in both hemispheres have risen in altitude and shifted toward the poles. The jet stream in the Northern Hemisphere has also weakened. The changes fit the predictions of global-warming models and could affect the frequency and intensity of future storms.

Cristina Archer

Archer and Caldeira tracked changes in the average position and strength of jet streams using various records. The data included outputs from weather prediction models, conventional observations from weather balloons and surface instruments, and remote observations from satellites. Their results were published in the April 18 *Geophysical Research Letters*.

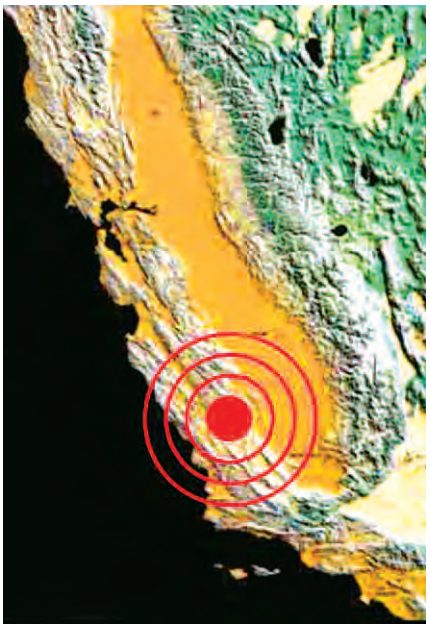
Jet streams twist and turn in a wide swath that changes from day to day. The poleward shift in their average location discovered by the researchers is small, about 19 kilometers (12 miles) per decade in the Northern Hemisphere. "The jet streams are the driving factor for weather in half of the globe," said Archer. "So, as you can imagine, changes in the jets have the potential to affect large populations and major climate systems."

Storm paths in North America are likely to shift northward as a result of the jet stream changes. Hurricanes, whose development tends to be inhibited by jet streams, may become more powerful and more frequent as the jet streams move away from the subtropical zones where hurricanes are born.

The observed changes are consistent with numerous other signals of global warming found in previous studies, such as the widening of the tropical belt, the cooling of the stratosphere, and the poleward shift of storm tracks. This is the first study to use observation-based datasets to examine trends in all the jet stream parameters, however. "At this point we can't say for sure that this is the result of global warming, but I think it is," said Caldeira. "I would bet that the trend in the jet streams' positions will continue. It is something I'd put my money on." □

Do Pre-earthquake Changes Foretell Quake?

Measurement techniques surrounding earthquakes have improved enormously over the last few decades, but it remains very difficult to measure changes in the crust that could enable earthquake prediction. Now scientists, including Paul Silver at the Department of Terrestrial Magnetism, have measured interesting changes in the speed of seismic waves that preceded two small earthquakes by 10 and 2 hours, respectively. These measurements, published in the July 10, 2008, issue of *Nature*, hold promise for the field of earthquake prediction. The work was covered widely by the national and international media.



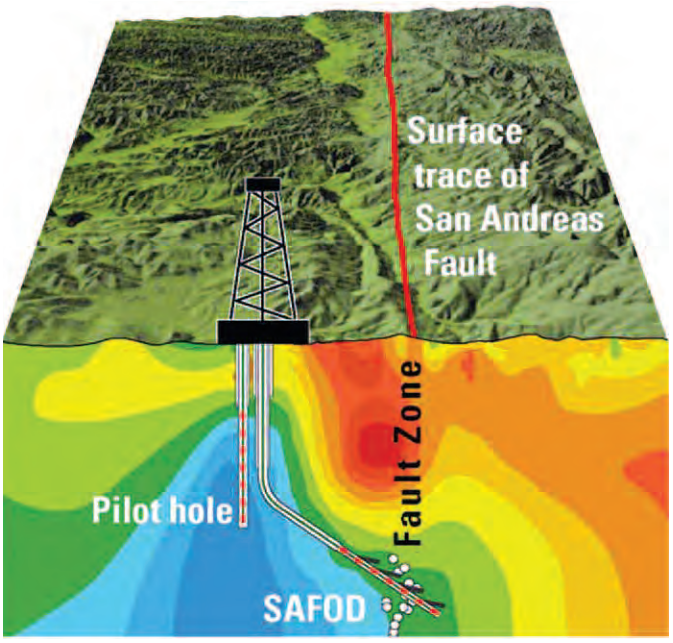
Parkfield, located on the San Andreas Fault in central California, has been used as a laboratory for studying earthquakes since the late 1970s. Scientists can observe the fault and crust before, during, and after an earthquake to observe earthquake processes and develop better earthquake prediction tools.

Image courtesy USGS

"Detecting stress changes before an earthquake has been the Holy Grail in earthquake seismology for years and has motivated our research," said Silver. "We used a specially designed system to generate and record seismic waves before, during, and after two earthquakes on the San Andreas Fault. It's been shown in the lab that the speed of seismic waves varies with the level of stress, due to the effect on the opening and closing of cracks. So measurements of changes in wave speed should, in principle, constitute a 'stress meter' that could provide an indication of an imminent earthquake. That is, precursory changes in stress should be revealed as preseismic changes in wave speed. Researchers have been trying to precisely and continuously measure these velocity changes for decades, but it has been possible only recently, with improved technology, to obtain the necessary precision and reliability."

The experiment took place in a 0.6-mile-deep (1-kilometer) well over two months at the San Andreas Fault Observatory at Depth (SAFOD) at Parkfield, California. The seismologists measured the velocity of shear waves and how it varied over time. They first calibrated their stress meter by measuring velocity changes from a known source of stress—barometric pressure. In a previous study, Silver and colleagues found that seismic wave speed is affected by changes in the barometric pressure. They found the same thing in this study: higher barometric pressure coincided with a faster seismic wave speed, due to the closure of cracks.

The researchers found two other wave-speed anomalies. One in particular was the largest signal observed over the entire two-month period. It was unrelated to barometric



This schematic shows a cross section of the San Andreas Fault Zone at Parkfield, California. The drill hole for the San Andreas Fault Observatory at Depth (SAFOD) and the pilot hole are shown. The subsurface colors represent electrical resistivity of the rocks, which can tell researchers a lot about what is there. The lowest-resistivity rocks are red-orange.

Image courtesy USGS

[CONTINUED ON PAGE 14]

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pressure changes. "We found that this anomaly occurred at the time of the largest local event, a magnitude 3 earthquake, and most importantly began 10.6 hours before the event. Such preseismic changes are consistent with lab experiments that exhibit precursory phenomena, namely an increase in microcrack density preceding the occurrence of an earthquake," Silver commented.

"We are very encouraged by these preseismic signals and are planning a series of experiments to expand on them, so that we may further understand their timing and physical basis," said lead author Fenglin Niu of Rice University, formerly a Carnegie postdoc. □

Former Carnegie postdoc and lead author Fenglin Niu (left), now at Rice University, and Carnegie's Paul Silver take a break at the Parkfield, California, site.
Image courtesy Paul Silver

This research was supported by the National Science Foundation EarthScope program, Rice University, the Lawrence Berkeley National Laboratory of the Department of Energy, and the Carnegie Institution.

Carnegie Launches Math for America Chapter in D.C.

The District of Columbia, like many other cities, has a continuing need for highly qualified mathematics teachers in its middle and high schools. This nationwide shortage has left American students unable to compete with students in other nations and ill prepared for university studies and the workforce. To combat this trend, the Carnegie Institution's Carnegie Academy for Science Education (CASE) has launched a partnership with Math for America (M*f*A) to improve the mathematics education of Washington, D.C., public and charter school students.

The D.C. Math for America chapter will recruit, train, and mentor 34 fellows over five years. In the first year, the fellows will obtain a Master of Arts in teaching and teaching certification. CASE joined forces with the American University (AU) School of Education, Teaching, and Health, and the Department of Mathematics and Statistics to provide the master's degree and certification. The fellows will commit to teaching for four years in D.C. schools after completing the AU program.

The first fellows will be recruited in the fall of 2008 from colleges and universities in the Washington, D.C., Virginia, and Baltimore area. Six fellows will begin the program in the spring of 2009. Eight will be enrolled in 2010, 10 in 2011, and 10 in 2012. The program will provide full tuition and stipends. During the four years the fellows teach in D.C., they will receive frequent professional development sessions and will be provided with an experienced personal mentor.

James H. Simons, mathematician and president of Renaissance Technologies Corporation, founded Math for America in 2004. Its mission is "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 150 fellows in over 50 New York City schools. Additional M*f*A sites have been created in San Diego and Los Angeles. This past year, M*f*A's program was the congressional model for the National Science Foundation Teaching Fellowship and the enhanced Robert Noyce Scholarship program.

"The Carnegie Institution is extraordinarily pleased to have formed this alliance with AU and Math for America to strengthen mathematics education in the District," said Carnegie president Richard Meserve. "A strong education is the vehicle to improve the lives of the District's children." □

James H. Simons, mathematician and president of Renaissance Technologies Corporation, founded Math for America (M*f*A) in 2004. He spoke at the kickoff dinner for the new Washington, D.C., M*f*A chapter June 2 at Carnegie's administration building.

InBrief

❶ Mary-Claire King

❷ Bianca Abrams

❸ Doug Koshland

Trustees and Administration

❶ Trustee **Mary-Claire King** received an honorary degree from Princeton at its June commencement for her groundbreaking research in genetics.

—

Carnegie president **Richard A. Meserve** moderated a discussion of energy issues at a US-Russian Interacademy Meeting at the National Academies on July 1 and participated in an online discussion on nuclear power for NewTalk on July 15-17 (see http://newtalk.org/2008/07/is-nuclear-power-essential-to.php). He attended a meeting of the National Academies' Committee on America's Energy Future on July 21 and Aug. 26 in Washington, and on Sept. 18-19 in Irvine, CA. He participated in a meeting of the External Advisory Panel to the MIT Nuclear Fuel Cycle Study on Sept. 3, and chaired a meeting of the National Academies' Nuclear and Radiation Studies Board (NRSB) Sept. 11-12. He gave a presentation in Ottawa to the staff of the Canadian Nuclear Safety Commission on Sept. 24 and made three presentations at the General Conference of the International Atomic Energy Agency (IAEA) in Vienna, Austria, Sept. 29-Oct. 3.

—

Science writer **Alan Cutler** won the 2008 James H. Shea Award from the National Association of Geoscience Teachers for his book *The Seashell on the Mountaintop*.

—

Kristen Michelle Fisher, special events/facility coordinator, arrived July 21.

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❷ **Bianca Abrams** joined Carnegie as the director for the Math for America program.

Embryology

Joe Gall was the invited speaker at the Sept. 10 Biology Colloquium at The Johns Hopkins U.

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❸ **Doug Koshland**, research associate **Vinny Guacci**, and graduate students **Lamia Wahba** and **Jill Heidinger** all presented their work at the June FASEB meeting. Doug was also an invited speaker at the 10th Annual Beckman Scholars Symposium in July.

—

Carnegie trustee **John Crawford** was awarded the Order of the Rising Sun, Gold Rays with Rosette,

on behalf of Emperor Akihito by the Japanese ambassador to France, His Excellency Yutaka Iimura, on June 19. Crawford received the honor for his work ensuring that Japanese nationals in France, Eastern Europe, the Middle East, and Africa receive excellent medical care, in their own language, at the American Hospital of Paris, and for his continuing efforts in strengthening relations between Japan and various other countries. Crawford was also recognized for his work in organizing concerts in Tokyo involving outstanding musicians from South Korea, China, and Japan.

Trustee John Crawford receives the Order of the Rising Sun, Gold Rays with Rosette, from Ambassador Yutaka Iimura. Image courtesy John Crawford

Marnie Halpern lectured on zebrafish neurobiology at the Finnish Graduate School of Neuroscience, U. Helsinki, Aug. 11-15. She also hosted visiting U. Helsinki graduate student Madhusmita Priyadarshini for three weeks.

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Marnie Halpern and **Steve Farber** were invited speakers for the Society of Developmental Biology Education Roundtable at the society's annual meeting in July.

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Steve Farber was a Distinguished Lecturer in Nutritional Sciences at Columbia U. and presented seminars at Rensselaer Polytechnic Inst. in NY and Case Western U. in OH.

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Yixian Zheng presented seminars at the National Inst. of Biological Sciences and the Inst. of Genetics and Developmental Biology in Beijing. She also gave an invited talk at the Mitosis Meeting in Worcester, MA.

—

Judith Yanowitz spoke at a summer Gordon Conference, and lab member **Cynthia Wagner** presented her work in Madison, WI, at the 2008 *C. elegans* Development and Evolution Topic Meeting.

—

Gall lab graduate student **Zehra Nizami** presented her work at the Cold Spring Harbor meeting "Dynamic Organization of Nuclear Function."

—

Halpern lab postdoctoral fellows **Yung-Shu Kuan** and **Mary Goll** spoke at the 8th International Conference on Zebrafish Development and Genetics, June 25-29. Mary was also an invited speaker at the MDI Biological Laboratory Aug. 8-9.

—

The Carnegie Institution inadvertently left the names of the following donors out of the 2006-2007 Year Book. We sincerely apologize for this oversight. Carnegie deeply appreciates these gifts in support of Carnegie science.

Manuel N. Bass
Giuseppe Bertani
Gordon Burley
John A. Caldwell
Wen P. Chen
Michael B. Davis
Sandra M. Faber
Stanley R. Hart
H. L. Helfer
Olavi Kouvo
Harold H. Lee
Allan T. Leffler
Felix J. Lockman
Robert Metcalf
Charles J. Peterson
Nobumichi Shimizu
Alan M. Stueber
Tetsuo Takanami
Lawrence A. Taylor

Allan Spradling Won the 2008 Gruber Genetics Prize

Allan Spradling, director of Carnegie's Dept. of Embryology, was awarded the 2008 Genetics Prize by the Peter and Patricia Gruber Foundation in recognition of his contributions to fruit fly genomics and for "fundamental discoveries about the earliest stages of reproduction." It was presented to Spradling at the International Congress of Genetics in Berlin on July 13.

Allan Spradling (right) with Peter and Patricia Gruber at award ceremony in Berlin.

The Embryology Dept. summer picnic was held at Conrad's Ruth Villa in Middle River, MD. In photo: Katie Spradling (left) and Connie Griffin (right).

❹ Lori Orosco

❺ Wesley Huntress, Jr.

❻ Ho-kwang (Dave) Mao signs the charter book at induction ceremony at the Royal Society of London on July 11.

Koshland lab graduate student **Margaret Hoang** presented her work at the EMBO Workshop "Recombination Mechanisms" in May.

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"Women Serious about Science," a program organized by **Marnie Halpern** to encourage girls to pursue careers in science, began its eighth year at the Baltimore Polytechnic Institute.

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Jeff Han and **Judith Yanowitz** hosted high school students this summer as part of the Science, Technology, and Education Partnerships (STEPS) program, a nonprofit organization that exposes underserved high school students to science- and technology-based careers.

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❹ Halpern lab graduate students **Lori Orosco** and **Courtney Akitake**, with senior technician **Michelle Macurak**, helped high school students with their project on zebrafish embryonic development at Frostburg State U.'s summer science center program.

—

Arrivals: Postdoctoral fellow **Frederick Tan** joined the Koshland lab in Aug. from The Johns Hopkins U. New graduate students joining the department in June were **Kate Lannon** (Gall), **Katie McDole** (Zheng), **Aaron Welch** (Koshland), and **Juliana Carten** (Farber).

—

Johns Hopkins undergraduates **Molly Broache**, **Jayati Jain**, **James Livengood**, and **Desiree Simpson** are doing research projects in the Halpern lab. **Joan Pulupa** and **Frazer Heinis** joined the Yanowitz lab as student assistants.

—

High school student **Victoria Robinson** (Baltimore Polytechnic Inst.) joined the Halpern lab for a yearlong research internship.

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Departures: In Aug. Halpern lab postdoctoral fellow **Yung-Shu Kuan** took a position at the Inst. of Biochemical Sciences at National Taiwan U.

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Halpern lab postdoctoral fellow **Dan Gorelick** was selected for an AAAS Science Policy Fellowship in Washington, DC.

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Spradling lab graduate student **Dan Lighthouse** received his Ph.D. and is now a postdoctoral fellow at Yale.

Geophysical Laboratory

❺ Director Emeritus **Wesley Huntress** retired on Sept. 30.

—

Director **Russell Hemley** was elected Honoris Causa Professor for Energetics, Mechanics, Machinery, and Control Systems at the Russian Academy of Sciences, the leading scientific body in Russia. He presented invited talks at the Scottish Universities Summer School in Physics, May 26-June 6; EuroScience Open Forum, Barcelona, July 18-22; Diamond 2008 Conference, Sitges, Spain, Sept. 7-11; and the 46th EHPRG: International Conference, Valencia, Spain, Sept. 7-12.

—

❻ **Ho-kwang (Dave) Mao** was elected a Foreign Member of the Royal Society of London, the UK's national academy of science and one of the world's most prestigious scientific societies. The induction ceremony took place in London on July 11. Mao also presented at the New Fellows Seminar, Royal Society of London, and at the New Opportunities and Challenges for Liquid and Amorphous Materials Science, ESRF, Grenoble, Sept. 5. He also gave an invited talk at the Materials for Energy Symposium, ORNL, Oakridge, TN, Sept. 11.

—

Bjørn Mysen was one of seven scientists named a Geochemical Fellow for 2008 by the Geochemical Society and the European Association for Geochemistry.

—

Robert Hazen was an invited speaker at meetings of the Geochemical Society in Vancouver, the Santa Fe Inst. in New Mexico, and the International Society for the Study of the Origin of Life in Florence. As Sigma Xi Distinguished Lecturer he presented seminars on various aspects of mineralogy, origin of life, and evolution at Purdue, Penn State, Norwich U., and William and Mary. He was named to the Advisory Board of the National Academy of Sciences' Science and Entertainment Exchange, which connects the entertainment industry to science and engineering consultants.

—

Yingwei Fei organized the workshop "The Future of High-Pressure Research in China" at Peking U. and presented an invited talk on Mars exploration at the China Academy of Space Technology in June. He also organized a special session on deep Earth chemistry at the Vancouver Goldschmidt Conference in July.

—

Doug Rumble served as adjunct professor in the Dept. of Earth Sciences, Dartmouth College, in July and Aug.

—

Alexander Goncharov lectured in the Scottish Universities Summer School, May 26-June 6.

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Henderson James Cleaves presented a poster at the Goldschmidt Conference in Vancouver and gave talks at Georgia Tech in Atlanta, at the European Conference on Surface Science at Liverpool U., and at the International Society for the Study of the Origin of Life congress in Aug. in Florence.

—

Muhetaer Aihaiti gave an invited talk at NIST Center for Neutron Research (NCNR) of the National Inst. of Standards and Technology on July 7.

—

Amy Lazicki gave an invited talk at the high-pressure Gordon Conference on June 29 at U. New England.

—

Robert M. Hazen, **H. James Cleaves**, **Caroline M. Jonsson**, **Christopher L. Jonsson**, and **Dimitri A. Sverjensky** attended the Goldschmidt 2008 Conference on July 13-18 in Vancouver. Their research covers the adsorption of organics on mineral surfaces as well as mineral evolution, and was presented in the form of both oral presentations and posters.

—

Dominic Papineau delivered a talk at the Goldschmidt Conference in Vancouver and did fieldwork to study banded iron formations, phosphorites, and stromatolites in India and northern Canada.

—

Arrivals: John Armstrong, microbeam specialist (Sept. 2); **John Janik**, Carnegie Fellow (Sept. 2); **Gefei Qian**, IT/IS administrator (Sept. 2); Carnegie Fellow **Anat Shahar** (Sept. 15); **Luke Shulenberger**, postdoctoral associate (July 7); and Carnegie Fellow **Tim Strobel** (Sept. 22).

—

Departures: Tetsuya Komabayashi, JSPS Fellow (Sept. 23); **Takahiro Kuribayashi**, JSPS Fellow (July 30); postdoctoral associate **Simon Nicholas Platts**, Santa Fe Inst. (May 31); and **Eugene Zhao**, electronics engineer (Sept. 5).

—

Qiang Mei began postdoctoral research on Mar. 1. Before coming to HPCAT she worked at the Intense Pulse Neutron Source at Argonne National Laboratory. In Mar. HPCAT's **Yue Meng** gave an invited talk at Guelph U., Canada. **Wenge Yang** of HPCAT delivered a talk at the European Synchrotron Radiation Facility, France. **Melike Abliz** of HPSynC presented at the annual users meeting of Argonne National Laboratory, May 5-8, on the results of his high-pressure synchrotron X-ray diffraction experiments on two kinds of heavy fermion compounds.

—

Marjorie Imlay (Margie), assistant to GL director Rus Hemley, passed away Sept. 3. Director Phil Abelson hired Margie in 1955 as a stenographer; she served under five different GL directors for 52 years until her retirement in Dec. 2007. A skilled and dedicated assistant, Margie carried out myriad tasks for directors, staff, postdocs, support personnel, students, and visitors. She treated everyone in a very special way, and all who met her would agree that she was unforgettable. She will be truly missed by everyone at the lab.

2008 Summer Scholars Symposium at Broad Branch Road

Ten students participated in the annual Carnegie Summer Scholars Research Symposium on Aug. 6, making presentations from astrobiology to petrology. The 2008 Summer Scholars, from left, first row: Ellen Crapster-Pregont (Colby College), Caitlin Farnsworth (UC Davis), and Violeta Castro (Bucknell U.). Second row: Charlene Estrada (U. Arizona), Rohan Kundargi (UCLA), and Erin Wirth (NYU). Back row: Aric Mine (Rensselaer Polytechnic Inst.), Emily Heying (Wartburg College), Emme Johnston (Mount Holyoke College), and Jack Moriarty (Colby College).

❼ Chris Field

HPSynC predoctoral fellow **Qiaoshi (Charles) Zeng** attended a high-pressure Gordon Research Conference June 29-July 4.

Global Ecology

❼ Department director **Chris Field** was elected cochair of the IPCC Working Group 2. He was formerly a coordinating lead author on the 2007 IPCC report, *Impacts, Adaptation, and Vulnerability to Climate Change*, and was one of the two Americans to represent the IPCC at the 2007 Nobel Prize ceremonies.

—

Nona Chiariello, research coordinator at Jasper Ridge, received the Kenneth M. Cuthbertson Award for exceptional contributions to Stanford U.

—

Joe Berry and **Roland Pieruschka** attended the Gordon Conference, "CO_2 Assimilation in Plants: Genome to Biome," at U. New England. Berry was discussion leader for two poster sessions.

—

The Berry lab's **Adam Wolf** attended a workshop at the Max Planck Institute for Biogeochemistry Mar. 15-19 on biogeochemical changes in northern Eurasia. He visited the Laboratoire des Sciences du Climate et de l'Environment in Paris during Apr. and May.

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In May **Ken Caldeira** attended a meeting at the Council on Foreign Relations in Washington, DC, where political scientists discussed international governance issues associated with climate engineering. He also gave a pair of talks at EPA on ocean acidification and climate engineering. Caldeira was appointed chair of an ad hoc consultative group on ocean fertilization for the Intergovernmental Oceanographic Commission (IOC), a branch of the UN. He was the official representative of the IOC at the 31st meeting of the Scientific Group under the London Convention and the second meeting of the Scientific Group under the London Protocol in Guayaquil, Ecuador, May 19-23. The week of June 19, Caldeira visited Nice, [France,] where he served on the advisory board of EPOCA, the major European project investigating ocean acidification. Caldeira taught a unit on ocean carbonate chemistry and geochemical cycles at Italy's Urbino Summer School for Paleoclimatology at the end of July, and visited a site off the island of Ischia, where underwater volcanic CO_2 emissions are impacting marine life. He was appointed a member of the UK Royal Society study group on climate geoengineering. The Royal Society seeks to produce a report on climate engineering for release in spring 2009.

—

Dahlia Wist, greenhouse manager, talked at the annual meeting of the Association for Educational and Research Greenhouse Curators at Texas Tech U., July 28-31.

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Ted Raab traveled to Suriname and Tanzania and received a grant from NSF's Office of Polar Programs to study iron- and humic-reducing bacteria on the north coastal plain of Alaska.

—

Marion O'Leary, senior advancement advisor, gave a talk on Sept. 8 to members of a local Rotary Club about sustainability of succeeding generations between 1800 and 2100 using his family tree.

—

Arrivals: Postdocs **George Ban-Weiss** and **Jack Silverman** joined the Caldeira lab on Sept. 15 and Aug. 1, respectively; **Angela De Santis** (U. Alcala, Madrid) joined the Asner lab in early Sept.; **Christopher Doughty** arrived Sept. 16 as a Carnegie Fellow; lab associate **Russell Field** joined the Field lab on July 1; postdoc **James Kellner** joined the Asner Lab in Hawaii on June 2; **Scott Loarie** (Duke U.) joined the Asner on May 19. On July 28 KQED TV aired a story and slide show on Loarie's PLOS paper. **Jennifer Johnson** and **Alex Nees** are new grad students working with Chris Field.

—

Departures: Cristina Archer left the Caldeira lab Aug. 15 for UC Chico; Field lab postdoc **J. Elliott Campbell** joined the faculty at UC Merced; **Noel Gurwick** (Field lab) left Aug. 31 to join the US State Dept.; **Cho-ying Huang** (Asner lab) left Aug. 29 for National Cheng Kung U., Taiwan; lab tech **Timothy Varga** left the Asner lab May 31.

Observatories

Director **Wendy Freedman** gave a talk on supernovae at the STScI meeting in Baltimore May 5-8. On May 12 she hosted the Carnegie Supernova Project meeting at the Observatories, and on May 25-28 she gave a talk on the Giant Magellan Telescope in Rio de Janeiro. In June she visited the Institut d'Astrophysique in Paris and gave several talks. She also talked about the GMT at the Science with Giant Telescopes workshop in Chicago. In Aug. she gave an invited talk at the SDSS Asteroids to Cosmology Symposium, also in Chicago, and attended the COSMO08 conference in Wisconsin. She met with representatives from AURA, NSF, NOAO, and TMT to discuss a joint strategy for proceeding with the GMT and TMT as the National Academy of Sciences begins its decadal survey for astronomy and astrophysics.

—

As chair of the organizing committee, **Alan Dressler** participated in the workshop "Science with Giant Telescopes: Public Participation in TMT and GMT" in Chicago June 15-18.

—

Luis Ho also attended the Science with Giant Telescopes workshop and gave talks at the following institutions in Beijing: National Astronomical Observatories, Chinese Academy of Sciences, the Institute of High-Energy Physics, and Peking U. He also gave talks

Using the Carnegie Airborne Observatory (CAO)

and a network of field plots, the Asner lab completed a monthlong study of Kruger National Park to understand how animals, particularly elephants, and fire management are changing biodiversity and carbon storage in the African savanna. In July and Aug. members of the team, including David Knapp, Ty Kennedy-Bowdoin, Ruth Emerson, James Jacobson, Matt Colgan, and Greg Asner, began producing the first 3-D ecological maps of the park. In July Asner, Robin Martin, John Clark, and Kirill Caldeira, along with 20 Peruvians, collected leaves from more than 450 of the tallest trees for chemical, spectral, and genetic analyses—the first of more than 30 worldwide trips for the new Carnegie Spectranomics Project—to create a database of plant chemical and remote sensing signatures. In Aug. Asner joined 20 other experts in tropical ecology at the Smithsonian Tropical Research Institute in Panama to debate the magnitude and speed of the tropical species extinction crisis and develop a scientific consensus to guide policy development. Eben Broadbent and Angelica Almeyda have been setting up a field project linking 3-D forest structure from the CAO LiDAR to model forest photosynthesis in Hawaii. In Sept. they worked in the Nicoya Peninsula of Costa Rica linking land cover analyses from satellite imagery with detailed household economic surveys.

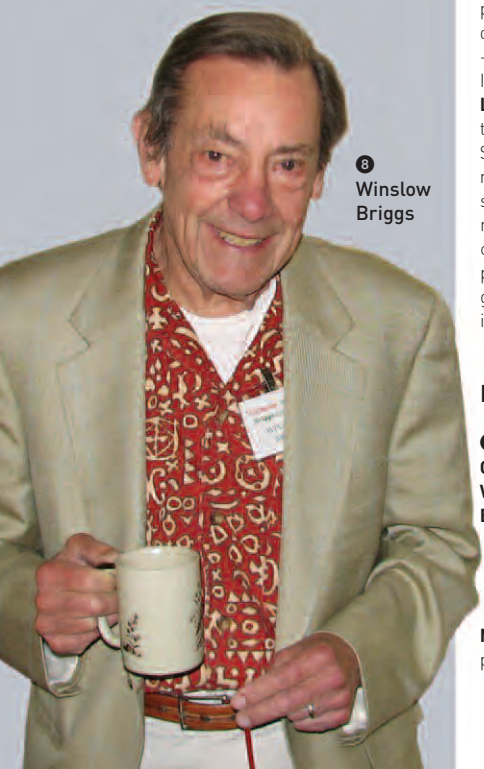
Elephants are an important driver to ecosystem changes in the African savanna.

Image courtesy Greg Asner

Welcome Juna Kollmeier!

Juna Kollmeier is the first scientific staff appointment in eight years. She is the first theorist to explore the formation and growth of supermassive black holes in the nuclei of galaxies; the intergalactic medium at high redshift; and the highest-velocity stars in the Milky Way.

Juna Kollmeier (above)



❽ Winslow Briggs

at the Nanjing Institute of Astronomical Optics and Technology.

—

Andy McWilliam participated in the ALTAIR meeting in Tucson in June.

—

Michael Rauch gave an invited talk at the Kavli Institute for Astronomy and Astrophysics at Peking U. in July.

—

Postdoctoral research associate **George Becker** attended the conference "Far Away: Light in the Young Universe at Redshifts Beyond Three" in Paris July 7-11.

—

Andreas Koch, a joint Carnegie-UCLA postdoc, has been awarded the 2008 Ludwig Biermann Prize for outstanding astronomers under the age of 35 by the Astronomische Gesellschaft. Koch gave his prize talk in Vienna on Sept. 8.

—

Carnegie Fellow **Masami Ouchi** was at Merton College, Oxford U., Aug. 3-16, and gave a talk on Aug. 7. He presented his vision of galaxy formation studies in the 2020s at the next-generation telescope meeting held at the National Astronomical Observatory of Japan.

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Spitzer Fellow **Jane Rigby** talked about the universe to the Webster Elementary School in Pasadena on June 10. She also presented results at the workshop "The Future of Far-Infrared Space Astronomy" in Pasadena May 28-30.

—

Carnegie-Princeton Fellow **Inese Ivans** gave talks at the Conference on the Chemical Evolution of Dwarf Galaxies and Stellar Clusters in Garching, Germany, and at the 10th Symposium on Nuclei in the Cosmos in Michigan.

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Former postdoctoral fellows **Ann Zabludoff** and **Dennis Zaritsky**, professors at U. Arizona, visited during June and July.

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In Aug. Carnegie-Hubble Fellow **Janice Lee** organized a two-day workshop for the Spitzer Local Volume Legacy (LVL) Survey team at the Observatories. LVL's multi-wavelength imaging data, which span from the ultraviolet to the midinfrared, for 258 galaxies will provide critical insight into two of the primary processes that shape the growth of galaxies: star formation and its interaction with the interstellar medium.

Plant Biology

❽ A symposium organized by **Arthur Grossman**, **Devaki Bhaya**, and **Zhiyong Wang** was held May 24 to honor **Winslow Briggs's** 80th birthday. **Arthur Grossman** presided and **Roberto Bogomolni**, **Clark Lagarias**, **Marta Laskowski**, **Peggy Lemaux**, **Hal McGee**, **Sheng Luan**, **Peter Quail**, and **Elaine Tobin** gave talks. **Dina Mandoli**, a former student, presented a pictorial tribute to Briggs. Briggs's wife, Ann, and their children Caroline, Lucia, and Marion shared their views of Winslow in "The Modern Global Scientist," a tribute in the style of Gilbert and Sullivan.

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In June, **Winslow Briggs** presented a seminar at the Kendrick C. Smith Interdisciplinary Symposium at the annual meeting of the American Society for Photobiology.

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Eva Huala presented a talk at the International Conference for *Arabidopsis* Research held in Montreal in July.

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Devaki Bhaya spoke at the 16th International Microbial Genomes Conference at Lake Arrowhead, CA.

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Matt Evans presented a talk at the XX International Congress on Sexual Plant Reproduction, held in Brasilia.

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Arrivals: The Wang lab welcomed postdoctoral research associate **Mingyi Bai** from the Chinese Academy of Sciences in June and **Jiangshu Liu**, a predoctoral research associate, from Hainan U., China, in May. In Aug. postdoctoral research associate **Clara Bermejo Herrero** joined the Frommer lab from the Universidad Complutense in Spain. Also joining the Frommer lab in Aug. was visiting researcher **Serena Schmidt von Braun** from LMU, Munich. In July **Lee Chae** arrived from UC Berkeley, joining the Rhee group as a postdoctoral research associate. In May **Avelino Carbajal** joined the maintenance staff as a greenhouse assistant. In June **Melissa Adams**, a Grossman graduate student, received her Ph.D. from Stanford and joined the lab for four months as a postdoc.

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Departures: Two postdoctoral research associates left the Frommer lab: **Farzad Haerizadeh**, to join Codexis, and **Friederike Hoermann**, for U. Hohenheim, Germany. In June the Somerville labs completed their moves to UC Berkeley with the departure of their remaining lab personnel. Chris Somerville's student **Michelle Facette** graduated from Stanford U. and left for Canada. **Liping Ji**, in the Rhee lab, left in May to return to China.

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Summer interns included **Ariana Afshar** (Stanford U.), **Michal Ahn** (Swarthmore College), **Farzin Bolourchian** (UC Santa Cruz), **Leonela Carrido** (Middle Tennessee State U.), **Jonathon Gelber** (Yale U.), **Matthew Blain-Hartung** (Colorado College), **Ricardo Leitao** and **Amy Radenbaugh** (San Jose State U.), **Leonardo Magneschi** (U. Pisa), **Michael Prior** (UCLA), **Alexandra Wormit** (Imperial College), and **Jiao Xue** (UC Berkeley, London); past participant in the intern program **Daniel Li**; recent high school graduates **Johanna Burch** (Palo Alto High School), **Kavid Ku**, **Amy Li**, **Emily Hulme**, and **Laura Rose** (Castilleja School, Palo Alto), and **Angela Lam** (Menlo-Atherton High School, Atherton).

Terrestrial Magnetism

In June **Sean Solomon** chaired a Committee of Visitors to the Deep Earth Processes Section of the NSF's Division of Earth Sciences and chaired a meeting of the NASA Advisory Council's Planetary Science Subcommittee held at the NASA Goddard Space Flight Center. He delivered lectures that month as part of the 25th anniversary of the Dept. of Earth, Atmospheric, and Planetary Sciences at MIT and the 40th Anniversary Lecture Series of the Lunar and Planetary Institute in Houston. In July he convened and spoke at a special session on the exploration of Mercury at the 37th COSPAR Scientific Assembly in Montreal. In Sept. he gave a seminar on the first MESSENGER flyby of Mercury at the Museum National d'Histoire Naturelle in Paris and an invited talk on the topic at the European Planetary Science Congress in Münster, Germany.

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Alan Boss reviewed exoplanet research at the Kepler Mission Science Team Meeting in Cambridge, MA, in May. He spoke about planetary systems theory at Exoplanet Forum 2008, in Pasadena. In Aug. Boss gave an assessment of Space Interferometry Mission simulations at NASA Headquarters, and he gave an invited lecture on the formation of planetary systems at the triennial meeting of the International Society for the Study of the Origin of Life, in Florence. In Sept. Boss spoke on the formation of giant planets and super-Earths at the SETI conference held at the UN Educational, Scientific, and Cultural Organization in Paris.

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In Aug. **John Chambers** gave a talk on terrestrial planets at the Great Planet Debate meeting at The Johns Hopkins U. Applied Physics Laboratory.

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Larry Nittler gave an invited talk on presolar stardust in the Solar System at the 10th Symposium on Nuclei in the Cosmos on Mackinac Island, MI, in July. In Sept. he gave colloquia at the Open U. and Manchester U. and spoke at a conference on "The Origin of the Elements Heavier than Fe" in Turin, Italy.

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In May **Vera Rubin** participated in the 2008 World Science Festival in New York City, joining actor Alan Alda onstage for a discussion about Nobel Prize-winning physicist Richard Feynman, with whom Rubin studied at Cornell 1948-1950. Alda portrayed Feynman in a reading of Peter Parnell's play, "QED." Rubin spoke at the National Academy of Sciences about the early days of the Space Science Board (SSB), 1957-1980, at a celebration of the SSB's 50th anniversary in June. In Sept. she spent time at the Lowell Observatory, working with former postdoctoral fellow

The department celebrated Vera Rubin's 80th birthday on July 16.
Longtime Rubin friend, Princeton's Eugene Higgins Professor of Astrophysics Neta Bahcall, gave a talk, "Weighing the Universe, Celebrating Vera's 80th Birthday," to honor her friend. A luncheon followed in the Greenewalt Building.

Neta Bahcall (left) discusses the current state of cosmology, including the state of research about dark matter and dark energy, in her talk celebrating Vera Rubin's 80th birthday.

Deidre Hunter. She accompanied Hunter on one of her regular visits to the classrooms of fifth and sixth graders on the Hopi reservation for a discussion on the universe.

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Steve Shirey gave colloquia in June on synthetic diamond growth and determining the ages of natural diamonds at the 50th anniversary celebration of the Institute of Geology and Mineralogy of the Russian Academy of Sciences. In Aug. Shirey attended the 9th International Kimberlite Conference in Frankfurt with former DTM visiting investigators **Sonja Aulbach** of U. Alberta and **Steve Richardson** and **Karen Smit** of U. Cape Town.

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In June **Paul Silver** presented evidence for a compositional boundary within the lithospheric mantle beneath the Kalahari Craton at the 2008 IRIS Workshop held in Stevenson, WA. In July Silver conducted fieldwork on strain behavior along a portion of the San Andreas Fault in Parkfield, CA.

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In July postdoctoral fellow **Alceste Bonanos** gave a talk at an International Astronomical Symposium at Keele U., UK.

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In July Hubble Fellow **Mercedes López-Morales** gave a talk at the Cool Stars 15 workshop in St. Andrews, UK.

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In Aug. postdoctoral associates **John Debes** and **Guillem Anglada** gave a presentation at the NASA Exoplanet Science Institute in Pasadena on combining the results of the European Space Agency's Gaia mission and the NASA Space Interferometer Mission.

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Postdoctoral associate **Maureen Long** gave a colloquium on subduction zone flow fields inferred from seismic anisotropy at Rutgers U. in Sept.

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In Aug. postdoctoral fellow **Jessica Warren** presented a poster at the 2008 Gordon Research Conference on rock deformation in Tilton, NH. She presented research on peridotites at the 2008 AGU Chapman Conference on Shallow Mantle Composition and Dynamics in Mount Shasta, CA, and participated in fieldwork on the Josephine peridotite in southern OR in Sept.

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The 2008 Goldschmidt Conference was held in Vancouver in July. Several staff and postdocs from DTM attended, including **Conel Alexander**, **Rick Carlson**, **Steve Shirey**, **Ann Nguyen**, **Julie O'Leary**, and **Liping Qin**, and geochemistry laboratory manager **Mary Horan**.

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David James, **Rick Carlson**, postdoctoral associate **Maureen Long**, visiting investigator **Matt Fouch**, and summer interns **Emme Johnston** and **Erin Wirth** spent several weeks in July, Aug., and Sept. in eastern Oregon installing and maintaining seismometers as part of the High Lava Plains Seismic Experiment.

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DTM's summer interns arrived in June. **Emme Johnston** of Mount Holyoke College and **Erin Wirth** of New York U. worked with postdoctoral associate **Maureen Long** on evaluating models for subduction initiation and local shear wave splitting in Japan, respectively. **Jack Moriarty** of Colby College worked with **John Chambers** on Doppler velocity searches for extrasolar planets.

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Arrivals: Administrative assistant **Robin Seidel**, postdoctoral fellow **Matt Jackson**, formerly of MIT and WHOI, and postdoctoral associate **Ming-Chang Liu**, formerly of UCLA, arrived in Aug. Postdoctoral fellows **Nick Schmerr**, formerly of Arizona State U., **Evgenya Shkolnik**, formerly of U. Hawaii, and Hubble Fellow **Julio Chanamé**, formerly of the Space Telescope Science Institute, arrived in Sept.

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Departures: Alceste Bonanos began a Giacconi Fellowship at the Space Telescope Science Institute in Sept.

GL/DTM

Joseph Neumann, an archivist from History Associates, Inc., began work organizing and cataloging historic administrative and research records of GL and DTM in the campus archives in July. □

2008 2009 Carnegie Capital Science Evenings & Special Events

NINETEENTH SEASON
All programs start at 6:45pm

Capital Science Lectures

THURSDAY, OCT 16, 2008
Cooperation and Collective Behavior, from Bacteria to the Global Commons
Simon Levin, Princeton University, Department of Ecology and Evolutionary Biology, Center for BioComplexity

WEDNESDAY, NOV 12, 2008
Geysers of the Solar System
Susan Kieffer, University of Illinois at Urbana-Champaign, Center for Advanced Studies, Department of Geology

THURSDAY, JAN 29, 2009
The Creation of Everything: The First 2 Billion Years
Steven Beckwith, University of California, Vice President for Research and Graduate Studies

THURSDAY, FEB 12, 2009
Hazy Skies on the Early Earth: Lessons from Saturn's Moon Titan
Margaret Tolbert, University of Colorado, Department of Chemistry and Biochemistry

THURSDAY, APR 16, 2009
Cell-to-Cell Communication in Bacteria
Bonnie Bassler, Howard Hughes Medical Institute and Princeton University, Department of Molecular Biology

Special Events

THURSDAY, SEPT 25, 2008
WASHINGTON, D.C., BOOK EVENT
The Carbon Age: From Crisis to Stability
Eric Roston, Duke University, The Nicholas Institute for Environmental Policy Solutions
Author of *The Carbon Age: How Life's Core Element Has Become Civilization's Greatest Threat*
James Gustave Speth, Yale School of Forestry and Environmental Studies
Author of *The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability*

TUESDAY, OCT 28, 2008
2008 BALZAN LECTURE
The Shifting Notion of Mathematical Truth
Enrico Bombieri, Institute for Advanced Study, School of Mathematics

TUESDAY, JAN 27, 2009
WASHINGTON, D.C., FILM PREMIERE
In Search of Memory
A documentary film about Eric Kandel by Petra Seeger, FilmForm Köln, 2008

THURSDAY, MAR 26, 2009
SMITHSONIAN RESIDENT ASSOCIATES PROGRAM LECTURE
The Crowded Universe: The Search for Living Planets
Alan Boss, Carnegie Institution for Science, Department of Terrestrial Magnetism

Tickets are required for this Smithsonian program only. Call 202.633.3030 or visit www.ResidentAssociates.org for details.

Alumnus Stanley Hart Thanks Carnegie in Day Prize Acceptance

Stanley Hart is preparing to dive into the summit crater of Vailulu'u volcano.
Image courtesy Hubert Staudigel

Since 1972, the National Academy of Sciences has awarded the Arthur L. Day Prize every three years to individuals who have made lasting contributions to understanding the physics of the Earth. Day was the first director of Carnegie's Geophysical Laboratory. The 2008 recipient was Stanley R. Hart, who was a Carnegie Fellow in 1960 and 1961 and a staff member from 1961 to 1975 at the Department of Terrestrial Magnetism. Today he is with the Woods Hole Oceanographic Institution. During his April 27 acceptance speech, Hart thanked Carnegie with these words:

> . . . What I especially acknowledge this day is the pivotal role the Carnegie Institution of Washington had in my career and in the way I view the scientific endeavor as a whole. Though I was only one year old when Arthur L. Day passed on, his remarkable 30-year tenure as the first director of the Geophysical Lab at Carnegie imprinted his lab and infected Carnegie's nearby Department of Terrestrial Magnetism with a template that has persisted to this day.
>
> I spent the first 15 years of my career at the Department of Terrestrial Magnetism, and the then-director Merle Tuve repeatedly espoused this simple philosophy of Carnegie —"At Carnegie, we buy your time and give it back to you." At this time of narrowing government investment in science, we may wish that Carnegie was more "copied." I thank Carnegie for trusting me with my time, and more generally for thriving for over a century as a model without peer.

Three Carnegie staff scientists are among the 14 recipients of the Day Prize: Hatten Yoder (1972), Ho-kwang (Dave) Mao (1990), and Sean Solomon (1999). For more information see http://www.nasonline.org □

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