CarnegieScience

THE NEWSLETTER OF THE CARNEGIE INSTITUTION [SUMMER 2007]

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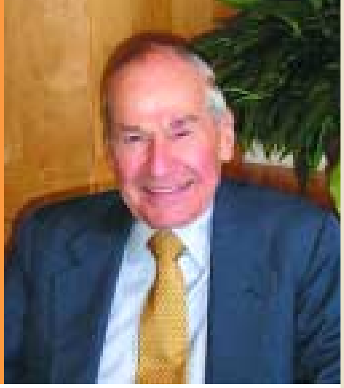

CARNEGIE INSTITUTION FOR SCIENCE

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Since its opening in 2002, the smallest Carnegie department, Global Ecology, has been astoundingly productive—in science, environmental policy, and raising public awareness of climate change. Now, after five years, it is time to help the department meet its full potential in understanding the underlying mechanisms of ecological processes.

The department was inaugurated as part of the 100th anniversary activities of the institution. It began with three faculty members—remote-sensing specialist Greg Asner, plant physiologist Joe Berry, and department director Chris Field. In 2005, climate scientist Ken Caldeira joined their ranks.

Since the beginning, this small cadre of researchers has been sought after by international organizations for their expertise. They publish prolifically in major journals and have brought issues surrounding climate change to the attention of policymakers and the public alike.

The Brazilian government, for instance, seeks Greg Asner's advice about illegal logging in the Amazon. And his remote-sensing work on invasive species in Hawaii prompted the Hawaiian Department of Natural Resources to ask for his help. His expertise also caught the attention of the World Bank, which asked him to present his research to its international audience.

Joe Berry has also been globe trotting. In an effort to understand how much CO_2 is being emitted in the non-industrial world—a major gap in current knowledge—he is establishing a program to monitor CO_2 in Africa and thereby help document how that continent contributes to the global carbon cycle.

Both Caldeira and Field participate on the highly acclaimed Intergovernmental Panel on Climate Change (IPCC)—the international body that addresses these important issues. They are also called to testify before the U.S. Congress on climate change-related topics.

In the last five years, this small group has published some 150 papers, including many in prestigious journals such as *Science* and the *Proceedings of the National Academy of Sciences*. Their work has also been featured extensively in the popular press. Asner's research on selective logging was covered in the *New York Times*. Caldeira was invited to write an Op-Ed for that publication, and his ocean acidification studies were featured in *The New Yorker*. Most recently, Field's work showing that CO_2 emissions are accelerating at an alarming rate worldwide appeared on the front page of *USA Today*.

Research at the department has also garnered generous support from some of the most discriminating foundations in the country, including MacArthur, Mellon, Moore, Packard, and Keck. Clearly, the Department of Global Ecology is flourishing. But to attain the critical mass essential for even greater success, it needs to grow.

A blue chip committee has recommended that we expand the current roster of four senior scientists to six; add the appropriate complement of staff associates, visiting scientists, and post-doctoral fellows; and upgrade or expand capital resources and equipment. The field of global ecology has so many dimensions that the department could add 50 faculty members and still not cover everything. But by selecting outstanding people, and encouraging strategic collaborations, this modest increase will allow the intellectual cross-fertilization and technical capability necessary to make many more path-breaking contributions.

We anticipate that more than $35 million is needed to provide start-up funds and permanent endowment to attract the best scientists and support them in building their research programs. In light of the threat posed by climate change, and the pressing need to understand this threat at a fundamental scientific level, we believe that friends of Carnegie will invest in this important expansion. I ask you to join me in congratulating the researchers and support staff at Global Ecology for their outstanding performance, and I ask for your help in supporting them in their important work.

—**Michael E. Gellert,** *Chairman*

TRUSTEE News

Carnegie Welcomes Two New Board Members

Michael Duffy

Mary-Claire King

The board of trustees unanimously elected two new members, Michael A. Duffy and Mary-Claire King, at the board meetings May 3 and 4 at the administration building in Washington, D.C.

Duffy is asset allocation strategist, managing director, and secretary/treasurer at Emerging Markets Management, L.L.C. (EMM) and the Strategic Investment Group (SIG). Both firms are located in Arlington, Virginia.

Duffy brings a wealth of investment expertise to the institution. He received a B.A. in economics at the University of Michigan, and an M.A. and Ph.D. in economics at the University of Chicago. He is a Chartered Financial Analyst (CFA). Before the formation of the EMM and SIG, he was an economist with the Federal Reserve Board and a senior pension investment officer at the World Bank. Duffy is a trustee and treasurer of the China Medical Board, and a member of the CFA Institute, the CFA Society of Washington, and the American Economic Association.

Mary-Claire King is American Cancer Society Professor in the departments of Medicine and Genome Sciences at the University of Washington. She is a pioneer in breast cancer research, proving that the disease can be inherited by identifying the BRCA1 gene. Her research also includes studying the genetics of inherited hearing loss (with colleagues from the Middle East), and the role of new mutations in mental illness. King and her lab also work with the United Nations forensic anthropology team to identify victims of human rights abuses.

King received a B.A. in mathematics from Carleton College in Minnesota and a Ph.D. in genetics from the University of California, Berkeley where she served on the faculty from 1976 to 1995. She has been a faculty member at the University of Washington, Seattle, since 1995. Among her study section, committee, and council activities, she has served on the National Academy of Sciences committee on the use of DNA in Forensics and the Advisory Committee to the Director of the NIH. She has been elected to the Institute of Medicine, the American Academy of Arts and Sciences, and the National Academy of Sciences.

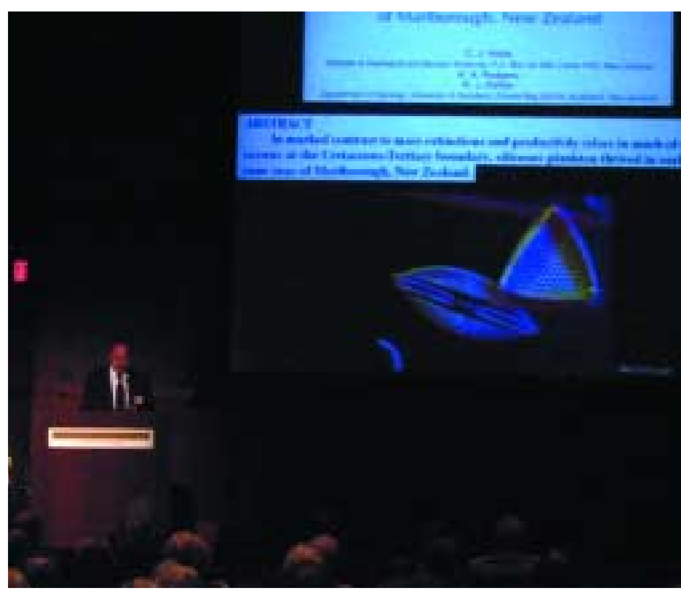
Caldeira Discusses Ocean Acidification at Carnegie Evening

Trustees, scientists, staff, and friends of the Carnegie Institution gathered at Headquarters in downtown Washington, D.C. on May 2 to hear Global Ecology's Ken Caldeira deliver this year's Carnegie Evening lecture.

As Caldeira explained in his talk, global warming is no longer the only environmental catastrophe linked to rising carbon dioxide emissions. The gas is also acidifying the world's oceans, and evidence from the ancient past provides a bleak glimpse of the future for marine ecosystems if the trend is not reversed. Coral reefs—the underwater equivalent of rain forests in terms of species diversity—are especially at risk, because the calcium carbonate that corals use to make their skeletons is very sensitive to acidic conditions.

[CONTINUED ON PAGE 4]

(Image courtesy Jennifer Wade.)



Carnegie Evening speaker Ken Caldeira

[CONTINUED FROM PAGE 3]

(Images courtesy Jennifer Wade.)

Trustees, scientists, staff, and friends of the Carnegie Institution gathered in the rotunda of the headquarters building for a Caribbean-themed reception following the Carnegie Evening lecture on May 2.

Caldeira studies this problem by comparing computer models with evidence from the fossil record. His work has revealed that the oceans turned acidic before, as a result of the same catastrophe that is believed to have killed the dinosaurs 65 million years ago. Following this event, corals and other organisms that depend on calcium carbonate suffered massive die-offs. Many remained at the brink of extinction for millions of years.

Evidence suggests that an enormous meteorite as large as six miles in diameter collided with what is now the Yucatán Peninsula, ejecting enough dust to blot out the Sun for months. It also launched tons of sulfur compounds into the air, which reacted with the water in the oceans to form sulfuric acid. Caldeira estimates that if even a small fraction—as little as five percent—of the sulfur compounds released from this impact rained down on the oceans, it would have been sufficient to cause the massive die-off of calcium carbonate-shelled species seen in the fossil record.

Today, carbon dioxide is posing a similar threat. When this gas reacts with water, as it does where the atmosphere meets the ocean's surface, it forms carbonic acid. At modest concentrations, the ocean is able to buffer this acid with the help of alkaline sediments from the ocean floor. But at the current high rate of input, largely caused by the tons of carbon dioxide that humans spew from tailpipes and power plants each day, the ocean is struggling to keep up. Caldeira believes that we will soon lose one of the rarest and most treasured ecosystems on Earth if we do not rein in carbon dioxide emissions soon.

Origins rese

It's like trying to hit the lottery. Over the last half-century, researchers have found that mineral surfaces may have played critical roles organizing, or activating, molecules that would lead to life. But identifying which of the countless possible combinations of biomolecules and mineral surfaces were key to this evolution has stumped scientists.

The molecules of interest are amino acids, the building blocks of proteins, and nucleic acids, the essence of DNA. Now a team of researchers led by Robert Hazen and Andrew Steele of Carnegie's Geophysical Laboratory has developed new protocols and procedures for adapting DNA microarray technology to quickly identify promising molecule/mineral pairs.

Hazen describes this work in his Presidential Address in the November/December issue of *American Mineralogist*. He begins by describing a first-of-its-kind comprehensive survey into research that has identified processes by which minerals may have prompted the transition from a geochemical world to a biological one almost 4 billion years ago.

Making the Primordial "Soup"

Scientists understand several probable steps in the origin of life, notably how the first organic molecules could have formed. In fact, prebiotic synthesis might have been so productive that the ancient Earth could have had far more types of molecules than could have been used by early life. A key question in origins research is how just the right blend of critical biomolecules was selected, concentrated, and organized from the diverse primordial "soup." Previous research by the Carnegie team and others has shown that many molecules, including amino acids, can adhere, or adsorb, to mineral surfaces, prompting further organic reactions. These findings have made surface/molecule interactions the subject of intense study.

Scientists suspect that organic material was likely introduced to Earth from sources such as molecular clouds in deep space that rained down on the early Earth. Other synthesis was driven by atmospheric lightning and ultraviolet radiation, or volcanic heat and chemical reactions in the deep oceans. Some of these building blocks were attracted to specific mineral surfaces, where they collected, concentrated, and reacted further.

Geophysical Laboratory scientist and origins of life researcher Robert Hazen.

(Image courtesy Robert Hazen.)

ARCH MEETS MICROARRAYS

Dark sprinkles of iron oxide prefer some faces over others on this quartz crystal. This preference points to the possibility that other molecules could be selectively adsorbed.

Neighboring faces of a calcite crystal have mirror-image surface structures. Experiments have shown that the left-handed amino acid aspartic acid preferentially adheres to left-faced calcite. This quirk of nature may be key to organizing, or activating, the molecules that led to life.

(Top photo by Robert Hazen.)
(Images reprinted with permission from the Mineralogical Society of America.)

Southpaw Power

"Some 20 different amino acids form life-essential proteins," Hazen explained. "In a quirk of nature, amino acids come in two mirror-image forms, dubbed left- and right-handed, or chiral molecules. Life, it turns out, uses the left-handed varieties almost exclusively. Nonbiological processes, however, do not usually distinguish between left and right variants. For a transition to occur between the chemical and biological eras, some process had to separate and concentrate the left- and right-handed amino acids. This step, called chiral selection, is crucial to forming the molecules of life."

Like amino acids, some minerals have pairs of crystal surfaces with a mirror relationship, called left and right faces. Calcite, one such mineral, is common today and was prevalent during the Archean era, when life first emerged. In 2001, Hazen and colleagues performed the first experiments showing that the left-handed amino acid aspartic acid preferentially adheres to left-faced calcite. That study confirmed previous theoretical suggestions of a plausible process by which the mixed right- and left-handed amino acids in the primordial soup could have been concentrated and selected on a readily available mineral surface. The challenge since has been to determine which of the untold biomolecule/surface interactions are the most likely candidates for the first steps to life.

"Crystal surfaces are complicated," Hazen continued. "They have crevices and craters, and are seldom flat. We need to find which surface types are the best 'docking stations' for different biomolecules. However, there are hundreds of mineral surface types and thousands of plausible prebiotic molecules, making literally millions of possible biomolecule/mineral pairs."

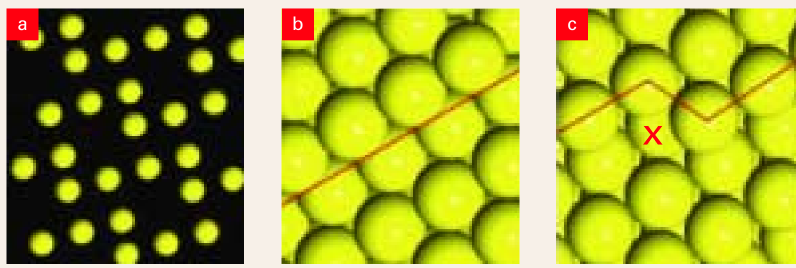
New Tools of the Trade

DNA microarrays provide a means to address this problem. Microarrays are produced by robotically spotting a slide with tens of thousands of microscopic droplets of DNA from as many genes, enabling scientists to measure which genes are activated. This rapidly developing technology can be used to identify, for example, the genes involved in disease.

Hazen, working with Geophysical Laboratory staff scientist Andrew Steele and his team, has modified this method to study molecule/mineral interactions. The scientists have devised protocols for cleaning mineral surfaces, spotting the surfaces with up to 96 different organic species, washing the surfaces to remove molecules that do not adhere to a mineral surface, and locating the remaining adsorbed molecules.

To discover "which molecules stick and which don't," as Hazen says, the Carnegie scientists are also collaborating with a team at the Smithsonian Institution led by Edward Vicenzi to employ a workhorse of chemistry called time-of-flight secondary ion mass spectrometry (ToF-SIMS). The mass spectrometer effectively blasts a sample with ionized particles, which fragment the surface-bound molecules and topmost mineral layer, allowing researchers to determine what's there. "ToF-SIMS will also allow us to detect the organic molecules that bind most strongly to mineral surfaces," commented Hazen.

Once Hazen and his colleagues have identified molecule/surface pairs of interest with the DNA microarray and ToF-SIMS, an arsenal of other techniques can be used to look at the details of the interactions. "What's particularly rewarding about this research is that it's an interdisciplinary effort from biology, chemistry, and geology," reflected Hazen. "It marries them in the search for an answer to a question that has intrigued humanity since the birth of consciousness: How did we get here?"



Crystals have several chiral, or mirror-image, surface features including an idealized terrace (a), a step-like structure chiral along the red line (b), and a twist at X (c). Experiments show that molecules prefer to adsorb at irregular features.

(Image reprinted with permission from the Mineralogical Society of America.)

Thanking Our Benefactors

A hundred years ago, Andrew Carnegie provided the sole source of funding for this institution. As the scale and complexity of the scientific endeavor grew, however, so did the institution's circle of support.

Today, Carnegie's contributors include a remarkable set of individuals who share and laud the Carnegie vision: when extraordinary minds are set free to study unique scientific questions, amazing discoveries result. To honor the exceptional supporters of this vision, the institution established five philanthropic societies. On May 3, 2007, chairman of the Carnegie Board of Trustees, Michael Gellert, and President Richard Meserve hosted a special inaugural event at Carnegie's elegant Washington, D.C., administration building to thank these donors by inducting them into the Carnegie Philanthropic Societies.

Chairman Gellert began the evening by welcoming the guests. Then, outgoing director of the Geophysical Laboratory, Wes Huntress, talked about the special place that Carnegie-style research has within the scientific community. An exquisite dinner of French cuisine followed.

Supporters Al and Honey Nashman (left and middle) receive their boxed pen as Carnegie president Richard Meserve (right) inducts them into the Second Century Society.

President Richard Meserve (right) inducts Geophysical Laboratory staff scientist Robert Hazen and wife Margaret into the Second Century Society.

Guests gather in the rotunda for the inaugural Carnegie Recognition Dinner held May 3, 2007.

After dinner, President Meserve opened the program by describing the three categories the societies recognize: benefactors who give annually, those who have contributed over their lifetimes, and those who are providing for the institution through planned gifts and bequests. Meserve began the ceremony by recognizing charter members of the Barbara McClintock Society, which consists of individuals who have contributed $10,000 or more in a given year. Beaming inductees stood as their names were called. Then Meserve presided over the induction of Second Century Society members—those individuals who have supported the institution through planned giving. As he called out the names of the new members, staff distributed a Second Century Society boxed pen.

After a captivating musical tribute by concert violinist and orchestra conductor Paul Hsun-Ling Chou, Meserve inducted charter members of the Vannevar Bush Society. Bush, the longtime Carnegie president, is often considered the dean of American science. This society recognizes individuals who have made lifetime contributions between $100,000 and $1 million. As Meserve read the names of those in the society who attended the event, each new member approached the podium and received a handsome medallion with Bush's likeness.

Chairman of the Development Committee Bruce Ferguson assisted Meserve with the presentations for the Edwin Hubble Society. In honor of the most famous astronomer of the 20th century, this society recognizes those who have contributed more than $1 million. Each of the attending recipients came to the podium and received a stunning three-dimensional, laser-engraved crystal representation of galaxy M81. The attending recipients—Michael Gellert, Robert Goelet, Jaylee and Gil Mead, and Cary Queen—all gave brief remarks about their rewarding experiences with the institution over the years.

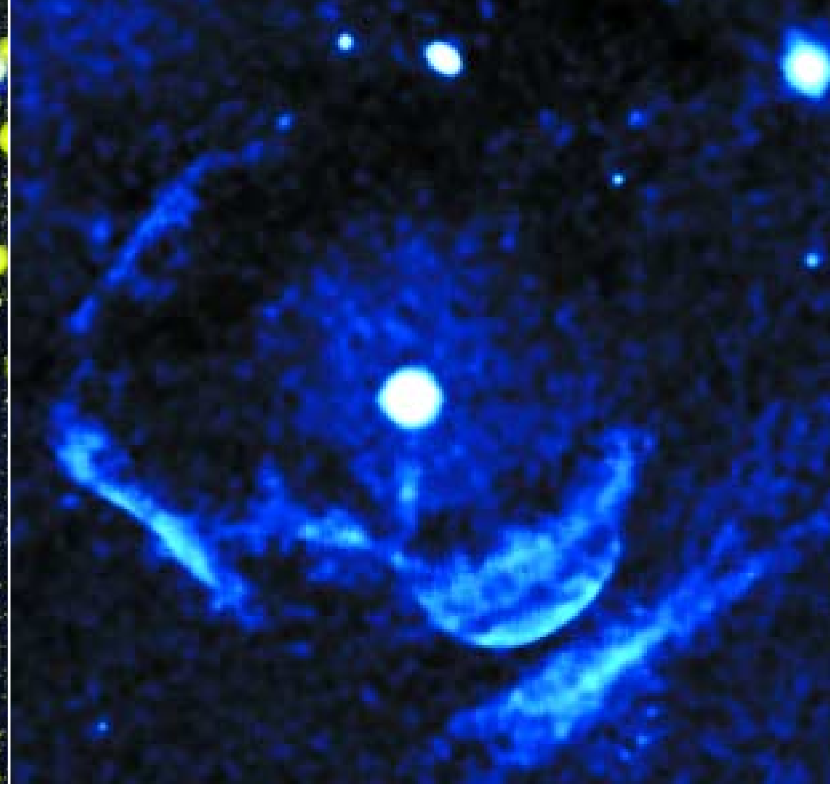
Then the two members of the Carnegie Founders Society were noted: the late Caryl Haskins, Carnegie's president from 1956 to 1971, and the late Bill Hewlett, a giant in the field of electronics and philanthropy. This society recognizes those who have given $10 million or more. After a final thanks to the outstanding generosity of Carnegie supporters, Meserve turned the podium over to trustee Michael Brin. Brin gave a witty, Russian-style toast to science, concluding the evening.

Chairman of the Development Committee Bruce Ferguson (left) assists with the Edwin Hubble Society induction. Trustee Robert Goelet (middle) receives his three-dimensional crystal representation of galaxy M81.

Medallions for the Vannevar Bush Society members

Carnegie astronomers helped to ensure the accuracy of the laser-engraved, three-dimensional crystal representation of galaxy M81—the gift of thanks for Edwin Hubble Society members. M81 is a spiral galaxy located in the northern constellation of Ursa Major. It is one of the brightest galaxies visible, and there is a very good estimate of its distance from Earth: 11.8 million light-years. The distance is known because M81 was studied by Observatories' director Wendy Freedman's team when she was leading the Hubble Space Telescope Extragalactic Distance Scale Key Project. Carnegie picked this galaxy because it is big and beautiful, and because there is a reliable mathematical model of its three-dimensional structure.

(Images courtesy Jim Johnson.)



This composite near- and far-ultraviolet image (top left) from NASA's Galaxy Evolution Explorer (GALEX) shows a ghostly shell around Z Camelopardalis (Z Cam), a double-star system about 530 light-years from Earth. The massive shell provides evidence that a huge "classical" nova explosion occurred a few thousand years ago. Z Cam is the largest white object in the image, located near the center; parts of the shell are seen as a lobe-like, wispy, yellowish feature below and to the right of Z Cam, and as two large, whitish, perpendicular lines on the left.

This image (top right), from the far-ultraviolet detector on GALEX, was processed to enhance the appearance of the diffuse emissions from the shell around Z Cam.

(Images courtesy NASA/JPL-Caltech.)

Double-Star Systems Cycle Between Big and Small Blasts

Certain double, or binary, star systems erupt in full-blown explosions and then flare up with smaller bursts, according to new information gathered by NASA's Galaxy Evolution Explorer (GALEX) and analyzed by a team of astronomers, including postdoctoral researcher Mark Seibert of the Carnegie Observatories.

The data bolster a 20-year-old theory suggesting that double-star systems experience both explosion types, rather than just one or the other. They also imply that the systems cycle between blast types, hiccupping every few weeks with small surges and experiencing giant outbursts every 10,000 years or so.

The discovery, appearing in the March 8 issue of the journal *Nature,* centers around a binary system called Z Camelopardalis (Z Cam). Astronomers have long known Z Cam to be a cataclysmic binary—a system that features a collapsed, dead star, or white dwarf, which sucks hydrogen-rich matter from its companion star like a stellar vampire. The stolen material forms an orbiting disk of gas and dust around the white dwarf.

Astronomers divide cataclysmic binaries into two classes—dwarf novae, which erupt in smaller blasts, and classical novae, which undergo huge explosions. Classical novae explosions are 10,000 to 1 million times brighter than those of dwarf novae, and they leave behind large shells of shocked gas.

In 2003, Seibert examined ultraviolet images collected during the GALEX mission's Survey of Nearby Galaxies. He noticed a never-before-seen arc and linear features surrounding Z Cam that indicated the presence of a massive shell—evidence that the dwarf nova had in fact experienced a classical nova explosion a few thousand years ago. The features had remained unnoticed up to that point because they are difficult to detect at optical wavelengths. However, they are easily seen at the ultraviolet wavelengths detected by GALEX.

"You could actually see it immediately, but we had to convince ourselves that we were really seeing a nova remnant," Seibert said. "If true, it would represent the largest nova remnant yet known. But it was especially shocking to find it associated with such a diminutive dwarf nova system. Everyone was skeptical, and it took a considerable amount of time and effort to be certain."

About 530 light-years from Earth, Z Cam was one of the first dwarf novae ever detected. For decades, observers have watched the system hiccup with regular outbursts. It brightens about 40-fold every 3 weeks or so, when an instability causes some of the material drawn by the white dwarf to crash onto its surface. Theory holds that Z Cam and other recurring dwarf novae should eventually accumulate enough matter and pressure from their swirling disks of hydrogen to trigger gigantic classical novae explosions. But no one had found definitive evidence for this until Seibert's discovery in 2003.

Other team members confirmed that the structures detected by GALEX were indeed parts of a massive shell of gas surrounding Z Cam, based on optical spectroscopic measurements made at the Lick Observatory near San Jose, CA, and narrowband images from Kitt Peak National Observatory near Tucson, AZ, Palomar Observatory near San Diego, CA, and the Wise Observatory at Tel-Aviv University, Israel.

"The new images are the strongest evidence yet in favor of the cyclic evolution scenario of these binary stars," said lead author Mike Shara of the American Museum of Natural History in New York. "It's gratifying to see such strong evidence for this theory finally emerge after all this time."

The California Institute of Technology (Caltech) leads the GALEX mission and is responsible for scientific operations and data analysis. NASA's Jet Propulsion Laboratory, a division of Caltech, manages the mission and built the science instrument. GALEX was developed under NASA's Explorer Program, managed by Goddard Space Flight Center in Greenbelt, MD. Funding for the mission was provided by NASA.

In addition to the Carnegie Observatories, Caltech, and the American Museum of Natural History, coauthors of the paper represent University of California at Los Angeles, Columbia University, Indiana University, Wise Observatory at Tel-Aviv University, and WIYN Observatory in Tucson, Ariz. Researchers sponsored by Yonsei University in South Korea and the Centre National d'Etudes Spatiales (CNES) in France also collaborated on the mission.

Under Pressure, Vanadium Won't Turn Down the Volume

Scientists at Carnegie's Geophysical Laboratory have discovered a new type of phase transition—a change from one physical form to another—in vanadium, a metal commonly added to steel to make it harder and more durable. Under extremely high pressures, pure vanadium crystals change their shape but not their volume, and do not take up less space as a result—unlike most other elements that undergo phase transitions. The work appears in the February 23 issue of *Physical Review Letters*.

The researchers*, led by High Pressure Collaborative Access Team (HPCAT) scientist Yang Ding, used a diamond anvil cell to subject vanadium crystals to pressures more than 600,000 times higher than the atmospheric pressure at sea level (which is about one bar). Using the high-resolution HPCAT X-ray facility, the scientists found that the basic atomic packing units of the crystals had changed shape from a cube to a rhombohedron, which resembles a distorted cube whose sides have been squashed into diamond shapes.

"Trying to understand why high-pressure vanadium uniquely has the record-high superconducting temperature of all known elements inspired us to study the high-pressure structure of vanadium," Ding said. "We had no idea that we would discover a completely new type of phase transition."

The most familiar phase transitions are those between gas, liquid, and solid forms of matter. In general, an increase in pressure or a decrease in temperature causes a substance to become denser and take up less space. Accordingly, gases and liquids will eventually form solids as their atoms become packed together. At extremely high pressures, some solids undergo further physical changes and can even change shape, which usually results in a change in volume. But in this respect, vanadium is unique.

Although it is expensive to mine and refine, vanadium is extremely important to the steel industry, where it is mainly used as an additive. Steel that contains vanadium is exceptionally strong and resistant to metal fatigue, making it ideal for a variety of products, from kitchen knives that stay sharp almost indefinitely to jet turbine blades that can withstand high speeds and heavy abrasion.

Pure vanadium crystals in cubic form were thought to be able to resist pressures of more than several million bars. Recent theoretical calculations, however, have suggested that extremely high pressures can cause unusual electronic interactions in vanadium that would destroy the cubic crystals. The new discovery suggests that vanadium avoids this structural collapse by changing shape.

"Although this type of transition was first observed in vanadium, it suggests that we should reexamine many other elements we thought were very stable," Ding explained. "Moreover, the transition provides a new explanation for the continuous rising of superconducting temperature in high-pressure vanadium, and could lead us to the next breakthrough in superconducting materials."

—By Matthew Early Wright

*In addition to Ding, the team includes Ho-kwang Mao (GL and HPCAT), Jinfu Shu (GL), Paul Chow (HPCAT), and Rajeev Ahuja and Wei Luo (Uppsala University, Uppsala, Sweden). This work was funded by the U.S. Department of Energy, the National Science Foundation, the U.S. Department of Defense, and the W.M. Keck Foundation.

Tiny Worms do the Chromo

Judith Yanowitz (foreground) takes a break from examining samples of *C. elegans* in her lab at the Maxine F. Singer building, home of the Department of Embryology. Carnegie Fellow Cynthia Wagner (background) works at another microscope.

(Image courtesy Matthew Wright.)

Like the kitchen in a cook's home, the microscope bench is a favorite gathering spot in Judith Yanowitz's lab. She and her colleagues spend much of their day peering at *Caenorhabditis elegans*, a tiny roundworm just barely visible to the naked eye. With magnification, however, the same eye can make out every organ inside the transparent worm's body.

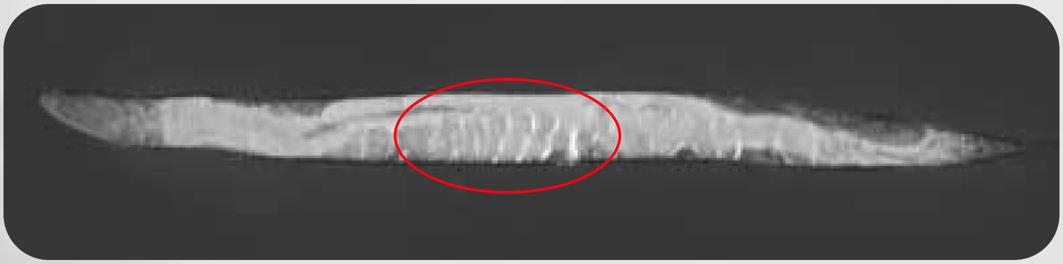
Because these features can be seen easily while the animal is alive, *C. elegans* is an ideal subject for biological research. Its sex organs occupy more than half of its body, making the worm especially well-suited for reproductive studies. Yanowitz's group takes advantage of this in their studies of genetic recombination—the process by which chromosomes swap DNA to create more genetic variation in sperm and egg cells.

The worms produce their sex cells in much the same way humans do, through meiosis. In this process, a "germ" cell undergoes two rounds of division, resulting in cells with half the normal number of chromosomes. During the first round of division, the chromosomes—ropelike clusters of DNA—exchange material in an effort to shuffle the genetic deck for the next generation.

The process is a carefully coordinated square dance that relies on a number of genes to regulate specific steps. By studying these genes, Yanowitz hopes to better understand not only how recombination works, but also how it can go wrong. Additionally, one of her latest projects focuses on how nongenetic factors such as aging and other stresses can affect the swapping of DNA between chromosomes.

"So many things can go wrong during development; I am often amazed that our species—or any species for that matter—survives," Yanowitz says. "The ability to properly segregate chromosomes into egg and sperm is essential, but this process is fraught with failure. Defects in this process are the major cause of miscarriage in humans, yet we know very little about the molecular controls of these events."

The *C. elegans* reproductive system has another important feature. Like most other animals, the worm has two sexes; but there are no females, only males and hermaphrodites, the latter of which produce both sperm and eggs. Males are typically rare, making up only about 0.1% of normal ("wild type") populations. They result from what would normally be considered a defect—



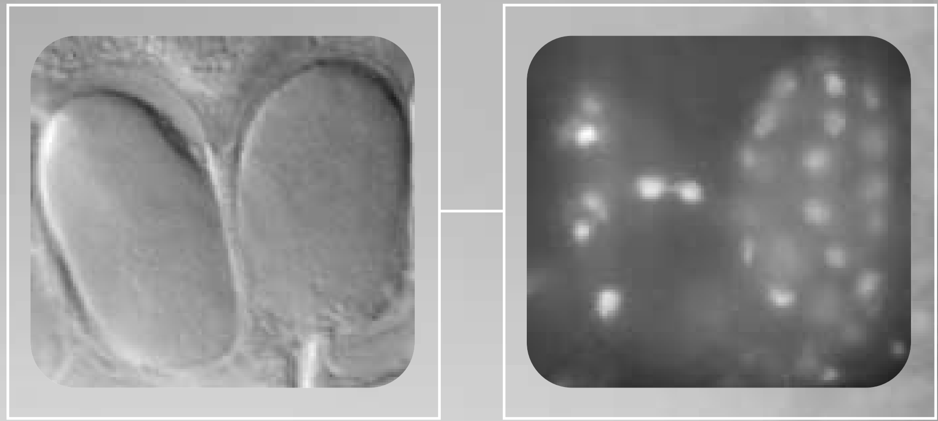
(Images courtesy Judy Yanowitz.)

Hermaphrodite (top) and male (bottom) adult *C. elegans* are shown with their heads oriented to the left. Differently shaped tails reveal which is which: hermaphrodites have a whip-like tail, while males have a flattened tail specialized for fertilization. This image also shows embryos developing in the hermaphrodite uterus.

some Dance at Embryology

they receive only one sex chromosome instead of two.

This happens because of a phenomenon called nondisjunction, in which a pair of chromosomes fails to properly separate during meiosis, resulting in either too many or too few chromosomes. Nondisjunction is difficult to study in humans because it is almost always lethal, with certain exceptions such as Down syndrome, which results from three copies of chromosome 21. But because *C. elegans* can survive the nondisjunction that results in a single sex chromosome, the worm is well suited to studying genes that control normal chromosome separation.



(Images courtesy Judy Yanowitz.)

At left, two *rfs-1* mutant *C. elegans* embryos can be seen using DIC imaging—a technique that makes transparent structures appear opaque. On the right, the same embryos have been stained with DAPI, a chemical that binds to DNA, making the nuclei easy to see. The embryo on the right appears normal, with most nuclei appearing as large round spheres. The embryo on the left, however, shows two nuclei connected by a bridge of DNA. This bridge never appears in normal embryos, but often does when the *rfs-1* gene is mutated, suggesting that *rfs-1* is required for maintaining the integrity of the genome.

Mutations in these genes can increase the percentage of males by as much as five hundredfold, from the normal 0.1% to nearly 50%. One such gene is *gak-1*, which appears to play a role in regulating the frequency of chromosome crossovers. In worms with a healthy *gak-1* gene, each chromosome pair crosses over at least once during meiosis, but rarely more than three times. In *gak-1* mutants, however, some chromosomes cross over more than they should, while others do not cross over often enough.

"No one knows for sure whether increased crossing over is detrimental to the cell," Yanowitz says. "But we do know that crossovers are required to hold the chromosomes together and allow proper segregation during meiosis. Thus, even if there is a small cost to having too many crossovers on some chromosomes, it is much less than the cost associated with nondisjunction of an entire chromosome."

Yanowitz is also interested in another gene, called *rfs-1*, which is important for maintaining telomeres—the repetitive sequences of DNA that cap the ends of chromosomes. Every time a cell divides, a little piece of telomere is lopped off of each chromosome. Cells will die if the telomeres get too short, so replacing these lost bits of DNA is important for regulating the lifespan of cells. In the case of germ cells, however, telomere shortening does not have many immediate consequences, since they divide relatively few times to produce sperm or egg cells.

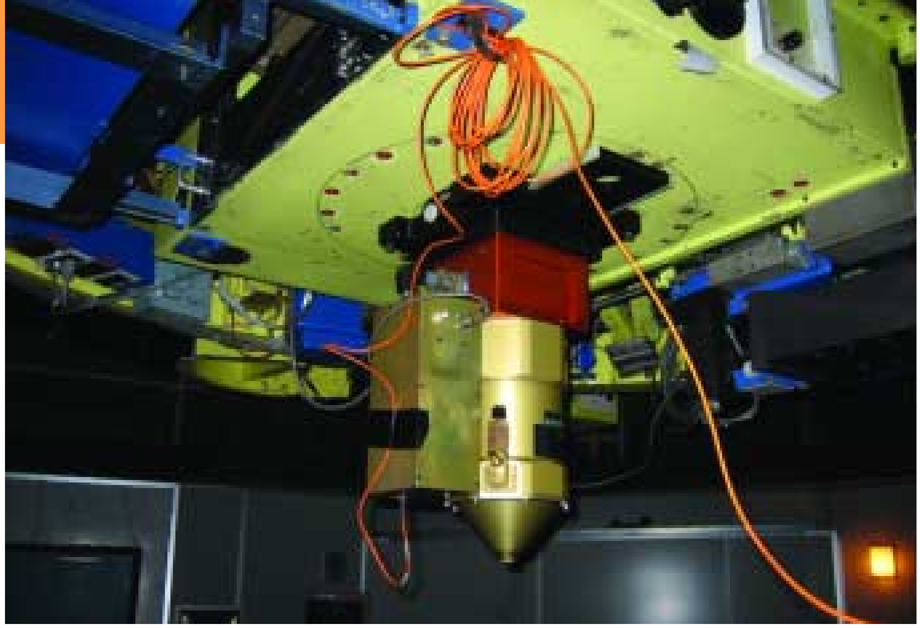
However, Yanowitz and her colleagues have found that reproduction rates drop to perilously low levels in strains of *C. elegans* with a defective *rfs-1* gene after several generations. Although shortened telomeres do not appear to affect germ cells on an individual basis, they do seem to affect the reproductive health and longevity of a mutated worm's descendants.

"There are several genes that repair telomeres, but *rfs-1* appears to occupy an altogether different class," Yanowitz explains. "It works by ensuring the proper copying of telomere DNA that already exists. By contrast, telomerase—a common telomere repair enzyme—works by adding new base sequences."

Yanowitz's lab is also looking at how nongenetic environmental factors such as high temperature, toxins, and radiation can affect recombination. So far, they have found that increased temperature can affect where crossovers happen on the chromosome. Normally, crossovers tend to spread out over the length of the chromosome, which helps shuffle the genes more thoroughly. But when the worms are raised at higher temperatures, crossovers tend to cluster, resulting in an uneven distribution—picture a card dealer who shuffles only a small portion of the deck, leaving the rest untouched.

"I am unnerved by recent data suggesting that a common chemical in plastics can lead to chromosome segregation defects—not in our children, but in our grandchildren," Yanowitz says. "We could be unknowingly creating our own demise. But there might be hope, and it depends on understanding how these processes work at the molecular level. We want to find the weak link in the process."

—By Matthew Early Wright



(Right) The Carnegie Astrometric Planet Search Camera (CAPSCam), built with support from the National Science Foundation and Carnegie, was installed on the 2.5-meter du Pont telescope at Carnegie's Las Campanas Observatory in March. The heart of the CAPSCam is a Teledyne Hawaii-2RG HyViSI array. The camera is optimized for high-accuracy astrometry of red dwarf stars.

(Below) Some members of the Carnegie Astrometric Planet Search team celebrate after the installation of the camera. From left to right are Fernando Peralta, Alan Boss, Greg Burley, Ian Thompson, Christoph Birk, and Frank Perez.

Astrometry: Back to the Future

Once upon a time, between 1905 and 1938 to be precise, Carnegie was home to a department called Meridian Astrometry. In the beginning, the discipline was cutting-edge—astronomers cataloged the positions and motions of stars to understand the structure of the universe. Lewis and Benjamin Boss, who were father and son, successively led the department during its distinguished three-decade run. But by the 1930s, astrophysics and cosmology dominated the field and the institution abandoned the effort.

Today, a third, unrelated Boss—Alan, of the Department of Terrestrial Magnetism (DTM)—is resurrecting astrometry, but with a twist. Boss, a stellar and planetary formation theorist, has headed a team, which includes DTM's Alycia Weinberger, and Ian Thompson, Greg Burley, and Christoph Birk from the Observatories, to develop and deploy the Carnegie Astrometric Planet Search Camera (CAPSCam).

In early March, they successfully installed CAPSCam on the 2.5-meter du Pont telescope at Carnegie's Las Campanas Observatory, and began using it. But instead of cataloging stars, these scientists are searching for Jupiter-mass planets among about 100 nearby low-mass stars in the Milky Way. Their goal is to find planetary systems that could harbor life. They are targeting the smallest and most abundant types of stars in the galaxy—M dwarfs or smaller, which are about 10% to 50% the mass of the Sun. More specifically, they are looking for colossal gas giant planets orbiting far enough from their parent stars to enable Earth-like planets to exist closer in.

The very precise astrometric method detects the wobble of a host star's position in the sky as it orbits the center of mass of the star-planet system. Using this feature, the researchers can calculate the mass of the planet based on the star's mass, and discern various characteristics of the planet's orbit around the star, such as its inclination (tilt) and shape (eccentricity). CAPSCam may be able to detect a planet with a mass as low as one-tenth that of Jupiter, and in a 12-year orbit, which is Jupiter's orbital period.

"M dwarf stars are attractive for several reasons," said Boss. "First, they are by far the most abundant type of star in the solar neighborhood—70% or so of the closest stars are M dwarfs. We want the closest possible stars, because astrometric detections get harder to make as the distance increases. Also, lower-mass stars show a bigger astrometric wobble, so we can probe to lower planet masses with a given sensitivity. Third, the radial velocity, (Doppler), searches for planets, such as those done by DTM's Paul Butler, concentrate on higher mass, brighter stars than the ones we will be studying, so we will not duplicate Paul's efforts. Finally, just in the last few years we realized the M dwarfs are likely to be hospitable to life, which was not previously thought to be the case. So this search fits in well with Carnegie's efforts in the NASA Astrobiology Institute in looking for habitable planets." •

(Images courtesy Greg Burley.)

ALARMING ACCELERATION IN CO_2 EMISSIONS WORLDWIDE

Between 2000 and 2004, worldwide carbon dioxide (CO_2) emissions increased at a rate of more than three times that of the 1990s—from 1.1% per year during the 1990s to about 3.1% per year beginning in 2000. Chris Field, director of Carnegie's Department of Global Ecology, was a co-author of the study published May 22 in the *Proceedings of the National Academy of Sciences* online Early Edition. The media widely reported on the results, including a front-page story in the May 22, 2007, issue of *USA Today*.

The scientists found that the accelerating growth rate is largely due to an increase in the energy required to produce a unit of gross domestic product (GDP) and the carbon intensity of the energy system (the amount of carbon per unit of energy), coupled with increases in population and per-capita GDP. "No region is decarbonising its energy supply," they state in the paper.

The increases in energy and carbon intensity constitute a reversal of a long-term trend toward greater energy efficiency and reduced carbon intensities. "Despite the scientific consensus that carbon emissions are affecting the world's climate, we are not seeing evidence of progress in managing those emissions in either the developed or developing countries. In many parts of the world, we are going backwards," remarked Field.

In addition, actual global emissions since 2000 grew faster than the highest emission scenario developed by the Intergovernmental Panel on Climate Change (IPCC). "The trends relating energy to economic growth are definitely headed in the wrong direction," said Field.

The acceleration of carbon emissions is greatest in the exploding economies of developing regions, particularly China, where the increases mainly reflect increasing per capita GDP. •

Crops Feel the Heat as the World Warms

Climate change caused average annual losses of roughly $5 billion in major food crop production over two decades, according to researchers at the Carnegie Institution and Lawrence Livermore National Laboratory.

From 1981 to 2002, the combined production of wheat, corn, and barley—the foundation of much of the world's diet—dropped by 40 million metric tons per year. The study, published in the online journal *Environmental Research Letters*, is the first to link this decline to human-caused increases in global temperatures. The story was also widely reported in the mainstream media.

"Most people tend to think of climate change as something that will impact the future," said Christopher Field, study co-author and director of Carnegie's Department of Global Ecology. "But this study shows that warming over the past two decades has already had real effects on global food supply."

Field and lead author David Lobell, a researcher at Lawrence Livermore National Laboratory, compared crop yield figures from the Food and Agriculture Organization to average temperatures and precipitation in the major growing regions. They found that global yields, on average, dropped by as much as 5% for every increase of 1°F.

Field and Lobell said that the study demonstrates a clear and simple correlation between global-scale temperature increases and crop yields. They also used this data to investigate the relationship between warming trends and agriculture.

"We assumed that farmers have not yet adapted to climate change—for example, by selecting new crop varieties to deal with climate change," explained Lobell. "A key moving forward is how well cropping systems can adapt to a warmer world. Investments in this area could potentially save billions of dollars and millions of lives," Lobell added. •

New Mechanism for Nutrient Uptake Discovered

"Every cell in every organism has a system for bringing in nutrition and expelling waste."

Biologists at Carnegie's Department of Plant Biology have discovered a new way that plant cells govern nutrient regulation: neighboring porelike structures at the cell's surface physically interact to control the uptake of a vital nutrient, nitrogen. It is the first time scientists have found that the interaction of neighboring molecules is essential to this regulation. Since plants, animals, bacteria, and fungi all share similar genes for this activity, the scientists believe that the same feature could occur across species. The discovery, published in the February 11th on-line edition of *Nature*, has widespread potential—from understanding human diseases, such as those that cause kidney malfunction, to engineering better crops.

"Every cell in every organism has a system for bringing in nutrition and expelling waste," explained lead author Dominique Loqué. "Some are through porelike protein structures called transporters, which reside at the surface of the cell's outer membrane. Each pore is capable of transporting nutrients individually, so we were really surprised to find that the pores simply can't act without stimulation from their neighbors."

In earlier research the Carnegie scientists, with colleagues, identified the genes responsible for initiating nitrogen uptake in plants. That identification has helped other researchers find the relatives of these genes in a variety of species from bacteria to humans. In this study, the scientists wanted to identify how ammonium transport is regulated.

Plants import nitrogen in the form of ammonium from the soil. The researchers found that the end portion, or so-called C-terminus, of the protein *Arabidopsis* ammonium transporter AtAMT1;1, located at the surface of the cell membrane, acts as a switch. "The terminus is an armlike feature that physically grabs a neighboring short-chain molecule, binds with it, and changes the shape of itself and its neighbor, thereby activating all the pores in the complex," continued Loqué. "The pores can't function without this physical stimulation."

"The rapid chain reaction among the different pores allows the system to shut down extremely fast and can even memorize previous exposures," noted coauthor Wolf Frommer. "Imagine a large animal marking its territory. A sudden flow of ammonia could be toxic to the plant. If it weren't for a rapid-fire shutdown, plants could die."

The conservation of this feature in the related transporters in bacteria, fungi, plants, and animals suggests that an ancient precursor organism had developed this feature because there was much more ammonia on the early Earth. The widespread presence of this structure in all of the known ammonium transporters suggests that the regulation is still necessary today for a variety of organisms and even in our kidneys, which excrete nitrogen.

The scientists don't yet know what triggers the rapid shutoff. They think it might be a very common regulatory event called phosphorylation, in which a phosphate molecule is introduced to another molecule, changing the latter and preparing it for a chemical reaction. They have found a site for phosphorylation and are looking at this possibility further.

In addition to Carnegie, this work was made possible by grants from NSF 2010, the Department of Energy, and the European Science award from the Körber Foundation.

IN Brief

❶ Trustee Jaylee Mead and husband Gilbert talk with Carnegie president Richard A. Meserve (left) at the inaugural Carnegie Recognition Dinner on May 3, 2007. The Meads have supported Carnegie generously over the years and were inducted into the Edwin Hubble Society that evening. Hubble members have made lifetime contributions of $1 million or more.

❷ Allan Spradling

❸ Marnie Halpern

Trustees and Administration

❶ Trustee **Jaylee Mead**'s husband, Gilbert, a retired NASA physicist, died on May 29 after a stroke. The Meads have been longtime supporters of Carnegie science. Gifts in his memory can be made to the Carnegie Memorial Fund.

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Carnegie President **Richard A. Meserve** has been elected to Harvard University's Board of Overseers. In Feb., he chaired a session on nuclear energy at the Annual Meeting of the AAAS in San Francisco. In Mar., he traveled to Mumbai, India, to chair a meeting of the IAEA's International Nuclear Safety Group and to speak at a Trombay colloquium at the Bhabha Atomic Research Center. In Apr., Meserve traveled to Aomori, Japan, to serve as president and speaker at the IAEA 50th Anniversary Symposium at the Japan Atomic Industrial Forum, and served as a panel moderator for a discussion on energy choices and climate change at a joint meeting of the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences. In May, Meserve gave the Couper Lecture to the Fellows of the Phi Beta Kappa Society and gave a presentation entitled "Nuclear Energy–The Role of Risk" at the 2007 Decision and Risk Analysis Conference at U. Texas-Dallas. In June, he served as moderator at the Forum on Assuring Nuclear Safety 2007 sponsored by the Nuclear Energy Agency of the OECD in Paris, France, and gave a presentation at the Nuclear Plant Safety Summer Course at MIT.

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There have been a number of changes in the accounting department. **Marjorie Burger** has become the new financial manager. **Yang K. Kim** has joined the administration as deputy financial manager, and **Dina Freydin** has come to the institution as senior grant accountant.

Embryology

❷ In Apr., department director **Allan Spradling** received the M. C. Chang Award and presented a lecture at UMass Medical School as part of the M. C. Chang Distinguished Lecture series for his pioneering accomplishments in developmental and reproductive biology and genetics. He was also elected president of the Genetics Society of America for 2007. In Mar., he delivered a keynote talk at a joint Keystone Symposium on Stem Cells and Cancer. He also presented lectures at Mt. Sinai School of Medicine, the Salk Institute for Biological Studies, UC-San Francisco, UC-Berkeley, Yale U., and Georgetown U. Medical School. In Apr., he traveled to Shanghai, China, to present his work at Fudan U. and participate in the Stem Cell Symposium at the Shanghai Institute for Advanced Studies.

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❸ **Marnie Halpern** spoke at the Dept. of Physiology at Columbia U. Medical Center. In Feb., she chaired a workshop at the 2nd Strategic Conference for Zebrafish Investigators in Asilomar, CA.

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❹ **Doug Koshland** spoke at New York U. Medical School, U. of Arizona, and Duke U. this spring.

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Yixian Zheng spoke at Columbia U., the Fred Hutchinson Cancer Research Center, and the American Society for Biochemistry and Molecular Biology meeting in Washington, D.C., this spring.

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Staff associate **David MacPherson** is organizing summer undergraduate seminars to expose undergraduates and high school students to research projects at the department. Carnegie postdoctoral fellows and graduate students volunteer to speak to the students about their work.

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Spradling postdoctoral fellow **Donald Fox** was awarded a Jane Coffin Childs Memorial Fund Fellowship, effective July 2007, for three years of support.

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Postdoctoral fellow **Kotaro Hama** has been awarded a 2-year Postdoctoral Fellowship for Research Abroad from the Japan Society for the Promotion of Science.

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In Apr., graduate student **Elçin Ünal** successfully defended her Ph.D. thesis. In Sept., she will begin her postdoctoral studies at MIT.

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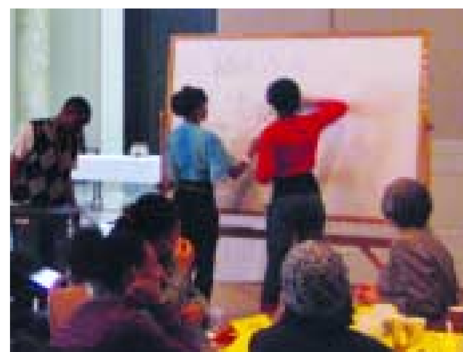
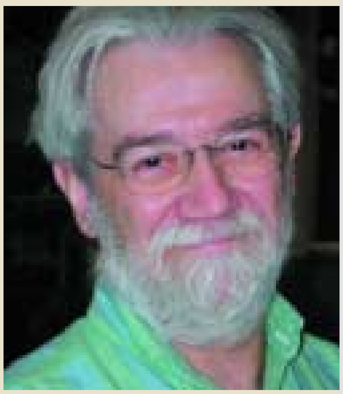
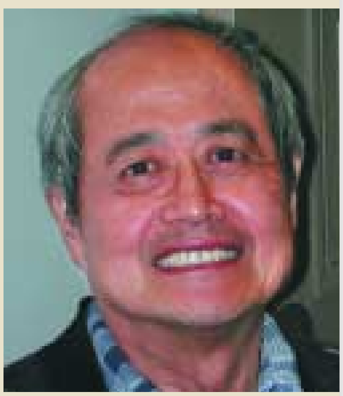


Students Antoine Bimbo, Rhia Hardman, and Safiyia Howard (left to right) from Ballou Senior High School in Washington, D.C., lead a lesson on dilution at the D.C. Biotech Mentoring Conference, hosted by CASE at Headquarters on Mar. 23. The event convened high school biotechnology educators from across the country to share strategies and ideas.

❹ Doug Koshland



❺ David George



(Image courtesy Veronica O'Connor.)

❻ Ji-an Xu

Recent Arrivals: Postdoctoral fellow **Sandrine Biau**, from the Ecole des Mines d'Ales, France, joined the Fan lab in Mar. Postdoctoral fellow **Lucilla Facchin**, from the U. of Padova, Italy, joined the Halpern lab in Mar. Halpern and Facchin received support from the Eppley Foundation for Research. High school student **David Lai** from the Ingenuity Project at Baltimore Polytechnic Institute joined the Koshland lab for the summer. Graduate student **Katherine Lewis** joined the Gall lab. Undergraduate **Ozlem Mert** came to the Koshland lab from Bilkent U. in Turkey. Postdoctoral fellow **Itay Onn**, from the Hebrew U. of Jerusalem, joined the Koshland lab in Apr. Postdoctoral fellow **Godfried Van der Heijden**, from the Nijmegen Centre for Molecular Life Sciences, Netherlands, joined the Bortvin lab in Apr.

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Recent Departure: Postdoctoral fellow **Jilong Liu** has taken a position as program leader in the MRC Functional Genetics Unit at Oxford U., beginning in Sept.

Geophysical Laboratory

Wesley Huntress is co-chairing a National Research Council (NRC) panel to assess NASA's progress in achieving the NRC science objectives and flight missions for planetary exploration from 2003 to 2013.

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Russell Hemley gave invited talks at the Stewardship Science Academic Alliances Program Symposium in Washington, D.C., in Feb., and at the Spring College on Water in Physics, Chemistry, and Biology in Trieste, Italy, in Apr. In May, he gave the Balzan Distinguished Lecture at the Institut de Physique du Globe, Paris, France.

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In Mar., **Ho-kwang (Dave) Mao** presented an invited keynote speech at the First EuroMinSci Conference in La Colle-sur-Loup, France. In Apr., he spoke at Penn State U. and at the Study of Matter at Extreme Conditions 2007 Conference, in Miami Beach, FL.

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Robert Hazen was named a Sigma Xi Distinguished Lecturer for 2008-2010. He will give about 20 public lectures in Europe and North America. He was a keynote speaker at a symposium on life's origins at the Biophysical Society annual meeting in Baltimore in Mar. He also spoke at Montclair State U. in NJ, U. Washington in Seattle, George Mason U., Ohio State U., the U. of Rome, the Smithsonian Institution, the National Science Foundation, and the National Research Council. He was named to the Advisory Board of the American Academy of Arts and Sciences' Working Group on Undergraduate Science Education. In Apr., he performed as solo trumpet with the Folger Consort.

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George Cody lectured at U. Maryland, Florida State U., and at the 38th Lunar and Planetary Science Conference in Houston, TX, this spring. He also gave an invited lecture at Harvard U. as part of the origins seminar series.

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Nabil Boctor presented a paper at the 38th Lunar and Planetary Science Conference in Houston, TX, in Mar.

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Hanns-Peter Liermann and **Haozhe Liu** (both with HPCAT) each chaired a session at the Study of Matter at Extreme Conditions 2007 Conference, in Miami Beach, FL, in Apr.

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❺ **David George,** who has worked at GL since 1975, retired. A party was held for him on Mar. 30.

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❻ **Ji-an Xu** retired and returned to China in Apr. He worked with Ho-kwang (Dave) Mao and Russell Hemley in the high-pressure group from Jan. 1976 to Aug. 1982. He served as a research associate from July 1999 to Dec. 2000, and then as a research scientist at HPCAT.

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Recent Arrivals: The Gramsch group is hosting **Ana Maria Molina Arcila**, from Colombia, as an intern. Visiting investigator **Liane G. Benning** from the U. of Leeds, UK, joined the Fogel lab in Mar. In June, postdoctoral associate **Raja Chellappa** from U. of Nevada, Reno joined the Hemley lab. **Yang Ding** left HPCAT and accepted a beamline scientist position at the newly formed HPSynC May 1. In Jan., former postdoctoral associate **Jennifer Eigenbrode** was a visiting investigator in the Fogel lab from the Goddard Space Flight Center. In Mar. and Apr., **Alexander Gavriliuk**, from the Russian Academy of Sciences, visited the Struzhkin lab. **Reto Gieré,** from the U. of Freiburg, Germany, visited the Rumble lab this spring. Predoctoral associate **Patrick L. Griffin** has been working with the Hazen and Hemley groups since Mar. In May, **Natalie D. Hanson** was a visiting investigator in the Fogel lab. **Lauren Kerr** is a research technician with Andrew Steele. Visiting scientist **Tetsuya Kombayashi** came to the Fei lab in Apr. In May, beamline scientist **Michael Lerche** began a position with the newly formed HPSynC. Research scientist **Qi Liang** joined the Hemley lab in May. Visiting investigator **Barry Maynard** from the U. of Cincinnati arrived at the Rumble lab this spring. Postdoctoral associate **Alexander Smirnov** from Slovakia arrived at the Cody lab in Feb. **Marilyn Venzon** is an accounts payable specialist beginning June 4. Balzan postdoctoral fellow **Lin Wang** started work at HPSynC in Mar. **Twanna Washington** will be working as a technical secretary from May 11 through Oct. 5. DOE postdoctoral research associate **Michelle B. Weinberger** from UCLA arrived at the

Carnegie launched a newly established organization, the High-Pressure Synergetic Consortium (HPSynC), on March 1.

It is an infrastructure center at the Advanced Photon Source, Argonne National Laboratory, for conducting high-pressure research, developing novel techniques, and serving the U.S. high-pressure research community. Ho-kwang (Dave) Mao is the director. Currently HPSynC has three staff and one part-time project manager. The plan calls for eight scientific staff and two supporting staff within the next 2 years.

❼ Staff associate Przemyslaw Dera departed June 1.

❽ Yu (Michael) Hu left HPCAT in April.

(Image courtesy Veronica O'Connor.)

Hemley lab in Mar. In Apr., the Fei lab welcomed predoctoral student **Yao Wu** from China U. Geosciences. **William Wurzel**, with the Smithsonian Environmental Research Center, joined the Fogel lab as an intern. Visiting scholar **Takamitsu Yamanaka** came to the Mao group from Osaka U. Also arriving to that group in June is predoctoral research associate **Qiaoshi Zeng** from Zhejiang U., China.

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❼❽ **Recent Departures:** Staff associate **Przemyslaw Dera** departed in June to be a research beamline scientist at GeoSoilEnviroCARS at the Advanced Photon Source at Argonne National Laboratory. **Yu (Michael) Hu** left HPCAT in Apr. for a position with an options firm in Chicago. Former postdoctoral research associate **Penny Morrill** has accepted a postdoctoral fellowship at McMaster U. **Shuhei Ono**, a GL fellow, has been appointed assistant professor of geochemistry at the Dept. of Earth, Atmospheric, and Planetary Sciences at MIT starting in July. Former postdoctoral research associate **Jan Vorberger** accepted a postdoctoral fellowship at the U. of Warwick, UK, in June.

Global Ecology

❾ **Chris Field** attended the International Panel for Climate Change (IPCC) fourth assessment report meeting in Brussels in Mar. and Apr. Also in Apr., he spoke before a U.S. Senate subcommittee about the IPCC report. Field delivered the Townsend Lecture at U. South Carolina.

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Greg Asner gave a public presentation about the Carnegie Airborne Observatory at the Hawaiian State Capitol in May. He has also been selected to chair the NASA Senior Review Committee.

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Two papers coauthored by **Joe Berry** have passed major citation milestones, according to Thomson's Web of Science. One has been cited more than 1500 times, and another more than 1000 times. A third paper is also poised to exceed 1000 citations, as it has been cited more than 990 times already.

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Ken Caldeira delivered the Eighth Annual Roger Revelle Commemorative Lecture, sponsored by the Ocean Studies Board of the National Academy of Sciences, in Mar. In Apr., he spoke to BBC TV, gave an invited talk in Paris, spoke at the Dirksen Senate Office Building by invitation from the American Meteorological Society, and testified before the House Subcommittee on Fisheries, Wildlife, and Oceans. Caldeira has also been appointed a professor of geological and environmental sciences, by courtesy, at Stanford. He will partner with the Stanford Center for Computational Earth and Environmental Science (CEES) and gain access to its large-scale computational resources.

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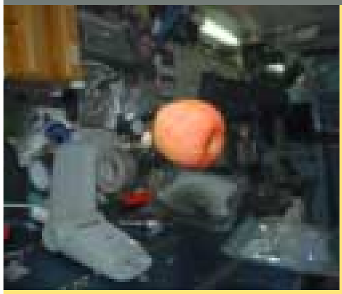
Carnegie's Lab-on-a-Chip Debuts on International Space Station (ISS)



On March 31, GL's Jake Maule, project scientist for the Lab-On-a-Chip, talked about experimental procedures with International Space Station astronaut Suni Williams from a console in NASA mission control in Huntsville. The mini-lab allows the first biochemical analysis of microorganisms by an astronaut in space. It monitors microorganisms and potentially hazardous chemicals in the cabin environment. The equipment functioned well on its inaugural test and has since operated successfully on four other occasions. Also known as LOCAD-PTS, it was designed to give astronauts greater autonomy and flexibility in how they perform science and operational testing in space. It resulted from a collaboration among Carnegie's Geophysical Lab, Charles River Laboratories, and NASA Marshall Space Flight Center.

Jake Maule (top right) instructs International Space Station astronaut Suni Williams (bottom) on how to use the Lab-on-a-Chip.

❾ Chris Field

The American Philosophical Society elected Wendy Freedman, the Crawford H. Greenewalt Chair of The Observatories, to its membership on April 27, 2007.

David Kroodsma finished his intercontinental ride for climate, and began a similar ride across the United States in Apr. See www.rideforclimate.com for updates.

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Paulo Oliveira and **Rebecca Raybin** are finalizing a study of rainforest disturbance, logging, and deforestation throughout national parks in the Peruvian Amazon.

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Administrative assistant **Linda Longoria** received an M.A. in anthropology, with an emphasis in archaeology, from U. Texas-San Antonio in May.

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Recent arrivals: Cristina Archer joined the Caldeira lab as a research associate in May. Postdoctoral researcher **Lon Cao** began work in the Caldeira lab in Apr.

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Recent departures: Bob Haxo left for a position in private industry in Apr. **Mark Rogers** left the Field lab in May.

Observatories

Observatories director **Wendy Freedman** gave a Carnegie Observatories Colloquium and participated in the Spitzer-Cycle 4 Time Allocation Committee meeting at Caltech in Apr. In May, she gave a colloquium in the Dept. of Embryology, spoke at the Canadian Institute for Advanced Research Meeting on Cosmology and Gravity in Whistler, B.C., and participated in the Space Interferometry Future of Hubble Constant Workshop at Caltech.

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Staff astronomer **Alan Dressler** gave a colloquium at NASA's Jet Propulsion Laboratory (JPL) in May.

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Staff astronomer **Luis Ho** visited Hong Kong U. and the High-Energy Physics Lab in Beijing. He gave a Capital Science Lecture at Headquarters in May.

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The Carnegie Lecture series at the Huntington Library included presentations by the Observatories' **Dan Kelson**, **Inese Ivans**, and **Ivo Labbé**, as well as **John Chambers** of the Dept. of Terrestrial Magnetism.

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Pat McCarthy, **Matt Johns**, **Steve Shectman**, **Andrew McWilliam**, and **Inese Ivans** participated in the GMT High Resolution Optical Spectroscopy Workshop in Mar. at the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA.

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Carnegie-Princeton and Hubble Fellow **Edo Berger** has been chosen by the Astronomical Society of the Pacific (ASP) to receive the 2007 Robert J. Trumpler Award for an outstanding recent Ph.D. thesis. As described by ASP, "Dr. Berger's thesis has made seminal contributions to our understanding of gamma-ray bursters, revealing fundamental aspects of their nature almost 40 years after they were first discovered."

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Carnegie-Princeton Fellow **Inese Ivans** gave two invited lectures at the VISTARS Workshop in Russbach, Austria. She also participated in the spring 2007 SDSS-II & SEGUE Collaboration meetings at Drexel U. in Philadelphia.

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Carnegie-Princeton and Hubble Fellow **Juna Kollmeier** spoke at the U. of British Columbia, Vancouver, the Herzberg Institute of Astrophysics in Victoria, Canada, and UC-Santa Cruz in Mar. In Apr., she spoke at Caltech and Harvard, and attended the Hubble Fellows symposium.

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Spitzer Fellow **Jane Rigby** spoke at the Spitzer Fellows symposium in Pasadena in Mar., at the Carnegie-Caltech postdoc workshop in Apr., and at JPL's Spitzer Science Day in May. She also gave the Astrophysics Seminar at UC-Irvine in May.

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Postdoctoral research associate **Violet Mager** presented a poster at the New Zeal for Old Galaxies conference in Rotorua, New Zealand, in Mar.

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The Observatories held the inaugural Carnegie-Caltech postdoc workshop at UCLA. Approximately thirty participants from both institutions attended, representing astronomical fields ranging from instrumentation to the cosmic microwave background. The 2-day event was a great success, and the postdocs enjoyed the opportunity for intense cross-field scientific interaction.

Plant Biology

Department director **Chris Somerville** spoke at the Institute for Biotechnology in Cuernavaca, Mexico, and at a DOE symposium in Washington, D.C., in Feb. Also in Feb., he received an honorary doctorate from U. Guelph in Canada, and gave a seminar there. In Mar., Somerville spoke at the USDA Agricultural Outlook Forum in Washington, D.C., at the Department of Plant and Microbial Biology at UC-Berkeley, and at the Berkeley Energy Research Symposium. In Apr., he spoke at UCLA, and at a conference on sustainable biofuels at U. Illinois, Urbana-Champaign. In May, Somerville spoke at the Salk Institute in La Jolla, CA, and at a symposium on multiscale imaging at UC-Berkeley.

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Winslow Briggs gave an invited seminar at UCLA.

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Shauna Somerville presented seminars at the Max Planck Institute for Plant Breeding in Cologne, Germany, and at the Symposium on Communication in Plants in Halle, Germany.

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Arthur Grossman's project with Fritz Prinz in the Stanford Mechanical Engineering Dept. was featured on the front page of the *San Francisco Chronicle* on May 21. In Mar., Grossman spoke at the 8th International Marine Biotechnology Conference in Eilat, Israel and at the Weizmann Institute of Science in Rehovot, Israel. In Apr., he spoke at U. Arkansas in Little Rock and at UC-Riverside. Grossman also became the chief of genetics at Solazyme, Inc.

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Zhi-Yong Wang spoke at the 19th Federation of Asian and Oceanian Biochemists and Molecular Biologists conference in Seoul, Korea, in May. In June, Wang spoke at the 18th International Conference on Arabidopsis Research in Beijing, China.

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Postdoctoral fellow **Stephan Wenkel** attended the Berliner Wissenschaftskonferenz 2007 at the invitation of the German Scholars Organization and spoke at Free U. of Berlin.

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Predoctoral student **Josh Gendron** won a 1st place award for his poster at the Western Section of the American Society of Plant Biology meeting at UC-Davis in Feb. Gendron also won an ICAR Travel Award from MAASC to attend the 18th International Conference on Arabidopsis Research in Beijing in June 2007, where he delivered a short talk.

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Recent arrivals: Visiting postdoctoral researcher **Myles Barker**, of Imperial College, UK, arrived in Jan. Postdoctoral research associate **Kian Hematy**, of Paris-Sud Orsay U., France, joined Shauna Somerville's lab in May. **Nicolaas Hermans**, from Rijksuniversiteit Groningen, Netherlands, joined the Grossman lab. Postdoctoral researcher **Liping Ji**, of National U. of Singapore, came to the Rhee lab in Apr. **Yelena Kurashava** joined the administrative staff in Feb. In Apr., visiting investigator **Jelmer Lindeboom**, of Wageningen U., Netherlands, joined the Ehrhardt lab. Lab assistant **Thuy Nguyen** also from Rijksuniversiteit Groningen, arrived at the Grossman lab. The Rhee lab

❿ Paul Silver

David James and postdoctoral fellow Katie Cooper test seismic equipment before installation as part of the High Lava Plains Broadband Seismic Experiment in eastern Oregon.

(Image courtesy John West of Arizona State U.)

welcomed systems administrator **Lawrence Ploetz** from Stanford U. in Mar. **Yinglang Wan** returned to Winslow Briggs' lab for a 1-month research stay in Apr. Receptionist/procurement clerk **Naoia Williams** arrived in Feb. and intern **Adeline Wong**, of Stanford U. came to the Rhee lab in Apr.

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Recent departures: From the Rhee lab, systems administrator **Joseph Filla** left in Mar., and **Julie Tacklind Horvath** left for a web developer position in Feb. From the Grossman lab, postdoctoral research associate **Chung-Soon Im** left for a position at Solazyme, Inc., in Jan., and postdoctoral research associate **Oliver Kilian** left for a position at Aurora Biofuel in Apr. Rhee lab technician **Noah Whitman** also left in Apr.

Terrestrial Magnetism

❿ **Paul Silver** was elected a Fellow of the American Academy of Arts and Sciences in Apr. In June, he gave a keynote lecture at the Subduction Zone Geodynamics Conference in Montpellier, France.

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Sean Solomon delivered the McDonnell Lectures at Washington U. in St. Louis in Mar. and the Thomas A. Mutch Memorial Lecture at Brown U. in Apr. He also delivered seminars at the Institute for Astronomy, U. of Hawaii, in Apr. and at the MIT Dept. of Earth, Atmospheric, and Planetary Sciences in May. He chaired meetings of the NASA Advisory Council (NAC) Planetary Science Subcommittee in Feb. and June. He led a NAC-sponsored workshop on Science Associated with the Lunar Exploration Architecture, held in Tempe, AZ, in Feb., and he chaired an external review committee to the Dept. of Earth and Planetary Sciences of Washington U. in Mar. and Apr. In June, Solomon hosted at DTM a MESSENGER Science Team meeting focused on data returned from MESSENGER's flyby of Venus on June 5 and complementary data collected by the European Space Agency's Venus Express spacecraft.

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In Jan., **Alan Boss** spoke at the Extrasolar Planets Media Workshop, held at U. Colorado, Boulder. He gave an update on extrasolar planet discoveries and theories at the Kepler Mission Science Team meeting held at the SETI Institute in Mountain View, CA, in Apr. Boss gave an invited lecture in Apr. for the Symposium on Structure Formation in Astrophysics in Lund, Sweden. In May, Boss attended the Navigator Program Science Forum at NASA Ames Research Center in Moffet Field, CA. He spoke about astrobiology at the Stockholm Observatory in Sweden and gave an invited review about the rapid formation of planets at the Nobel Symposium titled, "Physics of Planetary Systems" in Uppsala, Sweden, in June.

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John Chambers gave colloquia on planet migration at the Lunar and Planetary Laboratory of the U. Arizona in Feb., UC-Santa Cruz in Mar., and U. Maryland in Apr. In May, Chambers spoke on the origin of the solar system for the Carnegie Observatories' Astronomy Lecture Series held at the Huntington Library in San Marino, CA. Also in May, he gave a talk at the AAS Division on Dynamical Astronomy Meeting at U. Michigan, Ann Arbor.

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In Apr., **Larry Nittler** spoke on applications for presolar grains at U. British Columbia and at the Tri-University Meson Facility, Canada's National Laboratory for Particle and Nuclear Physics.

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Steve Shirey gave an invited talk in June at the Geological Association of Canada's 2007 NUNA Conference on The Pulse of the Earth and Planetary Evolution in Sudbury, Ontario.

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Alycia Weinberger delivered an invited talk at the workshop on Transformational Science with ALMA (Atacama Large Millimeter Array): Through Disks to Stars and Planets at the NRAO in Charlottesville, VA, in June.

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In Mar., postdoctoral fellow **Alceste Bonanos** gave an invited colloquium at the Cerro Tololo Inter-American Observatory in Chile. In May, Bonanos spoke at Caltech and at the Carnegie Observatories' 2nd Carnegie Science Day in Pasadena.

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Postdoctoral associate **John Debes** spoke on young circumstellar disks at the Spirit of Bernard Lyot conference at UC-Berkeley, in June.

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In Feb., postdoctoral associate **Maureen Long** gave invited talks at the Dept. of Geology and Geophysics at Yale U. and at the Dept. of Mathematical Sciences at Rensselaer Polytechnic Institute.

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Postdoctoral fellow **Ivan Savov** gave a talk on ancient and young arc mantles at a State of the Arc meeting in Osorno, Chile, in Feb.

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Hubble Fellow **Scott Sheppard** served as a panel member for the NSF Planetary Grants Program in Mar. He gave invited talks at Las Cumbres Observatory Global Telescope Network in Santa Barbara and at the Space Telescope Science Institute in Baltimore in Apr.

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Visiting Investigator **Derek Richardson** of U. Maryland spent Jan.-June at l' Observatoire de la Cote d'Azur in Nice, France, working on projects related to the disruption and gravitational reaccumulation of asteroids. Upon return, he resumed his collaboration with **John Chambers** and postdoctoral fellow **Fred Ciesla** on simulations of solar dust dynamics.

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The 38th Lunar and Planetary Science Conference was held near Houston in Mar. Several from DTM presented, including **Sean Solomon**, **Conel Alexander**, **Alan Boss**, **Rick Carlson**, **Erik Hauri**, **Larry Nittler**, **Steve Shirey**, and postdoctoral fellows **Fred Ciesla** and **Isamu Matsuyama**.

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Sean Solomon and **Alan Linde** gave oral presentations at the 2007 Seismological Society of America Meeting held in Kona, HI, in Apr.

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Alan Linde, **Selwyn Sacks**, **Steve Shirey**, and postdoctoral fellow **Ivan Savov** presented papers at the spring AGU Joint Assembly held in Acapulco, Mexico, in May.

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Alan Boss and **Alycia Weinberger** gave invited talks at the 210th meeting of the AAS in Honolulu in May.

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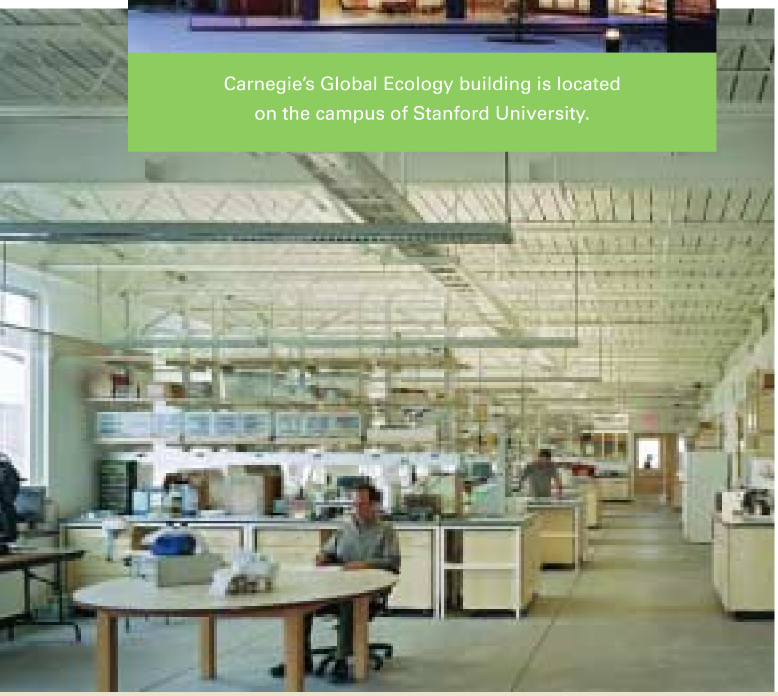
In Jan., members of the strainmeter group, **Alan Linde**, **Selwyn Sacks**, **Michael Acierno**, **Nelson McWhorter**, and **Brian Schleigh**, in cooperation with Pascal Bernard of the Institut de Physique du Globe de Paris, installed a three-component strainmeter near the Gulf of Corinth, Greece, close to an existing single-component strainmeter. It was the first installation of a strainmeter of the new design.

Carnegie's Global Ecology Building is among AIA's Top 10 Green

(Images courtesy Peter Aaron / Esto Photographics)

Carnegie's Global Ecology building is located on the campus of Stanford University.



The American Institute of Architects (AIA) named Carnegie's Global Ecology building among the top 10 "examples of sustainable architecture and green design solutions that promote and enhance the environment." Completed in 2004, the building sits on Stanford University's campus.

"The building proclaims our mission," said Global Ecology director Christopher Field. "The innovative design by EHDD Architecture, Rumsey Engineers, and the rest of a great team has resulted in reducing carbon emissions by 72% for operations and 50% for building materials. We hope others will follow our example."

Researchers at Global Ecology investigate the interactions between the Earth's climate and ecosystems from the smallest to the largest scales. From the outset, they wanted their building to have a minimal ecological footprint, while providing state-of-the-art laboratory and research space.

Richard A. Meserve, Carnegie president, observed that "the building is a success in every dimension. It is extremely energy efficient, but was not significantly more costly to build than a conventional building. Equally important, it is comfortable. There is no sense that any sacrifice has been made to achieve superb environmental performance."

The building's orientation allows natural lighting and maximizes ventilation. Radiant heat and evaporative cooling help manage temperatures. The exterior is covered in salvaged wine-cask redwood, and the interior wood is certified by the Forest Stewardship Council. Conference room and lobby furniture was made from salvaged trees, and about 20% of the concrete aggregate is recycled. Features such as no-irrigation landscaping, low-flow sinks, and dual-flush toilets have reduced water use by one-third.

Although the building uses a fraction of the energy of a typical California laboratory, Carnegie has purchased carbon offsets to reduce the carbon footprint of the building to zero.

AIA's Top 10 Green Projects Program began in 1997. For more information see http://www.aia.org/press2_template.cfm?pagename=release_042307_COTE

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