SPECTRA

THE NEWSLETTER OF THE CARNEGIE INSTITUTION

FALL 2004

New Horizons for Science

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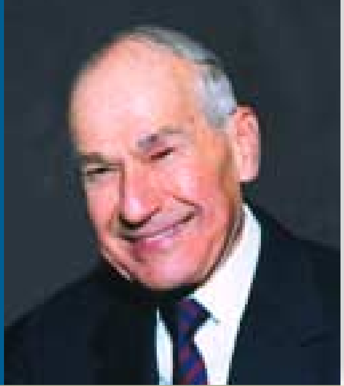

(Photo courtesy Richard Holden Photography.)

Terrestrial Magnetism at 100: Stronger Than Ever

Electrification was new, cars were rare, and use of the telephone was just emerging in 1904. The technological and scientific explosion of the 20th century was only beginning to spark when Louis Bauer was selected by the new Carnegie Institution to pursue an unprecedented project—to map the geomagnetic field of the entire Earth. The Department of Terrestrial Magnetism (DTM) was formed to accomplish the task, with Bauer at the helm. It was the start of a long legacy of excellence and leadership in investigating the Earth and its place in the cosmos.

Research at the department has changed dramatically over the decades, but DTM scientists have consistently been able to identify and pursue new and important research areas in advance of the rest of the world. Even before the department completed its geomagnetic surveys in 1929, its attention turned to physics. Many discoveries ensued—the confirmation of the ionosphere; revelations concerning atomic forces; insights into properties of the Earth's crust; and the birth of radio astronomy.

Scientists from many different disciplines have joined DTM to study myriad aspects of the Earth, its neighboring planets, planets around other stars, and beyond. Today the department has geophysicists, geochemists, cosmochemists, planetary scientists, atronomers, and astrophysicists. Many work side by side studying similar problems from different viewpoints. They share ideas, collaborate with one another, and lead multi-institutional projects. Startling breakthroughs result.

The DTM seismology group—Selwyn Sacks, Alan Linde, David James, and Paul Silver and their teams—have designed, built, and distributed Earth-sensing instruments worldwide. They have made enormous progress in understanding how and why the Earth moves and in identifying indicators that may precede earthquakes and volcanoes. Rick Carlson, Erik Hauri, Steve Shirey, and Fouad Tera complement these studies and expand our knowledge of Earth's evolution and the evolution of the other terrestrial planets. This research, in turn, is reinforced by the work of Conel Alexander and Larry Nittler, whose isotopic analyses of meteorites, asteroids, and interplanetary dust particles are revealing how our solar system came to be and where the ingredients of life may have originated.

Earth and its terrestrial neighbors are also the objects of department director Sean Solomon's interest. Now, with the successful launch of MESSENGER (page 8), he will be able to further examine the least-studied rocky world, Mercury, and help answer some of the most intriguing mysteries of planetary formation.

A decade ago, the concept that planets orbited other stars was theory. Paul Butler and his colleagues have changed that to fact. As co-leader of the team that has found most of the extrasolar planets now known, Butler was pivotal in developing the new field. The department is now home to a vigorous group that includes Alycia Weinberger, who studies disks from which these planets form, and Sara Seager, who investigates numerous features about these exotic worlds.

Because extrasolar planet discoveries have defied what we thought we knew about how solar systems form, theoretical work is booming. George Wetherill is a pioneer in planetary and solar system formation theory, winning the National Medal of Science in 1997. Alan Boss attracts international attention with some unconventional theories that may explain some idiosyncrasies of these planetary systems. Recently John Chambers joined DTM; his ultimate goal is to predict the existence and frequency of other Earths.

Beyond the study of our own Milky Way, astronomers Vera Rubin, John Graham, and their collaborators are making headway toward understanding the evolution and dynamics of galaxies. Among the many achievements are Rubin's investigations confirming the existence of dark matter, which won her the National Medal of Science in 1993.

Whether it's a question about the Earth, other planets, or the cosmos, DTM has made extraordinary contributions to the history of science. Our unique charter of encouraging the best minds to follow the most intriguing questions, unfettered by the obligations found in most organizations, has been the foundation of the department's past success and will be key to its future prominence. I am extremely proud to be associated with this strong, original, and forward-thinking group.

—**Michael E. Gellert,** *Chairman*

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Abelson Memorial Service

September 20, 2004

Comments of Richard A. Meserve
President, Carnegie Institution

I am very honored to have the opportunity to participate in this service in honor of Phil Abelson. I had the good fortune to know Phil for several decades and must state that he was one of the most remarkable people I have ever met.

The Carnegie Institution benefited by a long association with Phil. He started as a staff member at our Department of Terrestrial Magnetism in 1939 and then, after a brief interlude elsewhere during World War II, was appointed director of the Geophysical Laboratory in 1953. He served as president of the institution from 1971 to 1978 and thereafter was an active member of our board of trustees. Carnegie had the advantage of his wisdom for 65 years and was greatly strengthened as a result. We are deeply indebted to him.

Philip Hauge Abelson
April 27, 1913 – August 1, 2004

Philip Abelson at an October 21, 2003, symposium in honor of his 90th birthday.

(Image courtesy Richard Holden.)

There are several dimensions of Phil that I would like to discuss today. First, I must mention his boundless energy. This certainly included physical energy. He ran regularly—and I don't mean jogging—until very recently. I remember hearing reports of an elderly gentleman who was seen running wind sprints on the American University track. More recently he slowed down to a swift 4-mile walk that he made every day, rain or shine.

Even more impressive than his physical energy, however, was his intellectual energy. The computer notion of "multitasking" reflects exactly how Phil lived his life. In fact, Phil was able to carry on several successful careers simultaneously. Perhaps the clearest example of that skill was his ability to carry out his duties as editor of *Science* at the same time that he ably fulfilled his administrative and scientific obligations as president of the Carnegie Institution. In response to a question from a reporter about whether he was undertaking too much, Phil observed, with his usual candor, that "most of those who assume I am attempting to do too much and will fail in the attempt have only one job and don't do that very well." (I can clearly picture his toothy grin and striking laugh as he added the zinger at the end.) In fact, Phil was still contributing to *Science*, to the Carnegie Institution, and to other enterprises as he entered his 10th decade. As far as I know, he never stumbled.

Perhaps Phil's most remarkable characteristic, however, was the range of his intellectual interests and accomplishments. When he was elected to the National Academy of Sciences, it was determined that he was eligible in any of seven sections: biochemistry, chemistry, engineering, geophysics, microbiology, physics, and geology. He was the codiscoverer of neptunium; the coinventor of a uranium isotope separation process that was crucial in World War II; the leader of a very active group that undertook pioneering research in biophysics; the author of a book on the biosynthesis of *E. coli* that is still in use in almost every biochemistry lab in the country; and an investigator who conducted and directed research on geochemistry, geophysics, and experimental petrology. And, in his role at *Science*, he kept an active eye on advances in a wide variety of other fields.

Even more remarkable, at the same time that Phil stayed current in a wide range of scientific fields, he provided policy advice through service on an array of advisory committees. Throughout his career, he was one of a handful of wise men who have skillfully navigated the interface between science and government. He served the scientific community and the general public in a way that is a model for us all.

I have painted a picture, I hope, of a person of almost astonishing capability—a capability that certainly would justify a large measure of arrogance. But, as you all know, Phil was a person of great modesty—even shyness. When he retired as president of the Carnegie Institution, his colleagues organized a symposium in his honor. Phil came to the first morning of talks, and then left silently. He wanted no mention of himself or his contributions, or at least did not want to participate in any celebration of them. The organizers were a bit miffed, but it was very much in character for Phil to avoid being the center of attention.

I mentioned at the outset that I had the benefit of interactions with Phil over several decades. He was extremely loyal to his friends and I am very proud to count myself among them. I asked Phil how he was doing last spring, and he said that he was enjoying himself because he still had an opportunity to learn. He maintained a vigorous spirit of inquiry throughout his entire life. He was a truly remarkable man with an enormous span of interests and capabilities. He will be missed. •

Embryology Welcomes Two New Staff Members

Embryology Staff Member Alex Bortvin

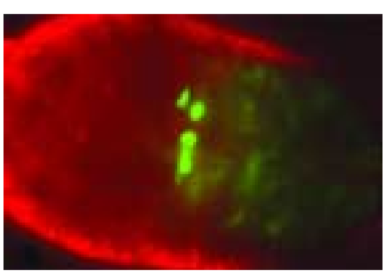
Staff member Alex Bortvin comes to Carnegie's Department of Embryology from the Whitehead Institute for Biomedical Research. Bortvin received both an M.S. in biochemistry and then an M.D. from the Pirogov Second Moscow Medical Institute in Russia. He received his Ph.D. in genetics from Harvard University in 1997.

At Harvard, Bortvin studied baker's yeast to understand how chromatin, the material of which chromosomes are made, regulates gene expression. He switched from yeast to mice when he joined Whitehead and now concentrates on germ cells—the cells that develop into eggs and sperm.

When a zygote forms upon fertilization, it is a *totipotent* stem cell—that is, it can become any type of cell in the body. Via multiple cell divisions during embryonic development, a ball-like structure called the blastocyst forms. Cells in its interior will become specialized cells in the embryo, including the next generation of germ cells. These interior cells are *pluripotent* stem cells; they can form most other cell types and are the subject of much medical research. Bortvin is interested in the genetic programming behind the origin of germ cells, the development of pluripotent cells, and other steps in embryonic development as undifferentiated stem cells become specialized.

Bortvin created a new way to visualize germ cell development in vivo, and found that primordial germ cells exist earlier than scientists formerly believed. This finding offers a new perspective on germ cell development and on early developmental events in mammalian embryogenesis overall.

Bortvin is also identifying genes that control early pluripotent cells in embryonic development. He has identified some 66 developmental pluripotency-associated genes (*Dppa*) and is testing whether these genes are responsible for creating or maintaining these intriguing cells. Along these lines, Bortvin has demonstrated that the inability of cloned mouse embryos to correctly express *Dppa* genes may be the leading cause of their poor development following nuclear transfer.



Primordial germ cells (bright green) are seen in this live mouse embryo. The red shows the extraembryonic area that surrounds the embryo.

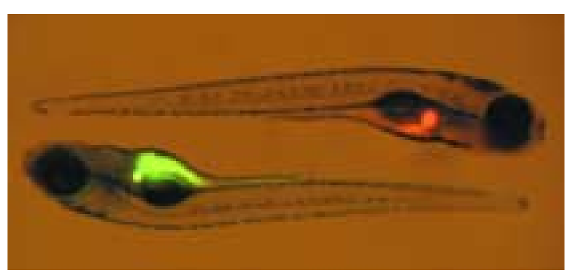
Embryology Staff Member Steven Farber

Steven A. Farber, former Barbara McClintock Fellow (1997-1998), has returned to the Department of Embryology as a staff member. Farber rejoins Carnegie from the Kimmel Cancer Center at Thomas Jefferson University, where he was assistant professor and director of the Cancer Center zebrafish facility.

Farber received his B.S.E. in electrical and biomedical engineering in 1986 from Rutgers School of Engineering. He went on to the Massachusetts Institute of Technology, where he received a master's degree in technology and public policy and then a Ph.D. in neurobiology.

Employing his unusual skill set, Farber has invented various techniques and devices for his research, including a microdyalisis probe to measure neurotransmitter release in rat brains in vivo, brain slice stimulation chambers, and methods to visualize biochemical processes in real time using a fluorescent phospholipid. The fluorescent lipids are ingested by animals and then processed by an enzyme called phospholipase A2 (PLA2). This enzyme releases lipid, which is important for the digestion of fats, signaling within and between cells, regulation of a variety of cell movements, and egg maturation—and has a role in neurotransmission. The signaling network of PLA2 is also thought to be involved in medical conditions such as arthritis, cancer, and septic shock.

When formerly at Carnegie, Farber was a postdoc in Marnie Halpern's lab. He, like Halpern, studies the zebrafish, *Danio rerio*. This fish is entirely clear when it is an embryo, making it ideal for visualizing biochemical processes in the live animal. Farber has employed these fluorescent lipids in a new type of genetic screen that has identified proteins that profoundly alter cholesterol absorption and may be important in a number of diseases such as atherosclerosis, some liver diseases, and some cancers. He also uses his glowing fish to understand how various drugs that control the digestion of fat and cholesterol work and to observe normal digestive processes, thus gaining information important for developing new therapies.



Farber's techniques using his fluorescent lipids allow for the visualization of live processes in the zebrafish, *Danio rerio*, shown here.

Hydrocarbons in the Deep Earth?

IN A TIME OF RISING OIL AND GAS PRICES, the possibility that there are untapped reserves is enticing. Since the first U.S. oil well hit pay dirt in 1859, commercially viable wells of oil and gas commonly have been drilled no deeper than 3 to 5 miles into Earth's crust. However, the findings of a study coauthored by Russell Hemley of Carnegie's Geophysical Laboratory suggest the possibility that these vital substances may exist much farther down. "These experiments point to the possibility of an inorganic source of hydrocarbons at great depth in the Earth—that is, hydrocarbons that come from simple reactions between water and rock and not just from the decomposition of living organisms," Hemley said. The study was published in the September 13-17 early online edition of the *Proceedings of the National Academy of Sciences.*

Methane is the most abundant hydrocarbon in the Earth's crust and is the main component of natural gas. Gas reserves are often accompanied by liquid petroleum. However, these reserves, at 3 to 5 miles beneath the surface, exist in relatively low-pressure conditions. Whether hydrocarbons exist deeper—and could even be formed from nonbiological matter—has been the subject of much debate. As depth increases in the Earth, the pressures can become so crushing that molecules are squeezed into new forms and the temperature conditions are so high that matter behaves very differently than at the surface. The team of scientists performed a series of experiments at three locations—the Carnegie Institution, the Carnegie-managed High Pressure Collaborative Access Team (HPCAT) at Argonne National Laboratory, and Indiana University South Bend—to mimic conditions that occur in Earth's upper mantle, which underlies the crust at a depth of about 12 to 37 miles (20 to 60 km) beneath the continents. They coupled the experiments with calculations performed at Lawrence Livermore National Laboratory.

With a diamond anvil cell, the researchers squeezed samples of iron oxide (FeO), calcite ($CaCO_3$), and water—common at Earth's surface—to pressures ranging from 50,000 to 110,000 times the pressure at sea level (5 to 11 gigapascals). They heated the samples using two techniques—focused laser light and the so-called resistive heating method—to temperatures up to 2700°F (1500°C). Methane formed when the carbon in calcite was reduced over a wide range of temperatures and pressures. The best conditions were at temperatures and pressures of about 1000°F and less than 70,000 times atmospheric pressure.

Lead author Dr. Henry Scott, former Carnegie postdoc and now at Indiana University South Bend, explained the significance of the findings: "Although it is well established that commercial petroleum originates from the decay of once living organisms, these results support the possibility that the deep Earth may produce abiogenic hydrocarbons of its own."

Dr. Freeman Dyson, professor emeritus at the Institute for Advanced Study in Princeton, who reviewed the study, further commented that "this paper is important not because it settles the question whether the origin of natural gas and petroleum is organic or inorganic, but because it gives us tools to attack the question experimentally. If the answer turns out to be inorganic, this has huge implications for the ecology and economy of our planet as well as for the chemistry of other planets."

The research was supported by the National Science Foundation, the NASA Astrobiology Institute, and the Department of Energy(DOE)/National Nuclear Security Administration through the Carnegie/DOE Alliance Center.

Globular Clusters May Be Galactic Remnants

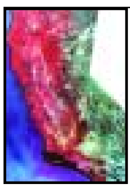
Globular clusters are collections of millions of stars crammed into an area of a few dozen light-years. Today the Milky Way galaxy has some 200 globular clusters, but it once had many more. According to theory, large galaxies today grew by feeding off of smaller galaxies and star clusters. New research by former Observatories Starr Fellow Paul Martini (now with the Harvard-Smithsonian Center for Astrophysics) and Observatories staff member Luis Ho shows that some globular clusters today may be remnants of dwarf galaxies that were partly consumed by larger galaxies. The research was published in the July 20, 2004, *Astrophysical Journal*.

Using the 6.5-meter Clay telescope at Carnegie's Las Campanas Observatory in Chile, the scientists studied 14 bright globular clusters in the large elliptical galaxy Centaurus A (NGC 5128). Brighter clusters tend to have more stars and more mass. The researchers were surprised to find, however, that the globular clusters of Centaurus A are 10 times more massive than most of these objects in the Local Group of galaxies—the collection of our galactic neighbors. "Whatever process makes them can produce some really huge objects—they begin to overlap with the smallest galaxies," commented Martini.

The findings suggest an important, albeit odd, association between the smallest dwarf galaxies and the biggest globular clusters. "Star clusters and galaxies are quite different from a structural standpoint," explained Martini. "Star clusters are much more centrally concentrated, and so the mechanisms that form them must be quite different. Identification of star clusters in the same mass range as galaxies is a very important step toward understanding how both types of objects form," he concluded.

The discovery of a suspected intermediate-mass black hole in the Andromeda galaxy globular cluster known as G1 is further evidence linking globular clusters to dwarf galaxies. Ho, a codiscoverer of the black hole, noted: "One of the most surprising findings is that the black hole in G1 obeys the same tight correlation between black hole mass and host galaxy mass that has been well established for supermassive black holes in the centers of big galaxies. This puzzling result is more understandable if G1 were once the nucleus of a larger galaxy. A very interesting question is whether some of the massive clusters in Centaurus A also contain central black holes."

Future studies of massive globular clusters will explore the formation processes for star clusters and galaxies.



(Image courtesy Goddard Space Flight Center/NASA.)

California Climate Alert: Major Impacts on the Horizon

"More frequent heat waves, dramatically reduced Sierra snowpack, and decreased quality of wine grapes are in California's future unless we take action now to minimize climate change," warned Christopher Field, director of Carnegie's Department of Global Ecology in Stanford, California. Field is a member of a team of scientists from leading institutions who published a study on the subject in the *Proceedings of the National Academy of Sciences* online early edition, August 16-20, 2004. The story attracted international media coverage.

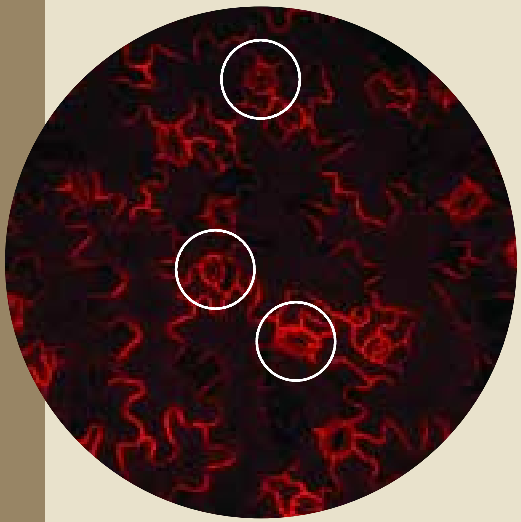
The amount of climate change in the state and the severity of its impacts strongly depend on emissions of heat-trapping gases, such as carbon dioxide, concluded the researchers. They compared the climate that could be expected in a future that made heavy use of traditional fossil energy, the source of most of these heat-trapping gases, with the climate that could be expected in a future that made heavy use of energy sources that did not emit heat-trapping gases. The results indicate that both scenarios result in significant climate changes over the coming decades. However, by reducing emissions, the amount of climate change can be cut by half *or more*.

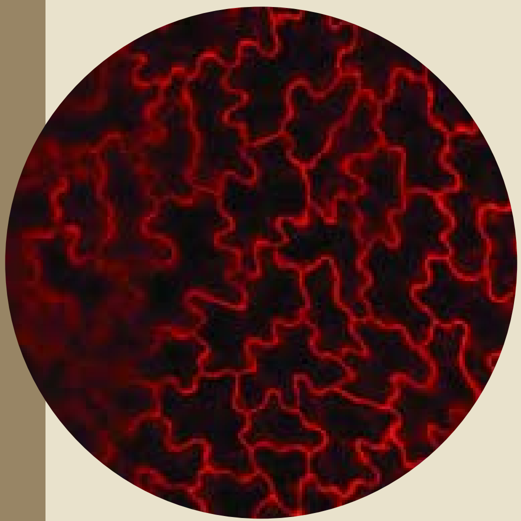
Using results from two of the latest generation of climate models, the team, for the first time, looked at a broad range of impacts for a particular region and assessed the sensitivity of the impacts to the future pattern of greenhouse-gas emissions at the global scale. All of the simulations showed increased temperatures by midcentury. Even with lower emissions, heat waves, extreme heat, and heat-related human mortality in Los Angeles could double to quadruple by century's end. The warming could be great enough for widespread impacts on agriculture, potentially threatening California's status as a producer of high-quality wines.

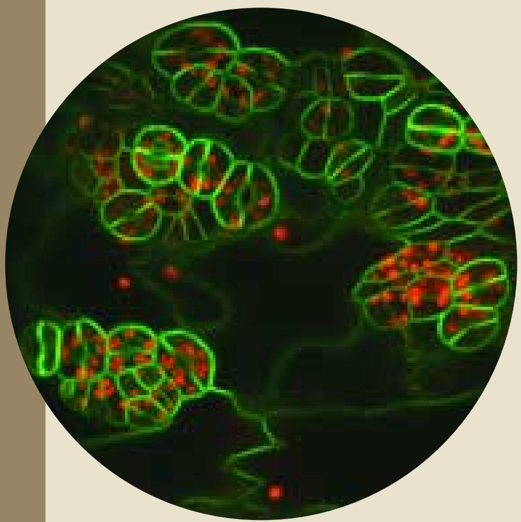
"We truly have a choice," said Field. "Leadership in developing innovative technologies, policies, and strategies can pave the way to a much more positive future."

Scientists from the following institutions participated in the study: ATMOS Research and Consulting; Climate Research Division, Scripps Institution of Oceanography; Department of Global Ecology, Carnegie Institution of Washington, Union of Concerned Scientists; Department of Civil Engineering, Santa Clara University; Atmosphere and Ocean Sciences Group, Earth Sciences Division, Lawrence Berkeley National Laboratory; Environmental and Societal Impacts Group, National Center for Atmospheric Research; Department of Biological Sciences, Stanford University; Institute for International Studies, Stanford University; Corvallis Forestry Sciences Laboratory, U.S. Department of Agriculture Forest Service; Department of Agricultural and Resource Economics, University of California, Berkeley; Center for Climatic Research, Department of Geography, University of Delaware; Department of Geography, Kent State University.

YODA the Master







Yoda, the whimsical, wise character in *Star Wars*, was the inspiration for a gene name because some plants defective in the protein the gene produces are not able to grow up normally; they turn out to be small and "fuzzy" like Yoda. Now, scientists at Carnegie's Department of Plant Biology have made a significant discovery about just how important the gene *YODA* is to plant development and survival. It is believed to initiate a series of chain reactions that control the development and distribution of vital plant components called stomata.

Stomata are tiny mouthlike features on plant surfaces that "breathe" in carbon dioxide for photosynthesis and "exhale" water vapor. They are thought to have been crucial to the evolution of land plants and are necessary to survival because they regulate the exchange of carbon dioxide and water. Stomata are composed of two guard cells that surround a pore and change its shape and size according to outside stimulation. To ensure maximum efficiency, stomata are precisely spaced and patterned around the plant. They are found more often on the shaded sides of leaves, never over veins, and they are separated from one another in the epidermis by at least one nonspecialized epidermal cell called a pavement cell.

Postdoctoral fellows Dominique Bergmann and Wolfgang Lukowitz, with Plant Biology director Chris Somerville, conducted research to find out what regulates the development and distribution of stomata. Their study, using the model plant *Arabidopsis*, was published in the June 4, 2004, *Science*. The researchers looked at the genes and signals involved in the development of *Arabidopsis* stomata. Stomatal guard cells are made by cell divisions in the young epidermis that produce two unequal daughter cells, one larger than the other. The smaller cell has the potential to become a guard cell, whereas the bigger cell usually becomes a common pavement cell. The final determination of which cell does what and how they are distributed is a product of a series of intercellular signals controlled by various genes.

It had previously been shown that two other genes, dubbed *TOO MANY MOUTHS* (*TMM*) and *STOMATAL DENSITY AND DISTRIBUTION1* (*SDD1*), were involved in regulating aspects of early stomatal development. Defects in these genes produced too many stomata, as well as some spacing and orientation problems. But neither of the defective genes totally scrambled the pattern or the abundance of stomata. So something else was at work. The scientists screened tens of thousands of plants looking for those with abnormal numbers or distributions of stomata on the leaves. They found mutant plants covered with stomata and discovered that they had mutations in the *YODA* gene.

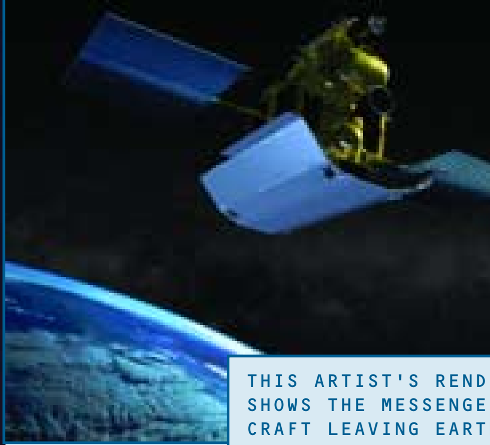
As it turns out, YODA belongs to a group of proteins called mitogen-activated protein kinase kinase kinases (MAPKKK), which is extremely important in yeast, in other plants, and in animals for cell division, development, and relaying signals from outside stimuli. By adding extra YODA activity to plants, the Carnegie group concluded that the *YODA* gene was the key to "switching on" the identity of each epidermal cell: without any YODA, the stomata overpopulated the surface, but too much YODA could prevent young cells from ever becoming stomata.

YODA's emergence as the master of signaling for stomata allowed the researchers to further identify over 100 other genes that may be involved in the development and location of guard cells. The challenge for scientists now is to unravel the tangle of genetic signals to determine which genes do what to serve *YODA*'s orders.

The top image is the normal wild-type *Arabidopsis* with normal stomata distribution (stomata are shown inside circles). The second has too much of the YODA protein and therefore no stomata. In the third image stomata proliferate (green areas). The small red disks inside the guard cells are chloroplasts and the larger cells (a combination of red and green) are pavement cells. The scale of each image is slightly different.

(Images courtesy Dominique Bergmann.)

10...9...8...MESSENGER LIFTS OFF!



THIS ARTIST'S RENDITION SHOWS THE MESSENGER CRAFT LEAVING EARTH.

(Image courtesy NASA/Johns Hopkins Applied Physics Laboratory/Carnegie Institution of Washington.)

The second time was the charm. At 2:15:56 a.m. on Tuesday, August 3, a Boeing Delta II rocket lit up the Florida night sky as it propelled the 1.2-ton MESSENGER spacecraft through the first phase of its 4.9-billion-mile voyage to Mercury, the innermost planet of our solar system. The suspense leading up to the launch was déjà vu for the spectators. Just 24 hours earlier, they had gone through the same drill for the first launch attempt. It was scrubbed at 2:09 a.m. because of the weather, just moments before the 12-second launch window opened.

The collective sigh of relief after liftoff was not immediate, however. MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) had first to reach solar orbit, then deploy its solar panels, and finally start sending back data. That milestone was reached 57 minutes after launch.

MESSENGER's journey to Mercury has already been long and fraught with challenges, as Principal Investigator Sean C. Solomon, director of Carnegie's Department of Terrestrial Magnetism, can attest. The only previous visit to the planet was in 1974-1975 when *Mariner 10*, a flyby mission, imaged less than half of the surface. That mission raised more questions than it provided answers. "For nearly 30 years we've had questions that couldn't be answered until technology and mission designs caught up with our desire to go back to Mercury," commented Solomon in an interview with the *New York Times*.

SECRETARY OF THE CARNEGIE BOARD OF TRUSTEES DEBORAH ROSE AND HER DAUGHTER SARAH WERE AMONG THE LAUNCH SPECTATORS.

(Image courtesy Oded Aharonson.)

The 37-Year Wait >

Solomon became interested in Mercury in the *Mariner* days, when he was an assistant professor at the Massachusetts Institute of Technology. But it was not until the spring of 1996, when a group at The Johns Hopkins University Applied Physics Laboratory (APL) tried to persuade him that the enormous challenges of a Mercury orbiter mission could be met, that Solomon accepted their offer to lead a team of engineers and scientists to design and propose a mission through the NASA Discovery Program, which focuses on efficient lower-cost space explorations.

The Discovery Program proposal process consists of two phases. In the first phase, NASA selects a handful of mission proposals, which are awarded funds for further study and scrutinized for a second culling. In December 1996 the team submitted their proposal. NASA selected it in phase one, only to reject the follow-on study in phase two because of concerns about the thermal system, particularly the solar arrays. Discouraged, but very determined, the team regrouped and performed numerous tests and simulations that showed that their design was robust. In 1998 they submitted a second phase-one proposal that addressed all the concerns. The mission concept passed both tests, and in July 1999 NASA formally selected MESSENGER for flight.

Over the years, the project has involved thousands of individuals throughout the United States and in six other countries, and has cleared countless managerial and technical hurdles. One of the final obstacles came in March 2004, when NASA postponed the launch from late May to early August for further testing of mission-operations scenarios and fault-protection software. Because of planetary realignments, the nine-week delay added almost two years to the flight plan.

SEAN SOLOMON, PRINCIPAL INVESTIGATOR OF MESSENGER AND DIRECTOR OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM, GATHERS WITH FAMILY MEMBERS FOR THE LAUNCH. SOLOMON'S GRANDSONS ALEX AND AUSTIN (FRONT LEFT AND RIGHT); WIFE, PAM (MIDDLE); SOLOMON WITH GRANDDAUGHTER SARAH IN ARMS; AND BARBARA NORTHROP OF THE APL AWAIT LIFTOFF JUST 60 SECONDS PRIOR TO THE 12-SECOND LAUNCH WINDOW.

(Image courtesy Oded Aharonson.)

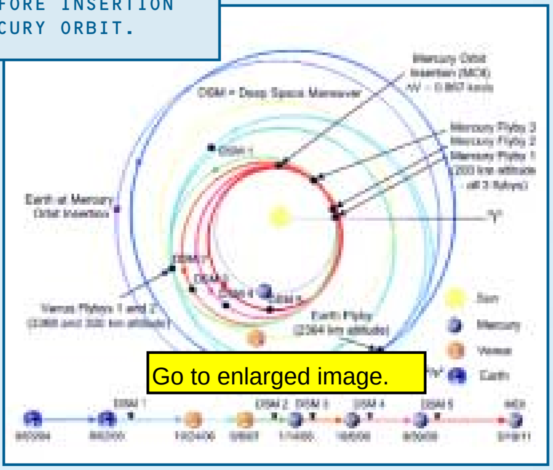
Mercury Is Hard to Get To and Study >

There are two main challenges for an orbiter mission to the innermost planet. First, the craft and its instrumentation have to withstand heating by the Sun and by Mercury. Second, a complex trajectory has to be plotted and executed to slow the craft enough to permit orbit insertion with the onboard propulsion system.

Mercury's nearness to the Sun means that it moves faster in its orbit than any other planet. Its rotation, however, is so slow that one solar day (noon to noon) equals the time of two full laps around the Sun. Thus, a solar day on Mercury lasts two years. Further, in Mercury's orbit, the Sun is as much as 11 times brighter than on Earth. The result of these oddities is that the surface is either blasted by the Sun during the very long day or put into deep freeze by a long, dark night. As a consequence, surface temperatures, at a daytime high near 840°F (450°C), are hot enough to melt lead. The chilling nighttime temperatures can go as low as -350°F (-212°C).

The seven miniaturized instruments on MESSENGER, designed and built by APL, Goddard Space Flight Center, and the universities of Colorado and Michigan had to accommodate these harsh conditions. The payload was, therefore, carefully selected to provide global observations of Mercury's surface, interior, exosphere, magnetosphere, and solar wind environment. Despite the grueling temperature conditions, the instruments will operate at near room temperature behind MESSENGER's heat-resistant, ceramic-cloth sunshade as they collect information on the planet's structure and composition, its geologic history, the nature of its core and thin atmosphere, the cause of its magnetic field, and a determination of the reflective substance at the poles, which could be water ice.

MESSENGER HAS A COMPLEX TRAJECTORY TO SLOW THE CRAFT DOWN. IT WILL FLY BY EARTH ONCE, VENUS TWICE, AND MERCURY THREE TIMES BEFORE INSERTION INTO MERCURY ORBIT.



(Image courtesy NASA/Johns Hopkins Applied Physics Laboratory.)

Loop-de-loop-1,2,3 >

MESSENGER will fly by Earth once, Venus twice, and Mercury three times during the 6.6-year, 15-lap journey around the Sun. The complex maneuvers will slow the craft gently and precisely enough to enter Mercury orbit with just the one engine thrust—the most critical operation of the remaining trip. As planned, MESSENGER will meet this mark in March 2011 (see figure).

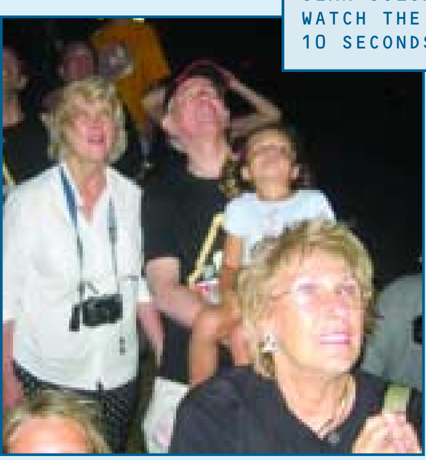
Although the flybys are necessary for "braking by physics," the flybys of Earth and Venus will also allow the scientists and engineers to take the instruments through their paces. The Mercury flybys will permit nearly the entire surface to be imaged, providing information that will allow the team to make the most of the Earth-year of data collection in Mercury orbit. After the craft completes its work, it will eventually crash into the planet as the gravitational attraction of the Sun and Mercury takes over the tiny craft.

What the Principal Investigator Wants to Learn >

With a background in planetary geology and geophysics, seismology, marine geophysics, and geodynamics, Solomon is particularly interested in learning more about Mercury's bulk composition and what that tells us about the processes that formed all the inner planets. He is also curious about Mercury's volcanic, tectonic, and internal evolution and how they are related. Additionally, he wants to understand how the planet's magnetic field originated and determine whether there is a liquid outer core.

To Solomon, the most geologically interesting aspect of Mercury is the hint from *Mariner 10* images that the planet has contracted enough to induce a global system of large faults. That contraction is believed to have come from interior cooling and may have a contribution from the partial solidification of Mercury's exceptionally large core. It is possible that Mercury is the only planet that has experienced enough contraction to be clearly visible in the geological record. Solomon is also anxious to see the geologic features that will be revealed as the other half of the planet is imaged for the first time.

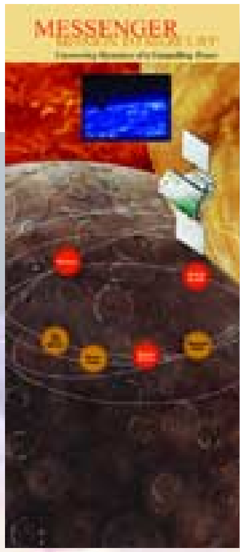
"I am fortunate in that I'll have witnessed the first two phases in the exploration of Mercury," commented Solomon. "The thousands of people who have worked on this project have set into motion an ability to answer questions that are now a generation old. It will be very satisfying for me to see some of these questions begin to be resolved, and I look forward to watching the next generation of planetary scientists handle the new challenges to be raised by MESSENGER with fresh eyes."



SEAN SOLOMON AND OTHER SPECTATORS WATCH THE ROCKET PIERCE THE SKY 10 SECONDS INTO THE JOURNEY.

AT 2:15:56 A.M., TUESDAY, AUGUST 3, THE BOEING DELTA II ROCKET CARRYING THE MESSENGER CRAFT LIFTS OFF.

(Image courtesy NASA.)



MESSENGER and CASE

Julie Edmonds, associate director of the Carnegie Academy for Science Education (CASE), is part of the MESSENGER education and public outreach team. For the past two years she has worked with colleagues at the Goddard Space Flight Center and the Challenger Center for Space Science Education to develop a module of hands-on science lessons based on mission science. The group has also trained 30 MESSENGER Fellows, K-9 teachers who are committed to training other teachers to use the module. The MESSENGER Fellows attended the launch as part of their curriculum.

Edmonds also developed a poster and a related, interactive kiosk for educators and the public. About 25,000 posters have been distributed through various organizations including the National Science Teachers Association, NASA, and the Geological Society of America. The kiosk (see image above) will travel to schools, conventions, and science museums in the coming years. It is currently on view at the planetarium of the Brevard Community College in Cocoa, Florida.

The MESSENGER kiosk will travel to schools, conventions, and science museums over the next few years.

Louis Brown of the Department of Terrestrial Magnetism Dies

Staff Member Emeritus Louis Brown of Carnegie's Department of Terrestrial Magnetism died Saturday, September 25, suddenly in New York City from a heart attack. He joined the department in 1961 and, although retired, continued to go to work every day. At the time of his death, he was completing a mass analyzer to study the isotopes in meteorites. Brown worked in nuclear physics and geochemistry and built instruments to make isotopic measurements and observe nuclear phenomena. He also served as acting director of the department from July 1991 through August 1992.

Brown was born January 7, 1929, in San Angelo, Texas. In 1950 he graduated from St. Mary's University and then joined the U.S. Army. He married Lore Elisabeth Frick of Ludwigsburg, Germany, in 1952. In 1958 he received a Ph.D. in physics from the University of Texas. After joining Carnegie, Brown worked on the Van de Graaff accelerator project, a joint U.S.-Swiss effort to investigate beams of heavy ions and nuclear interactions. He then headed a nuclear physics program on which Carnegie collaborated with the University of Basel, which led to his investigations of the isotopic composition of rocks and soils. This work required new designs and the creation of ion detectors for mass spectrometry. Brown was key to developing and using accelerator mass spectrometry. Using these techniques, he was instrumental in showing that oceanic sediments are ferried into the deep Earth at subduction zones and contribute to the magmas that erupt at volcanic island arcs.

Louis Brown at work in his lab, about 1993.

Brown, author of dozens of scientific papers, was also a historian. He recently completed a history of the Department of Terrestrial Magnetism, to be published this year by Cambridge University Press. In 1999 the Institute of Physics Publishing published his *Radar History of World War II: Technical and Military Imperatives*. Historian Richard Rhodes noted that it was "a great book, of permanent value: powerful...and freighted with deep insight into science and human affairs."

In 1963 Brown received the Amerbach Prize from the University of Basel. He was also a fellow of the American Physical Society. In his private life he was on the board of the Historical Electronics Museum in Baltimore and a member of the Society for the History of Technology. Opera and theater were two of his other great passions. He is survived by his wife, Lore; his brother Michael Brown; his sister-in-law Teresa Brown; and his nephew Matthew.

(Image courtesy NASA.)

This artist's rendition shows a Neptune-mass planet orbiting the M-dwarf star Gliese 436, some 30 light-years away in the Leo constellation.

New Class of Extrasolar Planets Discovered: New Era for Planet Hunting

"Our ability to find planets in the Neptune-mass range tips the scales for finding other Earths sooner rather than later,"

said R. Paul Butler, lead author of one of two papers announcing the discoveries of Neptune-mass planets around Sun-like stars—the smallest extrasolar planets confirmed to date. Butler, an astronomer with Carnegie's Department of Terrestrial Magnetism (DTM), also contributed to a second paper announcing the detection of another Neptune-mass extrasolar planet. The discoveries were formally announced at a NASA science update briefing on August 31. Although not involved in the research, Alan Boss, DTM planetary-formation theorist, also participated in the NASA update, declaring the finds the "gold medals of discoveries." The story was covered worldwide by broadcast and print media.

Butler and Geoffrey Marcy of U.C.-Berkeley lead the team that has found most of the extrasolar planets to date. The newest planet found by the group orbits a nearby low-mass 3-billion-year-old "M-dwarf" star named Gliese 436 in the Leo constellation, about 30 light-years away (1 light-year is 5.9 trillion miles). "Up to now, the technology has limited extrasolar planet detection to those in the Jupiter- and Saturn-mass range," said Butler. "We've entered a new era for planet hunting." The second planet orbits 55 Cancri, a Sun-like star about 41 light-years from Earth; three other known planets orbit that star.

These two newest planets join a growing roster of some 135 extrasolar planets. Both new Neptunes are very close to their parent stars, orbiting once every 2 to 3 days, and are likely to have similar masses, estimated to be between about 17 and 21 Earths—close to Neptune's mass.

The Butler/Marcy team is engaged in a multiyear project monitoring the telltale wobbles of about 2,000 Sun-like stars within 150 light-years of our solar system. Stellar wobbles can indicate orbiting planets. The team uses the precision Doppler velocity technique, which Butler and Marcy developed, to detect these movements. Further refinements of the technique have allowed the team to detect planets with less mass than Saturn.

The team monitored Gliese 436 with the Keck telescope in Hawaii from January 2000 to July 2004 and determined that the planet orbits every 2.64 days, has a mass of 1.2 Neptune masses, and is about 2.6 million miles (.028 astronomical units) from the star—close enough to sear the surface at 650°F.

So what kind of planet is it and how did it evolve? The fact that it is so close to its star suggests it may be gravitationally locked and thus shows only one face to its sun. If it is a gaseous planet like Jupiter or has a thick atmosphere like Venus, the entire planet will be very hot owing to the continual heat buildup. If it is a rocky world, then the back side will remain dark and frozen. For now, its composition, origin, and whether it formed close to its star or migrated there remain a mystery.

However, a pattern is beginning to emerge that shows a correlation between star type and planet mass. As the authors noted in their paper, giant Jupiter-like planets thus far have been rarely found around low-mass M-dwarf stars. But 41 high-mass planets have been found orbiting within 1 astronomical unit—the distance between Earth and our Sun—around higher-mass F, G, and K stars. "I expect that in the next few years we'll be able to tell with some certainty what kind of stars are more likely to harbor different types of planets," observed Boss.

"We've just made a huge leap toward finding planets that look like our own."

Both papers appear in the *Astrophysical Journal.* The research was funded by NASA and the National Science Foundation.

IN Brief

❶ Carnegie's new chief information officer Gotthard Sághi-Szabó.

❷ Vardan Tokmajyan

Carnegie's First Light

Saturday science school for middle school students from Washington, DC, public and charter schools started on Oct 23. **Toby Horn**, who was recently elected president of the National Association of Biology Teachers, is lead instructor. **Inés Cifuentes, Julie Edmonds,** and **Maxine Singer** will also periodically instruct. The new curriculum is based on the astrobiology program at Broad Branch Road.

Trustees and Administration

Carnegie president **Richard Meserve** was elected to the Council, the governing body of the American Academy of Arts and Sciences, with Neal Lane, former science advisor to the President, and Linda Greenhouse, the *New York Times* reporter who covers the Supreme Court. On Oct. 18-22 he served as president of a conference on operational safety of nuclear reactors sponsored by the International Atomic Energy Agency (IAEA) in Beijing. Meserve was also elected liaison to the electric power/energy systems engineering section of the National Academy of Engineering. He also coauthored the article, "Safety for All: the New INSAG" in the June 2004 *IAEA Bulletin*.

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❶ Systems administrator **Charles Kim** left Carnegie this summer. **Gotthard Sághi-Szabó** was appointed chief information officer (CIO) in Aug. He was with GL for eight years as a postdoc and information systems manager. As CIO he reports to the president and will coordinate the information technology (IT) activities for the administration and the Broad Branch Road departments.

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❷ **Vardan Tokmajyan** joined the IT team in Sept. He holds a degree in civil engineering from the Yerevan Institute of Architecture and Construction and an M.Sc degree in information systems from the London School of Economics and Political Science.

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On Sept. 29 the Carnegie Institution, the American Astronomical Society, the Embassy of Chile, and U. Chile joined forces to host *Chile and the United States, Partners in Astronomy.* The event celebrated the relationship between the two countries, which has led to the creation of "great astronomical telescopes."

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On Oct. 4-6 Carnegie cohosted a conference with the Royal Norwegian Embassy on the challenges of climate change and sustainable energy production and use. The Oct. 4 program, "The Search for Life in the Solar System," included talks by **Andrew Steele** and **Marilyn Fogel** of GL. **Richard Meserve** Carnegie president, gave opening remarks and **Chris Field,** director of Global Ecology (GE), was a keynote speaker on Oct. 5 for the talks on "Meeting the Climate-Energy Challenge." GE staff member **Greg Asner** also spoke at that session.

Embryology

In late July **Joseph Gall** received the Elsevier-SDB Lifetime Achievement Award from the Society for Developmental Biology at its 63rd annual meeting in Calgary. Gall was president of the society in 1984-1985. Also in July, Gall was an invited speaker at the international symposium "The Cell Nucleus," held at the Kristineberg Marine Research Station in Sweden by the Wenner-Gren Foundations and the Royal Swedish Academy of Sciences.

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Embryology welcomed two new staff members in Sept. 2004: **Alex Bortvin** and former Embryology postdoc **Steven Farber** (see page 4 for profiles.)

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Earlier this year **Ziqing Sun** joined the Farber lab. She earned her Ph.D. from Peking U. in Bejing and will study proteins that regulate intracellular cholesterol trafficking. She will be working with **Robert DeRose**, who joined the lab as a Ph.D. candidate at Johns Hopkins.

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Tim Mulligan joined the Farber lab. He too is a Ph.D. candidate at Johns Hopkins.

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New to the Spradling lab is **Tina Tootle** (Ph.D. Whitehead Institute), who will investigate the role of prostaglandins in the control of *Drosophila* oogenesis. Postdoctoral fellow **Alexei Tulin** of the lab joined the faculty at the Fox Chase Cancer Center in Philadelphia.

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Two new students recently joined the Gall lab. **Janet Chang** is a master's candidate and **Jovita Diaz** a Ph.D. candidate at Johns Hopkins. **Amber Hartman**, also a Ph.D. candidate at Hopkins, is on rotation in the lab. All three are working on Cajal bodies in amphibian oocytes.

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Tom Malooly, business manager from 1966 to 1985, died on Sept. 5. After retirement he and his wife, Lynn, moved to Ocean Pines, MD, where he lived until his death.

Geophysical Laboratory

The July 2004 issue of *Geochemical News* lists the 10 most notable geochemists of the 20th century. Four of them were GL researchers: **Norman Bowen, Arthur L. Day, Hans-Peter Eugster**, and **O. F. Tuttle.**

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Wes Huntress, director of GL, is the lead author of a four-year study by the International Academy of Astronautics on "The Next Steps in Exploring Deep Space." It outlines imperatives for human expansion into space beyond low Earth orbit.

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Robert Hazen lectured on interactions between minerals and molecules at the American Chemical Society's annual meeting in Philadelphia; at the Smithsonian Institution's Natural History Museum; and at the inaugural chemical engineering departmental seminar at Carnegie-Mellon U.

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Ronald Cohen presented an invited talk at the 20th General Conference of the Condensed Matter Division of the European Physical Society in Prague July 19-23, followed by invited talks in Israel at Hebrew U. and the Technion on relaxor ferroelectrics and on "First-Principles Multiscale Modeling of Earth Materials Properties." He is involved in two initiatives from NSF to increase computational power available to Earth science in the U.S. Cohen is also a member of the Committee on Petascale Computing for Earth Science, an ad hoc committee set up by NSF GEO to study the possibility of a large-scale national supercomputing facility. Cohen's work on computational mineral physics and the Earth's core was covered in John Vacca's *World's 20 Greatest Unsolved Problems*.

—

Dave Mao gave an invited talk at the 2004 APS Users Meeting Workshop 4: Inelastic X-ray Scattering: Present and Future at the APS, Argonne, IL, May 4; presented an invited talk at the Synchrotron Radiation in Materials Science conference in Grenoble, France, Aug. 23-25; and gave an invited talk at the Fifth International Conference on Cryocrystals and Quantum Crystals and Workshop on Properties of Novel Materials at Low Temperatures at Wroclaw, Poland, Aug. 29-Sept. 4.

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In June postdoctoral fellow **Olga Degtyareva** attended the international conference "Phase Transformations at High Pressures," hosted by the Institute of Solid State Physics in Chernogolovka, her hometown in Russia. She also attended the 22nd European Crystallographic Meeting held in Aug. in Budapest. At both conferences she gave a talk about the latest results on crystal structure of group-VI elements at high pressures, obtained in collaboration with her colleagues in GL.

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Postdoctoral research associate **Steven D. Jacobsen** was appointed a Barbara McClintock Fellow. He studies the structure and elasticity of Earth-forming minerals; hydrogen in the mantle; gigahertz ultrasonic interferometry; and high-pressure X-ray and neutron diffraction.

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Timothy Jenkins (Ph.D. Syracuse U.) has been appointed postdoctoral research associate. He will work with Viktor Struzhkin and Russell Hemley.

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Former postdoctoral research associate **Narayani Choudhury**, who was working on first-principles multiscale modeling of relaxor ferroelectrics and lattice dynamics and other work, returned to India to her position at the Bhabha Atomic Research Centre, Trombay, Mumbai.

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Former Carnegie postdoctoral fellow **Sung Keun Lee** returned to Korea, where he is assistant professor at Seoul National U.

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Former Carnegie postdoctoral fellow **Mario Santoro,** who was studying simple molecular systems under high pressure and high and low temperatures, returned to U. Florence in June.

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Catherine M. Corrigan (Ph.D. Case Western Reserve U.) has been appointed visiting investigator. Her research includes analysis of phosphate minerals in the "ungrouped" meteorites.

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Robert Downs (Ph.D. VPISU) is a visiting investigator specializing in crystallography and mineral physics. He will work with Przemyslaw Dera. He and Robert Hazen will also develop software to model the interactions of organic molecules on mineral surfaces.

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John M. Hanchar (George Washington U.) was appointed visiting investigator and will work with Yingwei Fei in trace element incorporation and partitioning between melts and other fluids and accessory minerals.

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Morgan Phillips is a new administrative assistant working with Stephen Gramsch.

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Guangtian Zou, director of the National Laboratory of Superhard Materials, Jilin U., Changchun, China, visited David Mao in Oct. Zou is one of the pioneers in examining the Earth's mantle under high pressures and helped establish the first ultra-high-pressure laboratory and the National Laboratory of Superhard Materials in China.

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Former GL administrative assistant **Rosa Maria Torres** is now with the Rand Corporation.

Global Ecology

Following the Aug. 16 publication of "Emissions Pathways, Climate Change, and Impacts on California" in the *Proceedings of the National Academy of Sciences*, coauthors **Chris Field** and graduate students **Kim Nicholas Cahill** and **Elsa Cleland** gave a number of interviews to help explain the results and implications of their research (see page 6).

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Chris Field presented the opening plenary lecture, "Global Photosynthesis," at the 13th International Congress on Photosynthesis in Montreal on Aug. 30. He also participated in the first lead authors' meeting for Working Group 2 of the Intergovernmental Panel on Climate Change, in Vienna Sept. 20-23, and in the final synthesis meeting of the Millennium Ecosystem Assessment, in Kuala Lumpur, Sept. 25-28. At an Oct. 1 event organized by The People Speak in Los Angeles, Field spoke on "Energy Choices and Environmental Challenges."

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Greg Asner, Amanda Cooper, and **David Knapp** attended the Third Science Conference of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), held in Brasilia July 27-29. Asner gave a presentation in the plenary session and also presented in a special session on disturbance events and forest ecology. Cooper and Knapp both presented posters.

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Kim Nicholas Cahill worked at the Nature Conservancy in CA this summer studying the ecological impacts of vineyard development and the potential for sustainable vineyard management practices to promote biodiversity.

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On Sept. 16 **Yuka Otsuki-Estrada** joined the Field lab as a research assistant.

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In Sept. former Asner lab postdoctoral associate **Lydia Olander** started as an AAAS Fellow on the staff of Sen. Joseph Lieberman.

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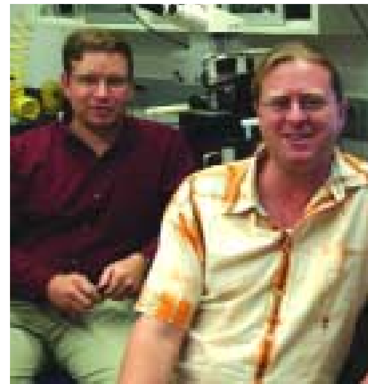

New Life-Search Tool

A new instrument, the multi-functional microscope, was installed at BBR in Sept. It was purchased as part of a successful proposal to the NASA Sample Return Laboratory Instruments and Data Analysis Program. The instrument, which combines scanning confocal Raman microscopy with an atomic force microscopy, scanning near-field optical microscopy, and fluorescence microscopy, is used by the astrobiology research group to prepare for *Genesis* and *Stardust* sample returns from the solar wind and the comet *Wild 2,* respectively. The primary goal is the analysis and characterization of materials, such as interstellar dust particles, to analyze *Stardust* samples, which will arrive on Earth in 2006. The work is led by GL staff member **Andrew Steele,** with coworkers **Larry Nittler** (DTM staff member), and **Marc Fries** and **Jan Toporski** (GL fellows).

The microscope is typically used in biomedical research and material sciences. It was built by the German company WiTec GmbH. This purchase is the first for application to extra-terrestrial materials and space sciences. The initial results of its use were presented at international meetings and news of the new application received wide media attention.

GL postdocs Mark Fries (above left) and Jan Toporski (above right) with the new Raman instrument.

On Aug. 1 **Robin Martin** began as a senior lab technician in the Asner lab, working on the Hawaii project researching leaf level spectroscopy and its relation to leaf pigment contents.

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New technicians joining the Asner Lab are **Kim Carlson, Paulo Oliveira, Eben Broadbent,** and **Kim Lo.**

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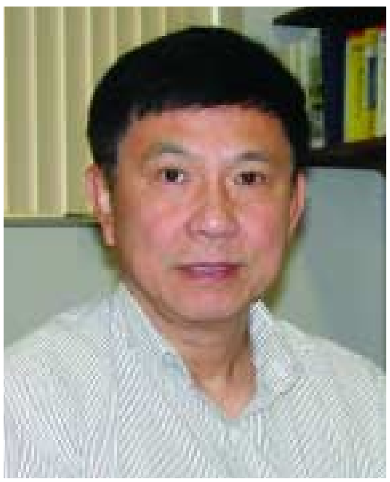

2005 Gregori Aminoff Prize

The Royal Swedish Academy of Sciences, which awards the Nobel Prizes, has awarded **Ho-kwang (Dave) Mao** the 2005 Gregori Aminoff Prize in Crystallography "for pioneering research of materials at ultrahigh pressures and temperatures." Named after Gregori Aminoff, the pioneering Swedish crystallographer, the prize is given annually to recognize a scientist, or a group, of international distinction who has made a major contribution to crystallography. The prize will be given at the academy's Ordinary Session on June 8, 2005, and will be followed by an award lecture and symposium.

Ho-kwang (Dave) Mao, winner of the 2005 Gregori Aminoff Prize in Crystallography.

David Lobell of the Asner lab recently received a graduate fellowship from the EPA.

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Winston Wheeler, graduate student in the Asner lab, received a NASA fellowship.

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Postdoctoral research associate **Andrew Elmore** completed his postdoc work in the Asner lab and accepted a faculty position at Dartmouth College.

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Former Asner lab employee **Amanda Cooper** arrived in Orlando just before the hurricanes and began her Ph.D. study at U. Central Florida under John Weishampel.

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Asner lab temporary employee **Amy Cooper** returned to her home in Conn., and **Dan Pendleton** returned to Ithaca, NY, to attend graduate school.

Observatories

Director **Wendy Freedman** was interviewed on KPCC's *AirTalk* on June 17 by radio host Larry Mantle. They discussed the history and future of the Observatories. On Sept. 2, in preparation for the Einstein Centennial Exhibit at the Skirball Cultural Center, Los Angeles, she spoke on the relevance of Einstein's theories to today's science. On Sept. 18 she gave a talk on the Carnegie Supernova Project at the annual Cosmo International Workshop on Particle Physics and Cosmology, hosted by the Canadian Institute for Theoretical Astrophysics in Toronto.

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❸ Chris Somerville at the International Conference on Agricultural Biotechnology.

This summer staff astronomer **Luis Ho** attended a conference in Johannesburg, South Africa, titled "Penetrating Bars through Masks of Cosmic Dust: The Hubble Tuning Fork Strikes a New Note." He gave a seminar at U. Michigan and at the Hertzberg Institute of Astrophysics, U. Victoria, on intermediate-mass black holes. He coorganized a workshop, "From X-ray Binaries to Quasars: Black Hole Accretion on All Mass Scales," and gave an invited talk, "Low-State Black Hole Accretion in Nearby Galaxies," in Amsterdam. He also coorganized the Fifth Microquasar Workshop: Microquasars and Related Astrophysics in Beijing.

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In July staff astronomer **Michael Rauch** gave an invited talk at the conference on "Concordance Cosmology and Beyond" in Cambridge, UK. In Aug. he spoke at the conference on "Environments of Galaxies" in Chania, Greece.

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Carnegie Fellow **Jeremy Darling** was appointed a Barbara McClintock Fellow.

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In Aug. Hubble Fellow **Marla Geha** gave a talk at the "Environments of Galaxies" conference in Chania, Greece. In July she taught a two-week summer course for accelerated high school students though the California State Summer School for Mathematics and Science (COSMOS) program at UC-Santa Cruz.

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Research Associate **Jon Fulbright** gave a talk at the "Nuclei in the Cosmos VIII" meeting in Vancouver, BC.

Plant Biology

❸ Director **Chris Somerville** was elected a fellow of the AAAS. He was also invited to the International Conference on Agricultural Biotechnology in Cologne on Sept. 15 and gave a symposium talk, which was interrupted by anti-GMO protestors.

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Winslow Briggs gave a seminar on Sept. 28 at Cornell U. on "Phototropins: Versatile Plant Blue-Light Receptors."

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Wolf Frommer was elected a member of the editorial board of the *Journal of Biological Chemistry*. On May 25 Frommer attended the XXII International Congress ISAC (International Society of Analytical Cytometry) and presented the Montpellier plenary lecture. He also spoke at the Plasmodesmata 2004, Fifth International Conference on Aug. 19 at Asilomar Conference Center, Monterey, CA. On Sept. 20 he attended the Stanford Bioscience Molecular Cell Biology retreat held at Asilomar Conference Center and presented a seminar.

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Karen Deuschle, a postdoc in the Frommer lab, presented a talk on July 6-10 at the International Workshop on Plant Membrane Biology 2004, Montpellier, NY.

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Marcus Fehr, a postdoc in the Frommer lab, gave a talk at the 15th International Conference on *Arabidopsis* Research, Berlin, on July 11-14. He also spoke at the conference on Nutrient Sensing through the Plasma Membrane, Cirencester, UK, on Sept. 26-29.

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Loren Looger, Frommer lab postdoc, presented a talk at the Sept. 20 Stanford Bioscience Molecular Cell Biology Retreat.

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In July **Leonore Reiser** gave a talk, "*Arabidopsis* as a Model System for Research and Education," to high school science teachers at the Plant Genomics Education workshop in Davis, CA, organized by Barbara Soots from the Partnership for Plant Genomics Education in the Department of Plant Pathology at UC-Davis. Reiser also gave a workshop on database mining for a Cold Spring Harbor course on July 20.

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The department helped organize and host a weeklong summer science camp for 7/8th-grade girls from Belle Haven Middle School in Menlo Park. The camp was the result of a partnership between Carnegie (**Leonore Reiser**), Stanford U.'s Office of Science Outreach (Pat Devaney), the Center for Polymer Interfaces and Macromolecular Assemblies (Marni Goldman), Jasper Ridge Biological Preserve (Cindy Wilber), Stanford's Dept. of Geological Sciences (Adina Payton), and the Solar Observatories/NASA (Debbie Scherrer). Nineteen girls spent a week at Stanford learning about plants, DNA, cells, the Sun, polymers, archaeology, ecology, fossils, minerals, rocks, and water, and presented posters describing their experiences at a barbecue on the Carnegie grounds. Funding for the camp was provided by IBM.

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Anjelica Vasquez joined the Carnegie staff full-time on July 1 as dishwasher.

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The *Arabidopsis* Information Research (**TAIR**) group welcomed two new members to their group: **Douglas Becker** (Stanford U.) on May 1, as the technical lead curator, and **Hartmut Foerster,** curator from Germany, on July 1.

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Mamatha Hanumappa (Colorado State U.) joined the Barton lab on May 1.

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The Wang lab welcomed two new postdocs: **S. Srinivas Gampala** (Texas Tech U.) on July 1, and **Wenqiang Tang**, who taught at U. Texas, Austin, on July 26.

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On July 1 the Grossman/Bhaya labs welcomed **Anne Soisig Steunou** (Université Paris XI) as a postdoc.

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Shauna Somerville added two new postdocs to her lab. **Melisa Lim** arrived from Washington U., St. Louis, on Sept. 1, and **Samuel St. Clair** from Pennsylvania State U. joined the lab on Sept. 16.

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Dave Ehrhardt's lab welcomed lab assistant **Raj Sandhu** on July 1.

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Gabriele Fiene arrived from the Max Planck Institute for Plant Breeding Research, Cologne, on Aug. 18. She is a lab technician in the Frommer lab.

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For the second year the department has sponsored a summer intern program to give students and teachers experience in the various labs. The interns this summer were **Christopher Wilks** and **Renee Halbrook** (TAIR group); **Christopher Wolf** and **Daniel Zimardi** (Grossman lab); **Erik Lehnert,** Thomas Dillig, and Isil Ozgener (Bhaya lab); Sophia Yu (Shauna Somerville lab) and Michael Manke (Wang lab). The intern program ended Aug. 24, when the interns gave seminars presenting what they learned. Carolyn Fortino, a teacher from Bret Harte Middle School in San Jose, CA, also joined the intern program and spent the summer in Matt Evan's lab. Carolyn was participating in an RET program through the Stanford Center on Polymer Interfaces and Macromolecular Assemblies.

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Visiting investigator Alisdair Fernie from the Max Planck Institute of Molecular Plant Physiology joined Chris Somerville's lab on June 1 for a three-month stay.

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The Frommer lab welcomed two visiting investigators for six months: Sylvie LaLonde from Canada on July 1 and Hong Gu from Risø National Laboratory, Denmark, on Sept. 1.

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Chris Somerville's lab technician Erin Osborne left for UC-Berkeley on July 20 to begin her graduate studies.

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Jie Cui Zhang left the TAIR group on May 31 to pursue a position in industry.

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After 26 years with the department, Pedro Pulido retired as the departmental dishwasher on June 30.

Terrestrial Magnetism

Director Sean Solomon was awarded NASA's Public Service Medal "for exceptional leadership in the development of NASA's Solid Earth Science Program." Solomon also delivered seminars at the College of Oceanic and Atmospheric Sciences at Oregon State U. in Sept.; the National Radio Astronomy Observatory in Oct.; and the Lamont-Doherty Earth Observatory in Nov. In Aug. he participated in a workshop in Woods Hole, MA, to organize a decadal study on Earth science and applications from space; and in Sept. he testified at a meeting of a National Research Council committee on PI-led missions in the space sciences. That same month he chaired the Advisory Committee to the Southern California Earthquake Center and delivered an invited talk at a workshop on the formation of the early crust of Mars.

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Conel Alexander and Larry Nittler attended the Workshop on Chondrites and the Protoplanetary Disk in Kaua'i, HI, in Nov.

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Alan Boss participated in a press conference in May at NASA headquarters, Washington, DC, on the possible discovery of the youngest planet by NASA's Spitzer Space Telescope. In Aug. he participated in Paul Butler's NASA press briefing on the discovery of a new class of Neptune-mass extrasolar planets. As a result, Boss was interviewed live on the Tom Hewell Show on KNX/CBS radio, Los Angeles; on the BBC World Service's *Science in Action*; and on *CBC News: CountryWide* for Canadian TV.

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Paul Butler, with astronomer colleagues, was featured in numerous publications, including the *New York Times* and the *Washington Post*, about his discovery of two Neptune-mass planets. Butler was also featured in PBS's *Origins* television series in Sept. He gave public lectures at Keck Observatory, Waimea, HI, and at San Francisco State U. in Aug. In Sept. he delivered the American Astronomical Society Centennial Lecture and gave a colloquium at the Anglo-Australian Observatory in Sydney. He gave invited talks at the North Carolina Astonomers' Meeting in Sept. and at the National Academy of Sciences Frontiers of Science meeting in Nov.

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This fall John Chambers helped write NASA's Space Science Enterprise Strategic Plan for 2006.

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David James presented his IRIS/SSA lecture "Revealing the Mysteries of the Earth's Deep Interior: Plates, Plumes, and the Birth of Modern Seismology" at U. Witwatersrand in Johannesburg, South Africa, in July and also at the Denver Museum of Nature and Science in Sept. In July and Aug. he traveled with former DTM postdoctoral fellow Matt Fouch to South Africa as part of a collaboration with South African colleagues to plan a major high-resolution seismic experiment in the Bushveld Province as part of a new African Array initiative.

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Vera Rubin attended the opening of the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, in early Oct. Also in Oct., Rubin chaired and spoke at a panel discussing "Universe: The Dark Side" at the Perimeter Institute for Theoretical Physics. Late that month, she met with students at Swarthmore College and gave a talk on the history of dark matter.

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Sara Seager gave the physics and astronomy colloquium at Johns Hopkins U. in Sept., hosted a Terrestrial Planet Finder Scientific Working Group meeting at the administration building in Oct., and that month participated in a meeting for the National Academy of Sciences reviewing progress toward the decadal vision in astronomy and astrophysics.

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Steve Shirey delivered a seminar at Boston U. in Nov.

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Research scientist James Cho gave the astronomy colloquium at UC-Santa Cruz (UCSC) in Oct. He was also a visiting assistant research astronomer with UCSC/UCO Lick from Sept. to Nov.

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Postdoctoral fellow Saavik Ford gave a public outreach talk to the Mid-Hudson Astronomy Association in Aug. on "How Science Is Really Done, or Build Your Own Spectroscope."

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Alison Shaw, postdoctoral fellow in the geochemistry group, gave a talk at the meeting of the International Association of Volcanology and Chemistry of the Earth's Interior in Pucon, Chile, in Nov.

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Nicole Foley arrived in Sept. as a postdoctoral associate. Her work has focused on the composition of Martian surface rocks through remote sensing and the early differentiation of Mars as revealed through isotopic studies of Martian meteorites. At DTM she will be working with Larry Nittler to determine the bulk Mn, Cr, and Ni abundance on asteroid Eros from data collected by the X-ray spectrometer on the Near Earth Asteroid Rendezvous Shoemaker mission.

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Hannah Jang-Condell arrived in Sept. as a postdoctoral fellow in the astronomy group. She works with radiative transfer models of circumstellar disks that include the temperature variations caused by shadowing and illumination effects around growing planets. At DTM she will extend her modeling efforts and integrate the latest observations of disks and planets.

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Mercedes López-Morales arrived in July to begin her postdoctoral fellowship. López-Morales received her Ph.D. from UNC-Chapel Hill. She will continue her studies of stars below one solar mass, as these objects are among the most likely to host Earth-like planets. In addition, she will participate in the construction of two new 32-inch robotic telescopes at Las Campanas and in Arizona to monitor the photometric stability of the 2,000 nearby stars that are currently being searched for extrasolar planets. The telescopes will be also able to detect planetary transits of those stars.

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Brian Savage arrived in July to begin his term as Harry Oscar Wood Fellow at DTM. Seismologist Savage, who received his Ph.D. from Caltech, will continue adapting two- and three-dimensional wave propagation codes to infer crust and mantle structure from seismic waveforms of regional and teleseismic earthquakes. At DTM he will expand his research to geographic areas beyond southern CA, using data from DTM's networks of portable broadband seismometers.

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Hubble Fellow Scott Sheppard joined the astronomy group this fall. As an observer, Sheppard studied the nature of Kuiper Belt objects and discovered a large number of irregular satellites of the giant planets. He will study our planetary system as well as extrasolar systems while at DTM.

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NAI postdoctoral research associate Margaret Turnbull arrived in Oct. Turnbull's interest is astronomically detectable biosignatures on solar system and extrasolar planets. She also plans to gain firsthand experience with field biology sample collection and analysis through collaboration with the Australian Center for Astrobiology.

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DTM seismologists have initiated fieldwork for a multi-institutional experiment to produce seismic images of the mantle beneath the Hawaiian hotspot, the most vigorous center of intraplate volcanism on Earth. In the first phase of the experiment, DTM's field seismologist Peter Burkett, assisted by postdoctoral fellows Brian Savage and Linda Warren, installed ten of DTM's portable broadband stations on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii.

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Mark Behn, postdoctoral fellow in the seismology group, departed DTM in July for an assistant scientist position at the Woods Hole Oceanographic Institution.

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Nader Haghighipour left DTM in Sept. for NASA's Astrobiology Institute at the Institute for Astronomy at U. Hawaii, where he will be initiating a research program on the formation of planets in binary star systems and water-delivery mechanisms to the planets.

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Postdoctoral fellow Ambre Luguet left DTM in July for a Marie Curie Fellowship at U. Durham, UK, where she will continue to study sulfides and platinum-group metal abundances in mantle rocks exposed along submarine fracture zones.

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Postdoctoral fellow Eugenio Rivera, who studied dynamics of extrasolar planetary systems, left DTM in Sept. to take a position at NASA Ames Research Center.

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Saad Haq was recently appointed a visiting investigator after successfully defending his Ph.D. dissertation at SUNY-Stony Brook.

DTM/GL

In Nov. there was a symposium at U. Houston honoring DTM-GL visiting investigator Kevin Burke. Titled "Plate Tectonics, Plumes, and Planetary Lithospheres," it featured numerous speakers, including DTM's Paul Silver and director Sean Solomon.

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Five decades of materials of late petrologist F. R. (Joe) Boyd were donated to GL's archives by Boyd's widow, Margo Kingston. An inventory and finding guide to the collection, prepared by library/archives intern Ann Mulfort, is available on the Carnegie Legacy Project Web site (http://www.carnegieinstitution.org/legacy).

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Kara Friend, an undergraduate at West Virginia U., was a history of science intern in the library this summer. She created a Web site on the history of DTM's marine magnetic survey expeditions (www.ciw.edu/library/ocean) for the department's centennial.

Terrestrial Magnetism **Turns 100!**

"We are here for the journey itself, for the scientific enterprise..."

*—**Sean Solomon,** director of the Department of Terrestrial Magnetism, speaking in celebration of the department's centennial.*

(Images courtesy Steve Shirey.)

Staff member Erik Hauri (left) describes the operations of the ion microprobe. Senior instrument maker Nelson McWhorter (right) chats with Susan Berry, Megan Falla, and Paul Butler (left to right) at the evening celebration.

On October 8 alumni, neighbors, friends, and staff of the Department of Terrestrial Magnetism (DTM) enjoyed tours, a symposium, and a party, of course, in honor of the department's 100^{th} birthday.

The day began with an alumni open house featuring lab tours conducted by DTM staff at the Broad Branch Road (BBR) campus. Richard Carlson gave an overview of the equipment in the mass spectrometry lab and the science that it makes possible. Erik Hauri talked about the work conducted with the ion microprobe, and Nelson McWhorter showed how strainmeters are made and used. Also on hand were John Graham and Brenda Eades representing the American Astronomical Society. After the tours, staff and guests boarded buses for a luncheon and symposium at Carnegie's administration building in downtown Washington, D.C.

After lunch, Carnegie president Richard Meserve welcomed speakers and attendees to the symposium for the 100^{th} anniversary celebration. He was followed by DTM director Sean Solomon. Solomon spoke about the research at the department and the contributions made by the late staff member emeritus Louis Brown to documenting the department's history. He then introduced the first speaker, Shaun Hardy, BBR campus librarian.

Pictures, anecdotes, and humor enlivened Hardy's history. He described the scientific milestones at the department since it was first christened Terrestrial Magnetism. He documented the course of DTM research from mapping the Earth's magnetic field a century ago to today, where researchers study astronomy, astrophysics, extrasolar planets, geophysics, geochemistry, cosmochemistry, and planetary science.

Hardy's history was followed by Thomas Jordan's talk, *Speculations on Some Problems of Continental Evolution.* Julie Morris then took to the podium with her presentation, *Ideas, Isotopes, and Instrumentation: Geochemical Studies of Subduction Zones.* The final talk, *The Formation of Terrestrial Planets and the Earth-Moon System,* was given by Robin Canup.

The day's celebrations culminated with a party under the stars at the Broad Branch Road campus.

Help Carnegie with the Kresge Challenge for the Department of Embryology

The state-of-the-art Maxine F. Singer Building, the new molecular biology laboratory under construction for the Department of Embryology on The Johns Hopkins University campus in Baltimore, will be completed in the spring of 2005 as planned.

The Kresge Foundation has issued Carnegie a challenge. It will contribute \$1.5 million only if Carnegie succeeds in raising the final \$6 million needed to complete the Maxine F. Singer Building Project by July 1, 2005.

Carnegie welcomes all contributions in support of the Maxine F. Singer Building Project. Contributions may be sent to Dr. Richard A. Meserve, President, Carnegie Institution, 1530 P Street, NW, Washington, DC 20005.

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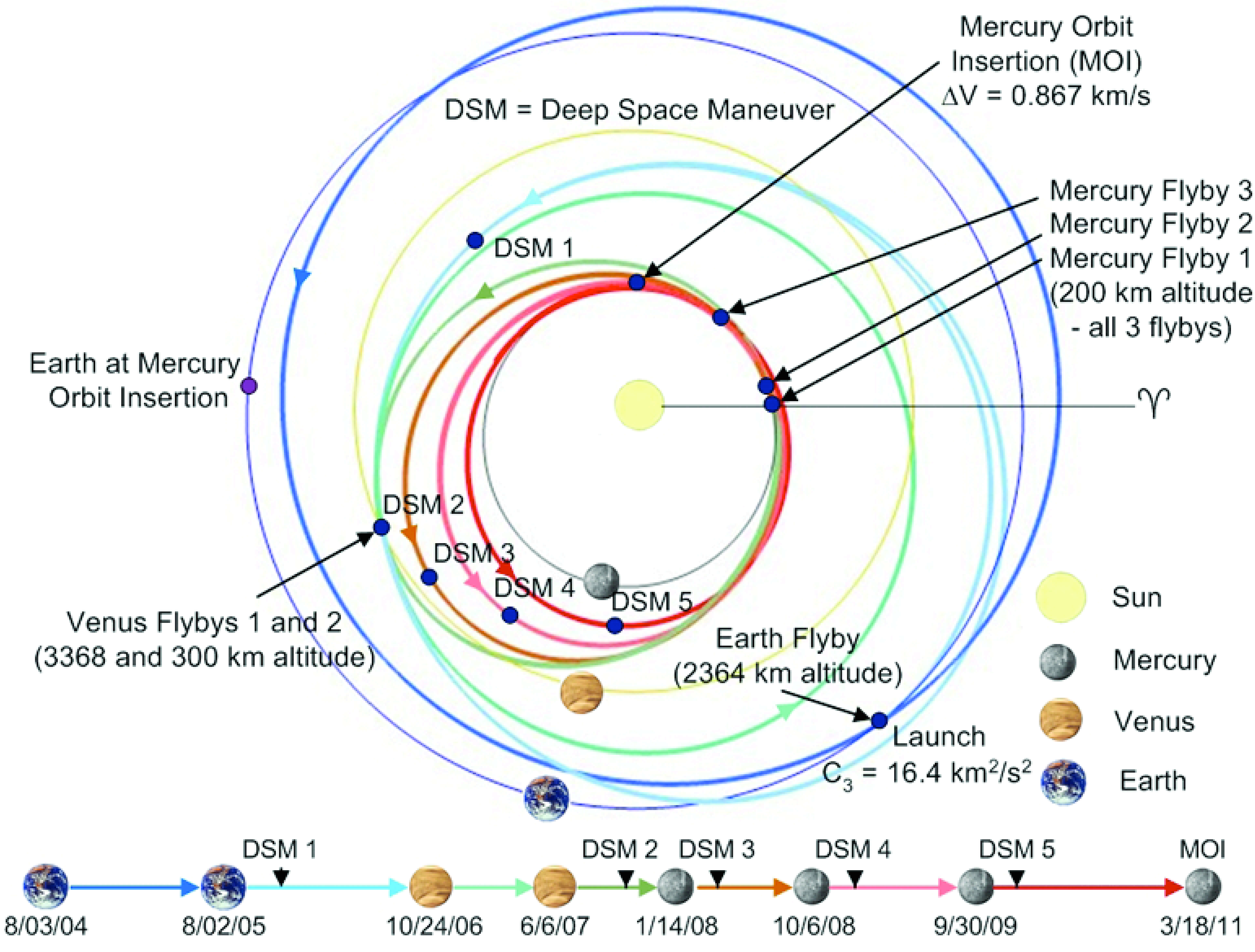

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