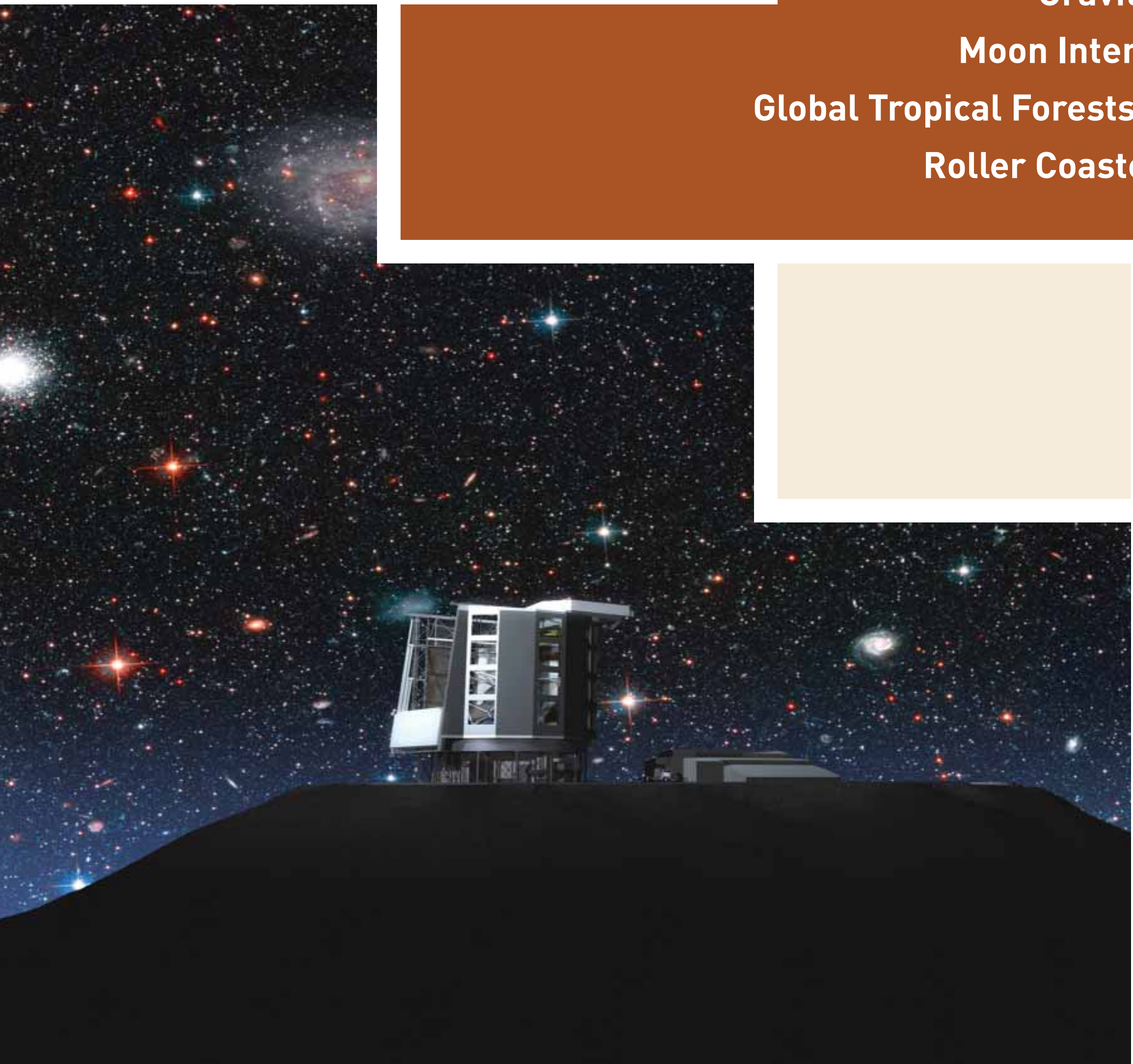
CarnegieScience

The Newsletter of the Carnegie Institution

FALL 2010

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

On the Inside



Carnegie's scientific research is renowned. But many are unaware of our scientists' leadership roles outside the lab. A small sample illustrates these undertakings.

In addition to presiding over many large international research projects, *Russell Hemley*, director of the Geophysical Laboratory, chairs the board of governors of the High Pressure Synergetic Consortium at Argonne National Lab. He is also an advisor and reviewer for numerous National Academy of Sciences (NAS) committees. *Bob Hazen*'s diverse professional memberships are many. But he also teaches, lectures around the world, writes popular books on science and science history, and is a professional trumpeter performing with the National Philharmonic, among other groups.

Embryology director *Allan Spradling* is active on many review and editorial boards. He has also served as president of the Genetics Society of America and the Society for Developmental Biology. Staff member *Marnie Halpern* is a reviewer for NIH and has been scientific advisor for the Damon Runyon. *Xixian Zheng* is an editor of two prestigious biology journals and has co-organized symposia sessions jointly held by the Chinese Academy of Sciences and the NAS.

Over the years *Sean Solomon*, director of Terrestrial Magnetism and principal investigator for the MESSENGER mission to Mercury, has belonged to countless editorial boards and served on or chaired dozens of prominent committees and advisory panels for the NAS, NSF, NASA, the USGS, AGU, and more. Staff member *Alan Boss* was in the thick of the Pluto debate as a member of the International Astronomical Union's group on the definition of a planet—just one of his innumerable committee relationships. He also writes popular books about searching for other Earths.

Wolf Frommer, director of Plant Biology, is a reviewer for a variety of international journals. He serves on scientific advisory boards and assists research foundations from Germany and Switzerland to Israel and New Zealand. Staff member *Sue Rhee*, a pioneer in bioinformatics, is on numerous advisory boards, including for the NSF. She also organizes national and international conferences.

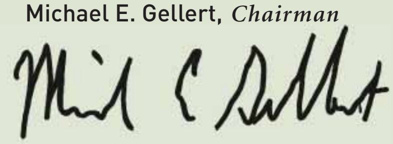
In addition to chairing the Giant Magellan Telescope Organization consortium, Observatories director *Wendy Freedman* chairs the Astronomy and Astrophysics Advisory Committee, which advises the NSF, NASA, and DOE. To provide direction and vision for their field, she and *Alan Dressler* are involved in the National Academies' Division of Engineering and Physical Sciences.

Scientists at Global Ecology work intensively to combat climate change. Director *Chris Field* cochairs the Intergovernmental Panel on Climate Change (IPCC), Working Group II. *Ken Caldeira* was the lead coordinating author on an IPCC special report and has served on advisory panels for the NAS, UNESCO, and others. *Greg Asner* has forged agreements with governments and nongovernmental organizations around the world related to ecological assessments using airborne or spaceborne technology. With colleagues from the World Wildlife Fund and in coordination with the Peruvian Ministry of the Environment, he recently revealed a new carbon-mapping system. His alliances are enabling the quantification of changes in tropical forests globally.

Carnegie president *Richard Meserve* is a leader on nuclear issues. He is on the Blue Ribbon Commission on America's Nuclear Future established by DOE Secretary Chu at the direction of the president, and he chairs the IAEA's International Nuclear Safety Group and the National Academies' Nuclear and Radiation Safety Board. He also cochairs the National Academies' Committee on Science, Technology, and Law.

All Carnegie researchers go beyond their own work to advance science. I applaud them. These few examples bring to light some of the ways in which our scientists are bringing added distinction to this institution.

Michael E. Gellert, *Chairman*



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High-Yield Crops Keep Carbon Emissions Low

Image courtesy Steven Davis

Global Ecology's Steven Davis

The improved crops from the 20th-century Green Revolution not only helped feed an expanding global population, but they have also helped keep global warming at bay. In a report published in the *Proceedings of the National Academy of Sciences*, Carnegie researcher Steven Davis and coauthors estimate that since 1961 higher yields per acre have avoided the release of nearly 600 billion tons of carbon dioxide into the atmosphere.

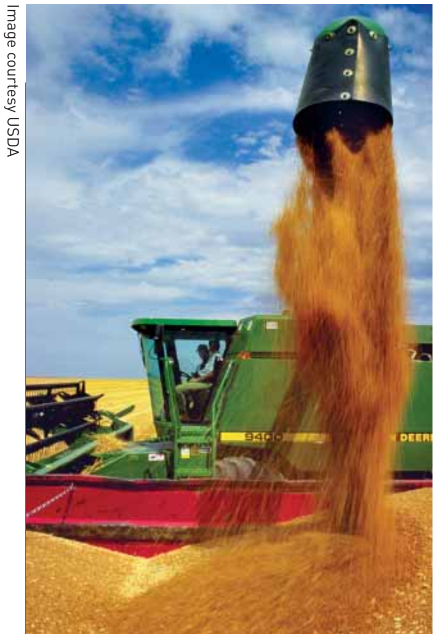
"That's about 20 years of fossil fuel burning at present rates," said Davis, a postdoc at the Department of Global Ecology. "Our results dispel the notion that industrial agriculture with its petrochemicals is inherently worse for the climate than a more 'old-fashioned' way of doing things."

Agriculture is a major source of greenhouse gases. Davis and his colleagues found that although modern farming requires more energy and more greenhouse gas emissions per unit of food output than did the lower-input methods of the past, crop yields have increased by 135%. This has greatly reduced the amount of land needed to grow a given amount of food. Without these advances, vast areas of natural habitats would have been converted to agriculture, causing much higher greenhouse gas emissions—the equivalent of nearly 600 billion tons of CO_2 since 1961.

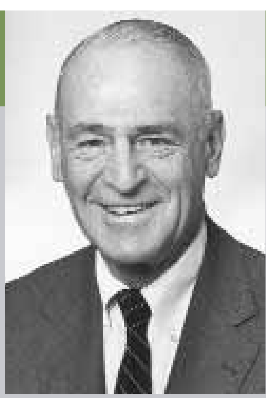
"Converting a forest or some scrubland to an agricultural area causes a lot of natural carbon in that ecosystem to be oxidized and lost to the atmosphere," said Davis. "What our study shows is that these indirect impacts from converting land to agriculture outweigh the direct emissions that come from the modern, intensive style of agriculture."

The researchers also calculated the benefits of investing in agricultural research as a strategy to reduce greenhouse gas emissions. Since 1961 agricultural research has averted carbon dioxide emissions at an estimated cost of about $4 per ton of CO_2 emitted. "Agricultural research is one of the cheapest ways of preventing greenhouse gas emissions," said Davis. "And if the past few decades are a guide, it is also a large source of potential reduction." □

Image courtesy USDA



Modern industrial agriculture is energy intensive, but high yields per acre reduce the amount of land needed to grow food. Since the Green Revolution of the 1960s, increased productivity has avoided the release of nearly 600 billion tons of carbon dioxide into the atmosphere.



TrusteeNews

SENIOR TRUSTEE
Sidney J. (Jim) Weinberg, Jr., Dies at 87

Senior Carnegie trustee Sidney J. Weinberg, Jr., died October 4, 2010, at his home in Marion, Massachusetts. He was a dedicated trustee who served the institution wisely and well for many years.

Weinberg was inspired by Andrew Carnegie's vision of giving exceptional scientists the independence to pursue their passions. He was elected to the Carnegie board in 1983 and served as a member of the Finance Committee. He became its chairman in 1984, a position he held through the late 1980s. He was a member of the Employee Benefits Committee and became chairman of the Nominating Committee in 1993. Weinberg became a senior trustee in 1999, but continued to participate actively in board meetings.

Weinberg served in the Army during World War II in the Philippines. He then completed his bachelor's degree at Princeton. He graduated from Harvard's Graduate School of Business Administration in 1949 and worked at Owens-Corning Fiberglas Corporation before joining Goldman Sachs.

The 1980s was an era of great change at Carnegie. In late 1984 Weinberg served on the committee that examined the co-location of the Geophysical Laboratory with the Department of Terrestrial Magnetism. Through his work on the Magellan Campaign Committee and the Observatories Visiting Committee, he helped the institution navigate the challenges of constructing the Magellan twin 6.5-meter telescopes at the Las Campanas Observatory in Chile.

Weinberg has been exceptionally generous to the institution over the last 25 years, with major gifts to every Carnegie campaign. He was a member of the Edwin Hubble Society.

President Richard A. Meserve noted that "Jim's wisdom, guidance, and commitment to Carnegie's mission have been unparalleled, and the institution is sincerely grateful for his decades of dedication." □

Asteroid Found in Gravitational "DEAD ZONE"

Gravitational "dead zones" exist in space where the gravitational tug between a planet and the Sun balance out, allowing other, smaller bodies to remain stable. These places are called Lagrangian points. So-called Trojan asteroids have been found in some of these stable spots near Jupiter and Neptune. Trojans share their planet's orbit and help astronomers understand how the planets formed and how the Solar System evolved. Scott Sheppard at the Department of Terrestrial Magnetism and Chad Trujillo with the Gemini Observatory have discovered the first Trojan asteroid in a difficult-to-detect stability region in Neptune's orbit, called the Lagrangian L5 point. They used the discovery to estimate the asteroid population there and found that it is similar to the asteroid population at Neptune's L4 point. The research was published in the August 12, 2010, online edition of *Science Express*.

"The L4 and L5 Neptune Trojan stability regions lie about 60 degrees ahead of and behind the planet, respectively," Sheppard explained. "Unlike the other three Lagrangian points, these two areas are particularly stable, so dust and other objects tend to collect there. We found three of the six known Neptune Trojans in the L4 region over the last several years, but L5 is very difficult to observe because the line of sight is near the bright galactic center."

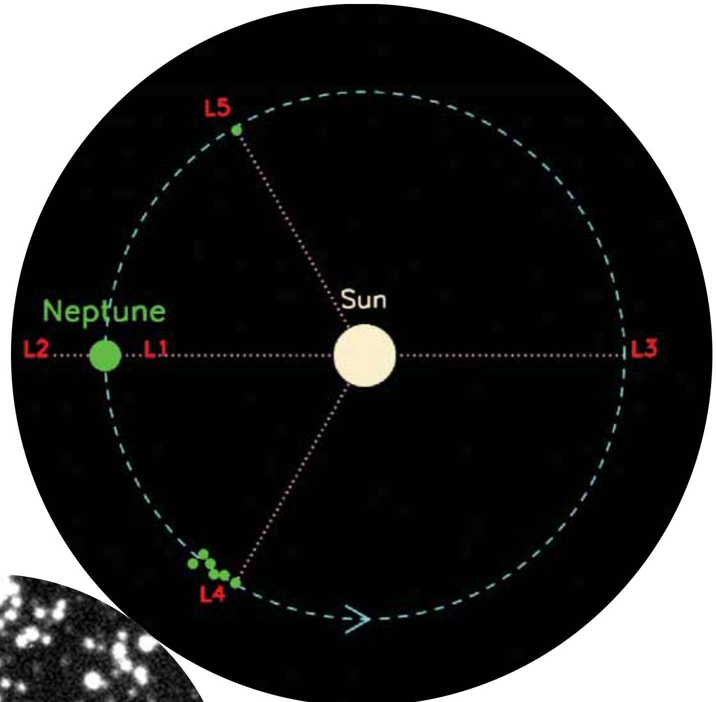
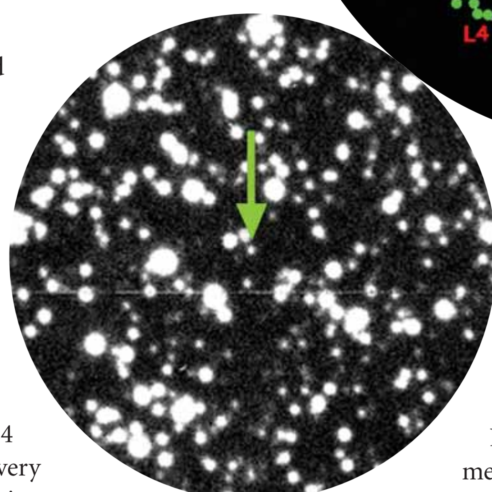


Image courtesy Scott Sheppard

The artist's rendition at right shows the relationship between the Sun and a planet and the five Lagrangian points where the gravitational tug between the two objects balances out so that other bodies in those areas remain stable.

The discovery image below shows the Trojan L5 asteroid at the green arrow tip.



The scientists devised a unique observing strategy. Using images from the digitized all-sky survey they identified places in the stability regions where dust clouds blocked out the background starlight, enabling them to see the foreground asteroids. They discovered the L5 Neptune Trojan, 2008 LC18, using the 8.2-meter Japanese Subaru telescope in Hawaii and determined its orbit with Carnegie's 6.5-meter Magellan telescopes at Las Campanas, Chile.

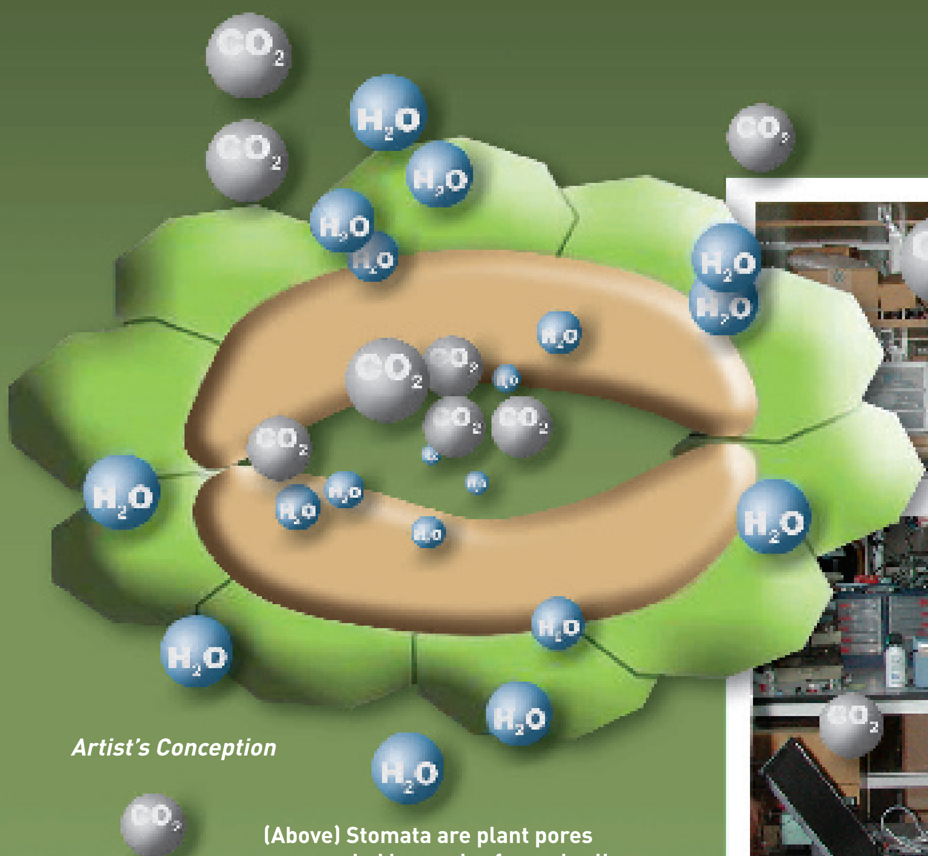
"We estimate that the new Neptune Trojan has a diameter of about 100 kilometers (km) and that there are about 150 Neptune Trojans of similar size at L5," Sheppard said. "It matches the population estimates for the L4 Neptune stability region. This makes the Neptune Trojans more numerous than those bodies in the 100 km range in the main asteroid belt between Mars and Jupiter."

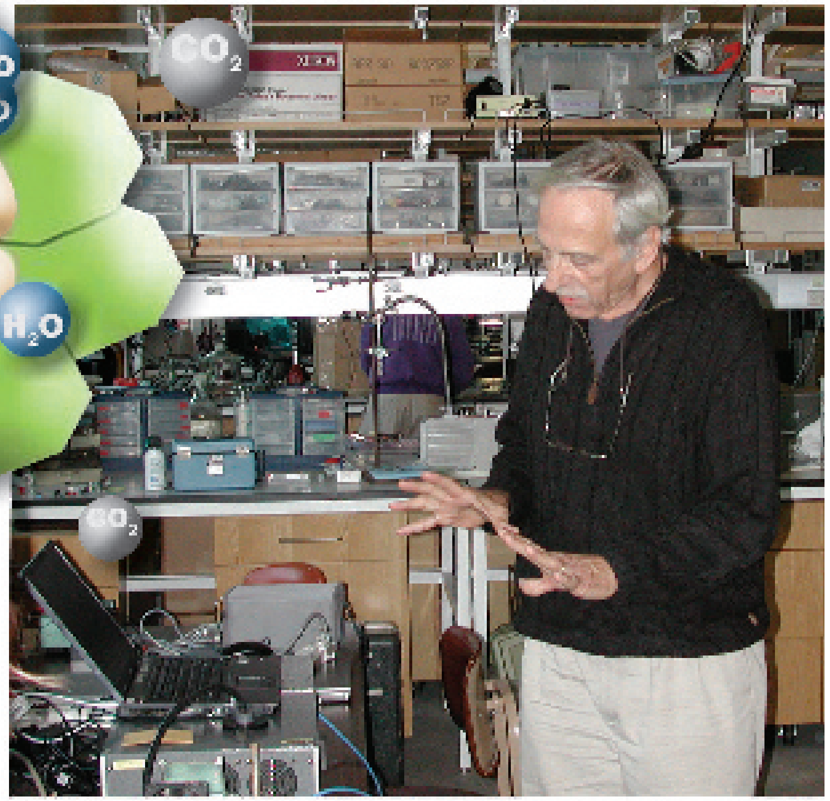
The L5 Trojan's orbit is very tilted to the plane of the Solar System, just like several in L4. This suggests they were captured during the very early Solar System when Neptune was moving on a much different orbit. Capture was either slow, through a smooth planetary migration process or, as the giant planets settled into their orbits, their gravity caught and "froze" them into these spots.

Scott Sheppard poses at Carnegie's Las Campanas Observatory.

Image courtesy Chad Trujillo

The work was funded in part by the New Horizons spacecraft mission to Pluto.





(Above) Stomata are plant pores surrounded by a pair of guard cells that control the size of the opening for "inhaling" carbon dioxide and "exhaling" water vapor.

(Right) Global Ecology's Joe Berry explains instrumentation in his lab.

Plants Take a Deep Breath

Weather forecasting, climate change, agriculture, hydrology, and more depend on a tiny, little-understood plant pore called a stoma. Now a study by Joe Berry at Global Ecology with colleagues has overturned the conventional belief about how these little "mouths" regulate water-vapor loss from the leaf in the process called transpiration. They found that radiation drives physical processes deep inside. The research was published in an online early edition of the *Proceedings of the National Academy of Sciences* in July.

Stomata are lip-shaped pores surrounded by a pair of guard cells that control the size of the opening. The size of the pores regulates the inflow of carbon dioxide (CO_2) needed for photosynthesis and the outflow of water vapor to the atmosphere. It has been assumed that the guard cells forming the pore have sophisticated sensory and information-processing systems to adjust the pores under different environmental cues.

Understanding stomata is important for climate-change research because transpiration cools and humidifies the air over vegetation, which moderates the climate and increases precipitation. Also, stomata influence the rate at which plants absorb CO_2.

Current climate-change models use descriptions of stomatal response based on statistical analysis of a few plant species, not on a solid understanding of the mechanism of stomatal regulation. "Scientists have been studying stomata for at least 300 years. It's amazing that we have not had a good grasp of the regulatory mechanisms that control how much stomata open or close in response to a constantly changing environment," remarked Berry.

For the first time, the researchers looked at how the exchange of energy and water vapor at the outer surface of the leaf is linked to processes inside the leaf. They found that the energy from radiation absorbed by pigments and water inside the leaf influences how the stomata control water levels.

"We illuminated a sunflower leaf with an incandescent light that was filtered to include or exclude near-infrared light," Berry explained. With light, the stomata responded by opening and indirectly stimulating photosynthesis. Light of different colors gave similar results, furnishing more evidence that heat is the driver.

The scientists replicated the experiment with five other plant species and over a range of carbon dioxide levels and temperatures. They also developed a model based on energy balance of the leaf system to simulate responses, and those results mimicked results from the lab. □

JEFF HAN

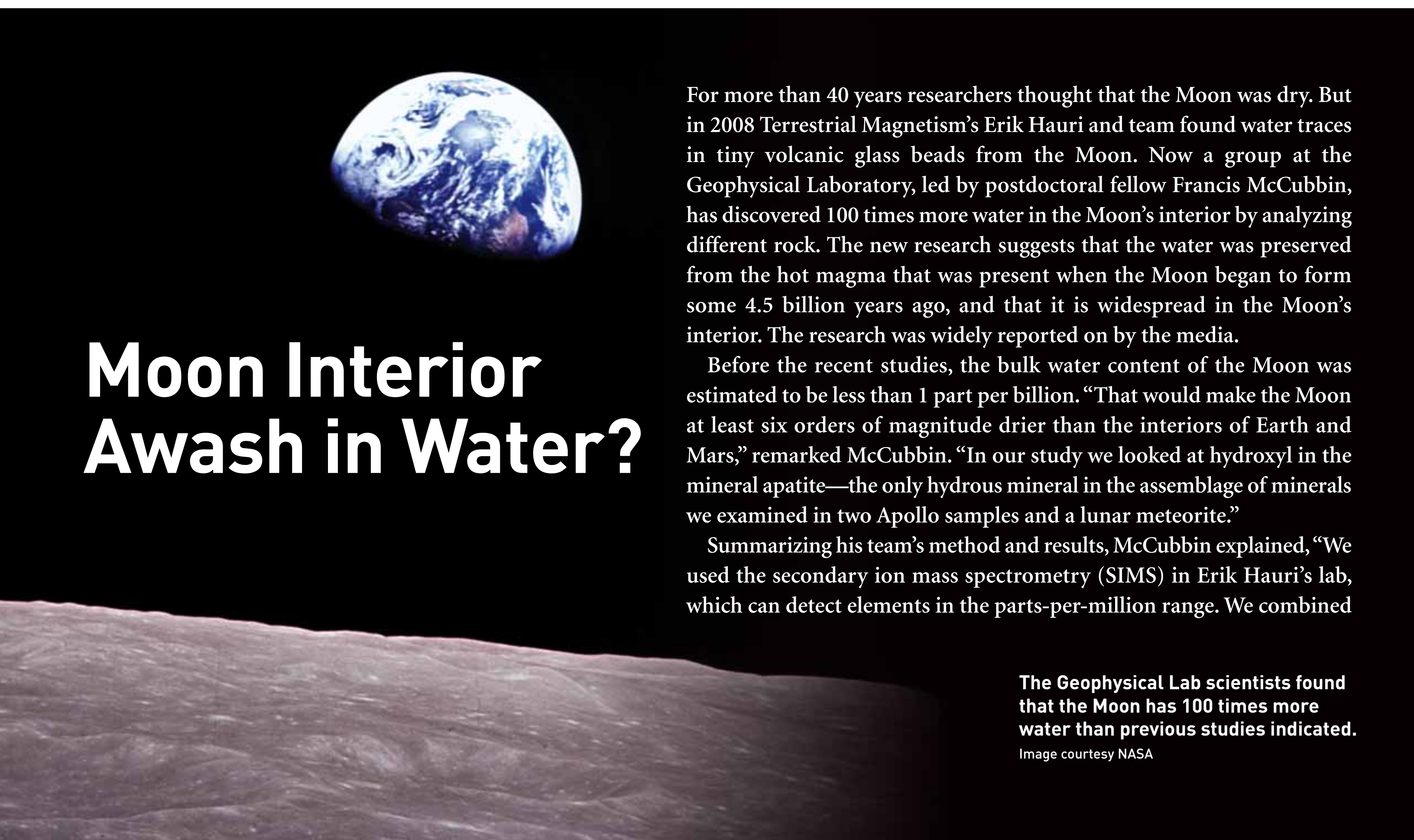
Jeff Han is a staff associate in the Department of Embryology. He earned his M.D./Ph.D. from The Johns Hopkins University and joined Carnegie in 2006. His long-term interests are in understanding the ongoing evolutionary battle between genomic parasites and the host organism, and the cellular programs that have evolved in response to these conflicts. In particular, he studies Long Interspersed Nuclear Elements (LINEs, or L1), which have been spectacularly successful in colonizing the human genome. Han shared his thoughts on being a scientist with *CarnegieScience*.

What led you to become a scientist?

When I was younger, I didn't have a particular interest in becoming a scientist. In fact, I hardly paid attention in high school science classes. This was probably due to the didactic manner in which science courses are usually taught. In college, I was thinking about going to medical school and was told that working in a research lab would be good for my application. Once I actually got into the laboratory and was designing my own molecular biology experiments I was hooked. Classes became superfluous, and I basically self-taught myself whatever I needed to know. In short order I came to feel that making your own discoveries (basic science) was much more fun than simply applying other people's discoveries (clinical medicine).

What led you to your particular field of study?

I initially was very interested in gene therapy (this was before the clinical trial disasters and all the subsequent bad press). At that time, viruses were the best vectors to deliver genes into cells, so my interests gravitated toward virology. I was particularly interested in retroviruses, which carry RNA instead of DNA. When I entered medical/graduate school, I looked for faculty members who worked on retrovirus replication, and the closest I could find was Jef Boeke at Johns Hopkins, who studies a type of jumping genes called retrotransposons. Many are very similar to retroviruses, with the exception that they generally do not leave the cell to infect other cells. He introduced me to LINE elements, which are a kind of retrotransposon that has a fundamentally



Moon Interior Awash in Water?

For more than 40 years researchers thought that the Moon was dry. But in 2008 Terrestrial Magnetism's Erik Hauri and team found water traces in tiny volcanic glass beads from the Moon. Now a group at the Geophysical Laboratory, led by postdoctoral fellow Francis McCubbin, has discovered 100 times more water in the Moon's interior by analyzing different rock. The new research suggests that the water was preserved from the hot magma that was present when the Moon began to form some 4.5 billion years ago, and that it is widespread in the Moon's interior. The research was widely reported on by the media.

Before the recent studies, the bulk water content of the Moon was estimated to be less than 1 part per billion. "That would make the Moon at least six orders of magnitude drier than the interiors of Earth and Mars," remarked McCubbin. "In our study we looked at hydroxyl in the mineral apatite—the only hydrous mineral in the assemblage of minerals we examined in two Apollo samples and a lunar meteorite."

Summarizing his team's method and results, McCubbin explained, "We used the secondary ion mass spectrometry (SIMS) in Erik Hauri's lab, which can detect elements in the parts-per-million range. We combined

The Geophysical Lab scientists found that the Moon has 100 times more water than previous studies indicated.
Image courtesy NASA

different and poorly understood way of replicating as compared with retroviruses. LINE elements have been very successful at colonizing the human genome and are still replicating to this day—there are approximately 1,000,000 copies in a typical human cell, and they are spread all over the genome.

What brought you to Carnegie?

After graduate school I felt quite independent, and the prospect of working in someone else's lab for another four or five years sounded tiresome. Carnegie is one of the few places that have enough trust in young scientists to allow them to start a lab, as a staff associate, right out of graduate school. Risk taking and sound science is valued over the focus on trendy topics that is common at other institutions. This, in combination with Carnegie's strong track record of developing young scientists, made the decision to come to Carnegie easy.

What are you working on now?

We used a budding yeast to study LINE retrotransposition. We use budding yeast as a model system because it is very easy to do chromosome manipulations and genetic screens with yeast. We are hoping to identify cellular proteins that are involved in retrotransposition. We can then move back to human cells and see if the roles of these proteins are the same.

Other projects on the horizon?

It turns out that in basically every model organism where it has been tested, loss of control over transposons leads to infertility or some other reproductive problems. This makes sense since transposons have evolved to be expressed in the germ line—cells leading to egg or sperm—and all classes of transposons need to break

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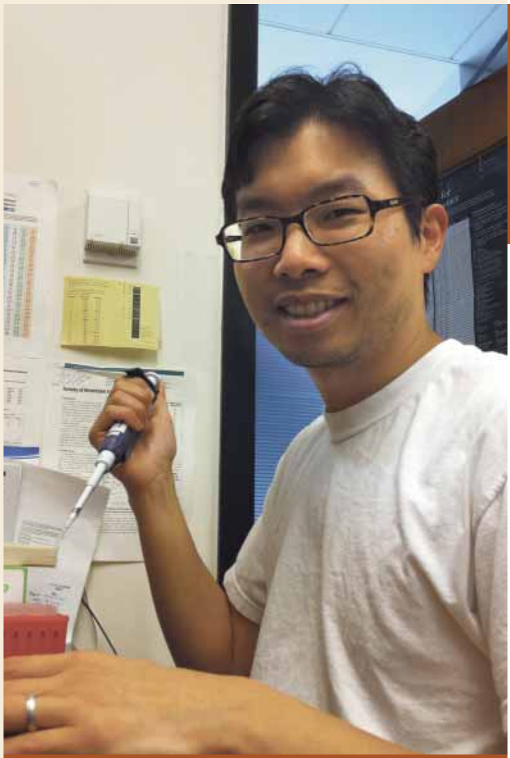

Image courtesy Jeff Han

Jeff Han

these measurements with models that characterize how the material crystallized as the Moon cooled during formation and found that the minimum water content ranged from 64 parts per billion to 5 parts per million—at least two orders of magnitude greater than previous results."

The prevailing belief is that the Moon came from a giant-impact event, when a Mars-sized object hit the Earth and the ejected material coalesced into the Moon. From two of the samples, the Carnegie scientists determined that water was likely present very early in the formation history as the hot magma started to cool and crystallize. This result means that water is native to the Moon.

The previous studies showing water on the Moon analyzed volcanic glasses. The new research looked within KREEP-rich rocks. KREEP comes from the last stages of crystallization. KREEP rocks contain more potassium (K), rare Earth elements (REE), phosphorus (P), and other heat-producing elements such as uranium and thorium. "Since water is insoluble in the main silicates that crystallized, we believed that it should have concentrated in the KREEP," explained coauthor Andrew Steele. "That's why we selected it to analyze." □

This research, funded by NASA ASTEP/MFRP and Carnegie, was published in the online early edition of the *Proceedings of the National Academy of Sciences* the week of June 14.

Lead author and postdoctoral fellow Francis McCubbin is shown working in Svalbard, Norway.

Image courtesy Francis McCubbin

CONTINUED FROM PAGE 7

Jeff Han

DNA to replicate. When you have too much DNA breakage, which is what we expect when transposon activity is elevated, the cell cannot repair everything and eventually dies. Since this seems to be the case in all model organisms, we think it is also likely in humans. We are beginning to look at the germ line of humans to see if some cases of infertility are due to "transposons gone wild." We are also in the initial phases of trying to develop drugs to inhibit retrotransposon activity in humans. Fortunately, LINE elements account for all known transposon activity in humans, so we have a very specific target to go after.

What aspect of your work gives you the most satisfaction?

Coming up with a completely new idea or project that presumably no one has thought of, or is working on, is the most exciting part of science for me—that's the kind of stuff that keeps you up at night. The actual verification of your idea would be even better, but sadly that happens too rarely to be a source of satisfaction.

Advice for up-and-coming scientists?

Always step back and look at the big picture (in science and in life). This is especially important as you get older, busier, and cannot possibly do all the experiments you would like to do. The difference between happiness and frustration is often the ability to effectively prioritize and identify critical experiments from interesting, but nonessential, experiments.

Other passions, interests, talents, or nonscientific achievements?

I am a big animal lover, and for that reason I have consciously chosen to not do research on live animals in my lab. If we ever have the time and money, my wife and I are hoping to one day have an animal shelter. □

Image courtesy Giant Magellan telescope—GMTO Corporation.

The University of Chicago Joins Giant Magellan Telescope Project

The Giant Magellan telescope will be built at Carnegie's Las Campanas Observatory in Chile.

The Giant Magellan Telescope Organization (GMTO) Corporation announced in July that the University of Chicago has joined the partnership that will construct the 25-meter Giant Magellan Telescope (GMT), a state-of-the-art astronomical observatory at Carnegie's Las Campanas Observatory in Chile. The GMT will be used to address fundamental questions in cosmology and astrophysics and to explore worlds around other stars.

The University of Chicago joins an international consortium of leading educational and research institutions from the United States, South Korea, and Australia to build and operate the GMT. The addition of Chicago raises the number of GMT founding institutions to ten. Together with recent major financial commitments to construction from the Korea Astronomy and Space Science Institute, the Australian National University, the Carnegie Institution for Science, and other founding partners, Chicago's participation brings the partnership closer to the funding level needed to begin construction, just over $240M or approximately 35% of the total project cost.

The GMT will have more light gathering power than all of the current telescopes in Chile combined. It will use the latest techniques in Adaptive Optics to remove blurring caused by the Earth's atmosphere, producing visible and infrared images that are up to ten times sharper than those from the Hubble Space Telescope. The unprecedented clarity and sensitivity of these images will provide astronomers with a powerful new tool to study still-unsolved mysteries of the universe, including the formation of planetary systems, the growth of black holes, and the nature of dark matter and dark energy.

"With the University of Chicago joining the GMT Project, our partnership is nearly complete. The GMTO board enthusiastically welcomes the addition of their diverse strengths to the consortium," said Wendy Freedman, chair of the GMTO board.

Patrick McCarthy, director of the GMTO, added, "The Chicago department has a great mix of scientific excellence, technical skill, and real-world know how. We are thrilled to have them on the GMT team." □

Global Tropical Forests
Threatened by 2100

By 2100 only 18% to 45% of the plants and animals making up ecosystems in global, humid tropical forests are likely to remain as we know them today, according to a new study led by Greg Asner at the Department of Global Ecology. The research combined new deforestation and selective logging data with climate-change projections. It is the first study to consider these combined effects for all such ecosystems and will help conservationists pinpoint where their efforts will be most effective.

Tropical forests hold more then half of all the plants and animal species on Earth. But the combined effect of climate change, forest clearcutting, and logging will likely force them to adapt, move, or die.

The scientists looked at land use and climate change by integrating global deforestation and logging maps from satellite imagery and high-resolution data with projected future vegetation changes from 16 different global climate models. They then ran scenarios on how different types of species could be geographically reshuffled by 2100. They used the reorganization of plant classes as a surrogate for biodiversity changes—changes in the variety and abundance of plants and animals in an ecosystem.

For Central and South America, climate change could alter about two-thirds of the humid tropical forests' biodiversity. Combining that scenario with current patterns of land-use change, the Amazon Basin alone could see biodiversity changes over 80% of the region.

Most of the changes in the Congo are likely to come from selective logging and climate change, which could negatively affect between 35% and 74% of that region. At the continental scale, about 70% of Africa's tropical forest biodiversity would likely be affected.

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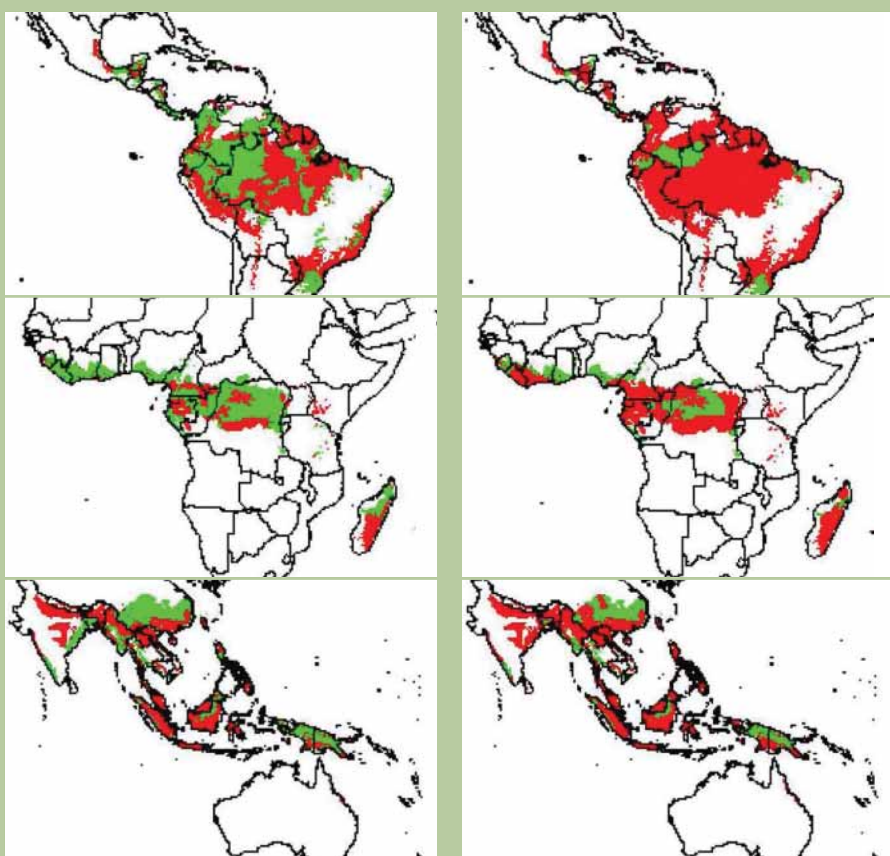
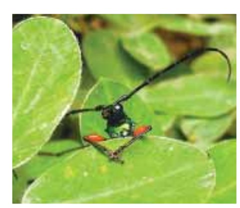
Refugia from moderate impacts **Refugia from severe impacts**

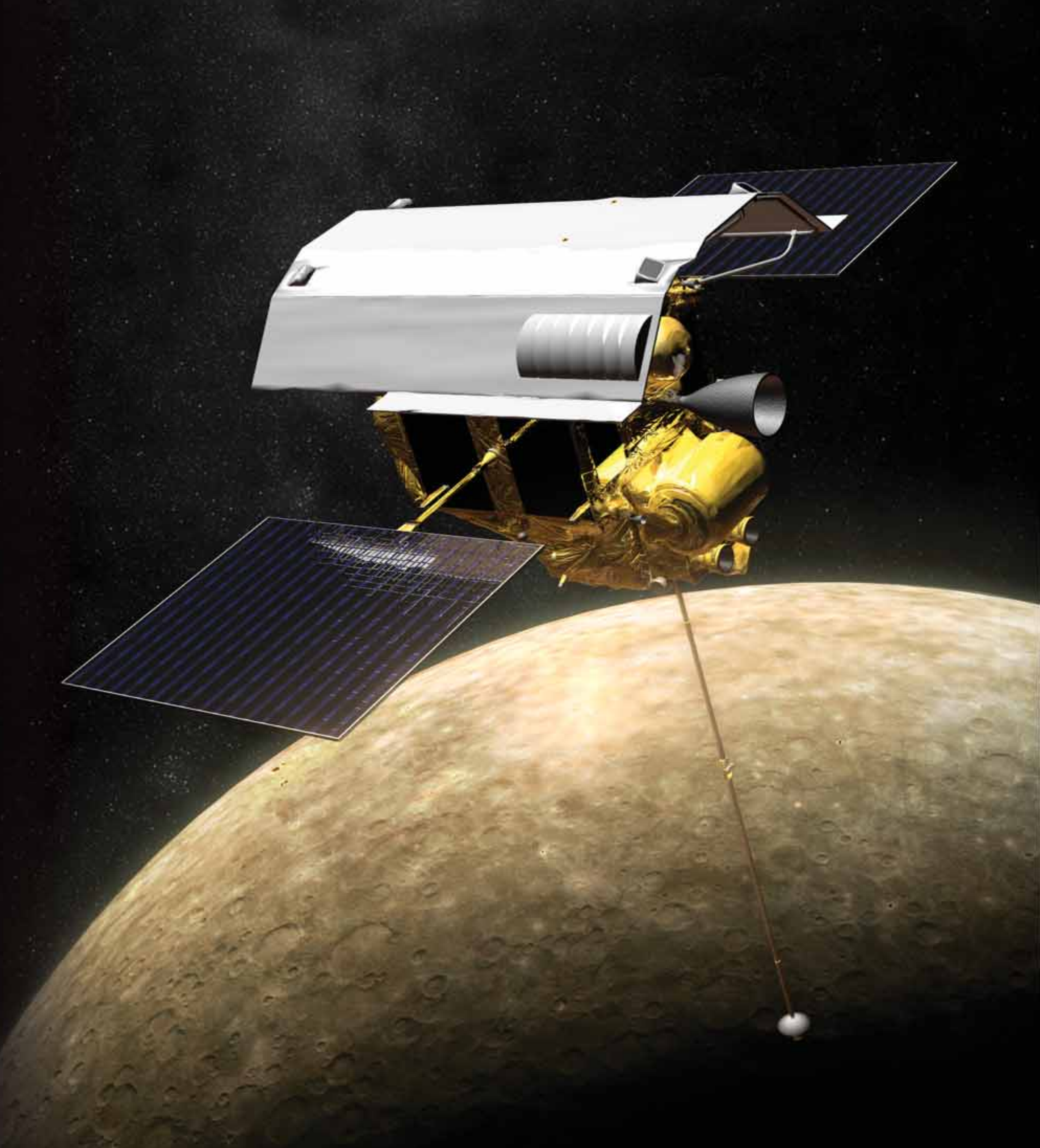


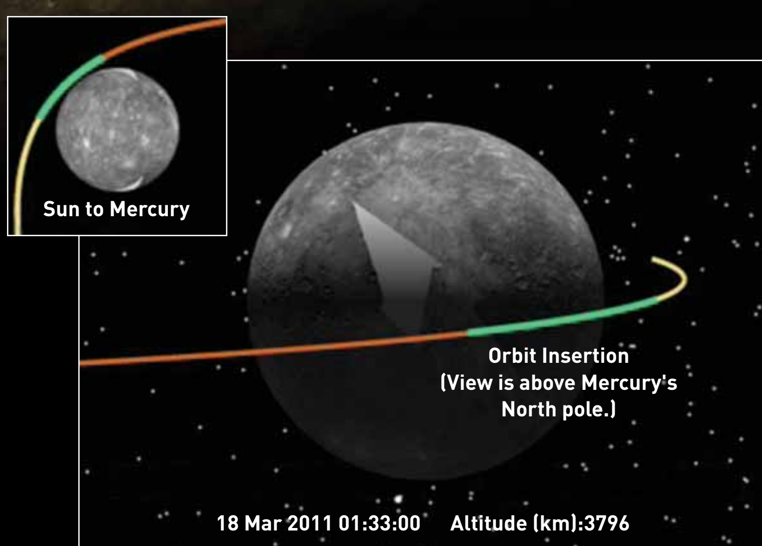
The above maps show the distribution of areas (green) that have not experienced extensive changes from recent deforestation, logging, and projected climate impacts. Moderate climate impacts are shown at left, severe impacts at right (red).



By 2100 only 18% to 45% of the plants and animals that currently make up ecosystems in global, humid tropical forests are likely to remain as we know them today. The combined effect of climate change, forest clearcutting, and logging will likely force most species to adapt, move, or die.

ALMOST THERE!





This artist's rendition shows the tiny MESSENGER craft at Mercury.

(Left) On March 18, 2011, the MESSENGER spacecraft will enter orbit around Mercury. It will be the first spacecraft ever to orbit the planet.

On July 7, 1999, Department of Terrestrial Magnetism's director, Sean Solomon, was selected by NASA to be the principal investigator of the MESSENGER mission. He is shown at center with a model of the MESSENGER craft in 1999 at a celebratory event. In March 2004 (left), he stands with the actual craft, cocooned for transport from the Goddard Space Flight Center to a prelaunch facility in Florida where it underwent testing.

Sean Solomon, Terrestrial Magnetism's director, is the principal investigator of the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission, which is sending the first spacecraft to orbit the innermost planet, Mercury. It's been a long wait. The craft required an extraordinarily complex trajectory designed to slow it down to the right speed so that it would not bypass the planet and will orbit it instead. MESSENGER was launched in August 2004. Six flybys harnessed the gravitational tug of Earth, Venus, and Mercury. The probe has flown by Mercury three times, the latest of which was September 2009. Although it collected a bounty of data from the flybys, the team is anxiously awaiting March 18, 2011, when the tiny craft will finally enter orbit for a year of data collection.

The first two flybys—in January and October 2008—yielded many surprises. They revealed nearly 50% of Mercury's surface never seen before by spacecraft and confirmed widespread volcanism early in the planet's history. Mercury's magnetosphere also appeared to be distinctly different from its state when seen by the only other craft to fly by Mercury, *Mariner 10* in the 1970s. Mercury has a very thin atmosphere of atoms and ions, called an exosphere. The first MESSENGER flybys detected emissions from sodium, calcium, and hydrogen in the exosphere, discovered that magnesium is also present, and sampled several "species" in Mercury's cometlike "tail," which extends at least 2 million miles from the planet.

MESSENGER's third flyby, in September 2009, revealed evidence of younger volcanism on the innermost planet than was previously recognized and new information about magnetic substorms—space-weather disturbances—and it indicated remarkably different spatial distributions among the neutral and ionized elements in the exosphere and tail. It also produced the first detailed altitude profiles of exospheric elements over the North and the South poles.

The flybys have returned a wealth of new observations. "But some of the observations we are most eager to make—such as the chemical makeup of Mercury's surface and the nature of its enigmatic polar deposits—will not be possible until MESSENGER begins to orbit the innermost planet," remarked Solomon.

PREPPING FOR ORBIT

During June, the MESSENGER Science Team met at the Massachusetts Institute of Technology in preparation for the year of observations. That same month MESSENGER was solar sailed to the point in space needed for a successful orbital insertion. Solar-sailing is a novel navigational technique that uses the pressure from sunlight to make small changes in trajectory without expending precious fuel. The spacecraft's predicted trajectory was within 1 mile of its target location and 7 seconds of the target arrival time as of late July. At that time, the mission had two rotations around the Sun to go—enough time to close the remaining gap.

The team reviewed events to take place before, during, and after the orbit insertion, also in June, with a panel of experienced engineers and managers from across the NASA centers. Twenty-three recommendations and actions were submitted to the team for completion and evaluation in the critical design review of the insertion burn sequence, scheduled for October.

The engineering and operations teams are establishing operational procedures, while the science planning and mission operations teams completed the most comprehensive "week-in-the-life" test of the mission to date. This six-week activity evaluated and refined the tools and techniques needed for orbital operations.

The instrument scientists held a series of meetings to evaluate the MESSENGER science software, while the operations teams continued to verify the command functions. Two teams are testing commands over the 52-week orbital schedule via simulations to ensure that the autogenerated command sequences work correctly. They will continue their analysis until all 52 weeks of scheduled science activities are successfully processed.

In August, the operations team performed a comprehensive flight test of orbital readiness. The team selected a period from within the 52-week orbit that most closely matches the Sun-Earth-Mercury orbital geometry to assess the MESSENGER system under flight conditions. Although there remain many detailed activities to complete before March 18, 2011, the MESSENGER team is poised for the next stage of this first-of-its-kind mission. □

Images (page 10) courtesy NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution

(Top) Eva Huala is the principal investigator and director of TAIR at Carnegie's Department of Plant Biology.

(Bottom) *Arabidopsis thaliana* is a widely used experimental plant related to mustard.

Image courtesy Eva Huala

Image courtesy Sue Rhee

Private Support Helps Public Plant Research

The private sector and an Austrian research institute are chipping in to help support one of the most widely used public biological databases in the world—the Arabidopsis Information Resource, TAIR (http://www.arabidopsis.org/). Most funding continues to come from the National Science Foundation. Almost 40,000 researchers worldwide use the database monthly to study everything from crop engineering and alternative energy sources to human disease. Although *Arabidopsis thaliana* is an experimental plant, it shares many of its genes and basic biological processes with other plants and animals including humans.

Two corporations have recently signed on as TAIR sponsors: Dow AgroSciences and, most recently, Syngenta Biotechnology Inc. In addition to the two corporations, the Gregor Mendel Institute (GMI), a public research institute affiliated with the Austrian Academy of Sciences, has also recently contributed to the support of TAIR.

TAIR curators extract experimental gene function data from published research articles and improve the accuracy and completeness of the *Arabidopsis* genome annotation. The Web site provides access to data on genes, clones, markers, mutant genes, proteins, publication protocols, DNA and seed stock information and more, and receives over 20 million page views annually from around the world.

"These contributions will have a significant impact on our ability to maintain the high-quality datasets researchers depend on," remarked Eva Huala, principal investigator and director of TAIR at Carnegie's Department of Plant Biology. "Diversifying our sources of funding will make it easier to sustain TAIR over the long term. We're very pleased that there is interest in sponsorship from the private sector and we hope to see more in the coming months." □

Roller Coaster Superconductivity

Xiao-Jia Chen

Superconductors carry electricity without resistance, making them much more efficient than copper wires. But, to attain the superconducting state, they have to be cooled to a low critical or transition temperature. Developing superconductors with higher transition temperatures is one of physics' greatest quests. Now, researchers at the Geophysical Laboratory (GL), with colleagues, have unexpectedly found that the transition temperature can be induced under two different intense pressures in a three-layered bismuth oxide crystal called Bi2223. The higher pressure produces the higher transition temperature. They believe this unusual two-step phenomenon comes from competition of electronic behavior in different layers of the crystal.

Until now, copper-laden materials called cuprates have been the only superconductors whose transition temperatures are higher than the liquid nitrogen boiling point at -321°F (77 K).

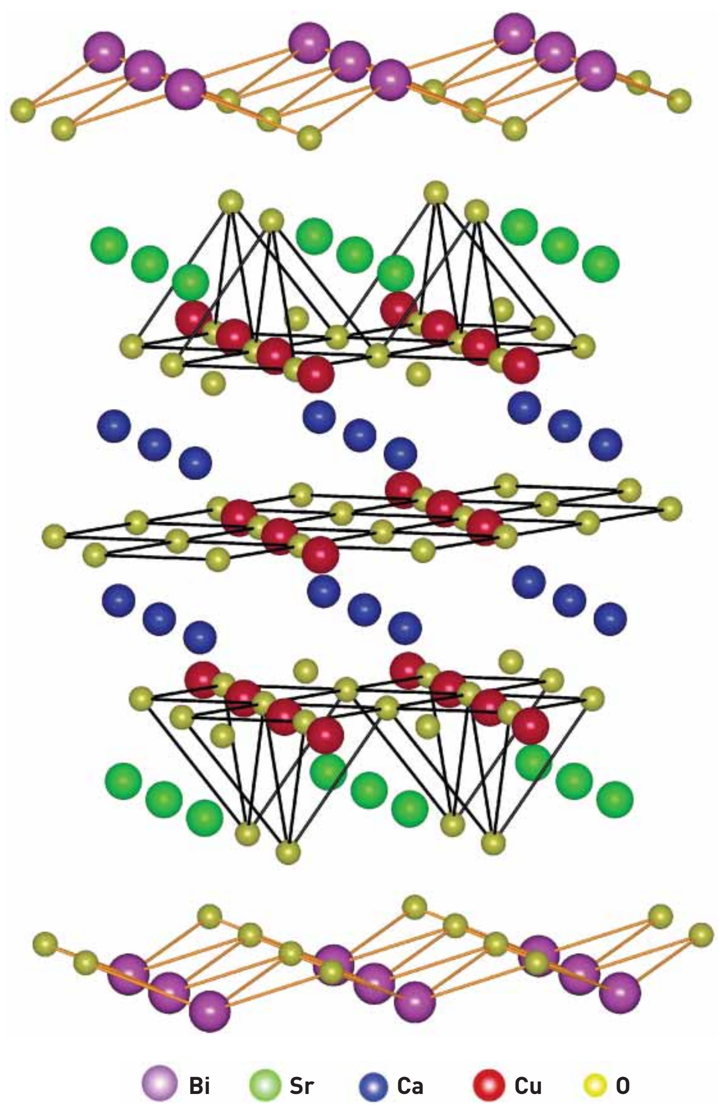
"Bi2223 is like a layered cake," explained lead author Xiao-Jia Chen at GL. "On the top and bottom there are insulating bismuth-oxide layers. On the inside of those come layers of strontium oxide. Next are layers of copper oxide, then calcium, and finally the middle is another copper-oxide layer. Interestingly, the outermost and inner copper-oxide layers have different physical properties, which results in an imbalance of electric charge between the layers."

One way scientists have found to increase the transition temperature of superconducting materials is to "dope" them by adding charged particles.Under normal pressure, the optimally doped Bi2223's transition temperature is -265°F (108 K). The scientists subjected doped crystals of the material to a range of pressures up to 359,000 times the atmospheric pressure at sea level (36.4 gigapascal), the highest pressure yet for magnetic measurements in cuprate superconductors. The first higher transition temperature happened at 100,666 atmospheres (10.2 GPa).

"After that, increasing pressures ended up with lower transition temperatures," said Chen. "Then, to our complete surprise, at about 237,000 atmospheres (24 GPa) the reduction of the transition temperature stopped. Under even more pressure, 359,000 atmospheres, the transition temperature rose to -215°F (136 K). That was the highest pressure our measuring system could detect."

Other research has shown that some multilayered superconducting materials exhibit different electronic and vibrational behaviors in different layers. The researchers think that 237,000 atmospheres might be a critical point where pressure suppresses one behavior and enhances superconductivity.

"The finding gives new perspectives on making higher transition temperatures in multilayer cuprate superconductors. The research may offer a promising way of designing and engineering superconductors with much higher transition temperatures at ambient conditions," concluded GL's Viktor Struzhkin, a coauthor. □



The layered crystal structure of Bi2223, bismuth oxide, is shown in this diagram.

Image courtesy Xiao-Jia Chen

The research, published in the August 19, 2010, issue of *Nature*, was supported by the U.S. Department of Energy, Carnegie Institution of Canada, and the National Natural Science Foundation of China. This work was conducted in collaboration with researchers at the South China University of Technology and the Max Planck Institute for Solid State Research in Germany.

CONTINUED FROM PAGE 9

Global Tropical Forests Threatened by 2100

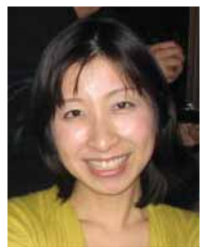
In Asia and the central and southern Pacific islands, deforestation and logging are the primary drivers of ecosystem changes. Model projections suggest that climate change might play a lesser role there. That said, the research showed that between 60% and 77% of the area is susceptible to biodiversity losses via massive ongoing land-use changes.

"This is the first global compilation of projected ecosystem impacts for humid tropical forests affected by these combined forces," remarked Asner. "For those areas of the globe projected to suffer most from climate change, land managers could focus their efforts on reducing the pressure from deforestation . . . On the flip side, regions of the world where deforestation is projected to have fewer effects from climate change could be targeted for restoration." The study was published in the August 5, 2010, issue of *Conservation Letters*. □

The John D. and Catherine T. MacArthur Foundation and the Gordon and Betty Moore Foundation support the Carnegie Landsat Analysis System, the Global Spectronomics project, and this study (http://claslite.ciw.edu; http://spectranomics.ciw.edu).

Balancing the Sulfur Budget

Image courtesy University of Arkansas Division of Agriculture



Nakako Shibagaki

David González-Ballester

Wirulda Pootakham

Images courtesy Arthur Grossman

Sulfur is an essential component of living cells. Plants can use mineral sulfur and convert it to valuable compounds like sulfur amino acids, which are essential for animal nutrition. Levels of environmental sulfur can vary greatly, although most organisms can store only limited amounts of this critical element. Therefore, organisms have had to evolve mechanisms to adapt to changing environmental sulfur levels.

Arthur Grossman's lab in the Department of Plant Biology has been investigating catalytic and regulatory features of sulfur metabolism for years. Three new papers provide insights on how the model organisms *Chlamydomonas* and *Arabidopsis* cope with changing sulfur conditions. *Chlamydomonas* is a dominant, single-celled green alga that lives in the soil, and *Arabidopsis,* the mustard plant, is a ubiquitous multicellular plant with different organ and tissue types. Work on these systems has broad implications on how organisms in general sense "sulfur need" and adjust their structural and metabolic features accordingly.

"In studying sulfur deprivation, we initially probed transporter activity and regulation," said Grossman. Most environmental sulfur exists as an oxidized sulfate anion (a negatively charged ion), which requires active transport into cells by transporter proteins. In one study, graduate student Wirulda Pootakham identified and characterized the relevant transporter genes and proteins in *Chlamydomonas*. Under low sulfur conditions, the genes for several transport proteins were switched on, allowing cells to efficiently scavenge sulfate in the environment. These transporters rapidly accumulate in the plasma membrane of cells. When high sulfur conditions are reestablished, the transporter genes are rapidly turned off and the proteins turned over by novel mechanisms, one involving a proteasome complex—a complex protein that breaks down other proteins—and another that is independent of the proteasome.

How low sulfur affects cellular metabolism was further revealed by a study led by David González-Ballester. González-Ballester used a powerful new technique called RNA-Seq to compare global expression of *Chlamydomonas* genes under sulfate-rich and sulfur-deprived conditions. "Altering sulfur conditions triggers major rearrangements in the cells' metabolic activities and in the architecture of both the intracellular and extracellular space," said Grossman. "Under low sulfur conditions, the cells appear to physically alter the photosynthetic apparatus and stop photosynthetic activity, eliminate most sulfur in their cell wall, and activate previously uncharacterized metabolic pathways that lead to the massive turnover of sulfur-containing compounds, freeing up sulfur for more critical needs."

Sulfur availability can also profoundly influence sulfur acquisition systems in *Arabidopsis*. In a study of root cells, Nakako Shibagaki discovered that sulfate transport is partly regulated through interactions between the transporter protein and the enzyme cysteine synthase, which incorporates reduced sulfur (sulfide) into the amino acid cysteine. This interaction helps the plant coordinate its sulfate uptake with its energy flow and metabolic need for sulfur. While regulation by gene expression can take minutes to hours, this type of regulation can take seconds to minutes. Grossman explained that the big concept of this work is that the proteins at the beginning and end of a biosynthetic pathway directly communicate with each other, efficiently coordinating the plant's acquisition capacity with its need for the nutrient. "Other transporter-assimilation systems are also likely to exploit this type of direct regulatory interaction, and macromolecular protein complexes may associate with plasma membrane–localized transporters to help control nutrient trafficking," he said. For the sulfate transporters in *Arabidopsis*, the interacting region on the protein is designated STAS (sulfate transporter and antisigma factor antagonist) domain. Sulfate transporters of *Chlamydomonas* also have STAS domains that may play a similar role in sulfate uptake and assimilation, despite more than a billion years of evolution separating the two organisms.

With respect to the big picture, Grossman aims to "elucidate mechanisms used by photosynthetic organisms to cope with limiting nutrient levels, and explore these mechanisms across evolutionary time, where differences in an organism's architecture, lifestyle, and environmental milieu can profoundly impact modes of nutrient acquisition and utilization." □

(Above left) Sulfur is critical for healthy plant growth. The photo shows the discolored leaves of sulfur-deprived rice plants.

González-Ballester, D., Casero, D., Cokus, S., Pellegrini, M., Merchant, S. S., and A. R. Grossman, RNA-Seq analysis of sulfur-deprived *Chlamydomonas* cells reveals aspects of acclimation critical for cell survival, *Plant Cell 22*, 1-27, 2010.

Pootakham, W., González-Ballester, D., and A. R. Grossman, Function, localization, and regulation of sulfate transporters of *Chlamydononas reinhardtii, Plant Physiol.* May 24, 2010 [ePub ahead of print].

Shibagaki, N., and A. R. Grossman, Binding of cysteine synthase to the STAS domain of sulfate transporter and its regulatory consequences, *J. Biol. Chem.* June 7, 2010 [ePub ahead of print].

InBrief

TRUSTEES AND ADMINISTRATION

❶ Carnegie president **Richard A. Meserve** participated in meetings of the Blue Ribbon Commission on America's Nuclear Future chartered by DOE Secretary Chu at the direction of the president in the District of Columbia, Idaho, Washington State, and Maine. He chaired a meeting of the National Academies' Nuclear and Radiation Studies Board (NRSB) on July 20-21. He spoke at an energy workshop at Stanford U. on Aug. 26, and chaired a forum sponsored by the IAEA's International Nuclear Safety Group on Sept. 20 in Vienna, Austria.

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❷ In Aug. science writer **Alan Cutler** left Carnegie to teach at Montgomery College.

❶ Carnegie president Richard A. Meserve

❷ Alan Cutler

EMBRYOLOGY

❸ Director **Allan Spradling** participated in an NIH Workshop about expanding the number of fellow positions. Leaders from Cold Spring Harbor, the Whitehead Institute, and the Fred Hutchinson Cancer Research Center described their programs offering positions similar to Carnegie's staff associate position. He also participated in a meeting in Shanghai, China, organized by **Tian Xu** (Yale U.) Speakers from the meeting visited Tibet U. Medical School in Lhasa and spent a few days touring the country. Spradling spoke at the joint meeting of the Society for Developmental Biology and the Japan Society for Developmental Biology in Albuquerque in Aug.

❸ Allan Spradling (left) and Tian Xu (right)

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In June **Joseph Gall** attended the 75th Cold Spring Harbor Symposium, "Nuclear Organization and Function," and presented the Reginald Harris Lecture.

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On May 14 **Steve Farber** gave a talk at the NYU Center for the Prevention of Cardiovascular Disease as part of the Marc and Ruti Bell Vascular Biology and Disease Program. In July he lectured for a European Molecular Biology Organization course and at U. Sheffield in the UK. He then spoke at the Welcome Trust in Hinxton, UK. In Aug. he spoke at the Hopkins Bayview Campus for the Div. of Pulmonary and Critical Care Medicine. He also chaired a session at the Society for Developmental Biology meeting, where BioEYES shared the John Doctor Best Education Poster Award. The $1,000 cash award is given to the best education poster presented by a member.

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Alex Bortvin gave talks at U. Renne and at the Institut Curie (France) and at the Germ Cells Satellite Symposium, SDB and JSDB Joint Meeting in Albuquerque.

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Gall lab senior scientist **Zheng'an Wu** spent a month in China, where he presented an invited lecture.

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Tony Mahowald, emeritus professor at U. Chicago, spent the summer in the Gall lab studying the *Drosophila* ovary.

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Gall lab visiting scientist **Svetlana Deryusheva** and graduate student **Zehra Nizami** presented a poster at the 75th Cold Spring Harbor Symposium. **Mario Izaguirre-Sierra** joined the lab as a postdoctoral fellow to work on the control of transposable elements in *Drosophila*.

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Bortvin lab postdoc **Godfried W. van der Heijden** has returned to Europe to write a book about his American experience. **Shreyas Jadhav** moved to Beth Israel Hospital, Boston, to continue his postdoctoral training. Undergraduate student **Neil Vranis** completed his lab project; visiting undergraduate student from Spain **Marina Reig** spent a month in the lab learning ES cell methods.

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Murray Whitelaw visited the Fan lab.

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Axel Horn, postdoctoral fellow from Germany, is studying the interaction between the host cell and LINE retrotransposons in the Han lab.

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New predocs are **Will Yarosh**, **Lydia Li**, **Michelle Rozo**, **Valeriya Gaysinskaya**, and **Abhignya Subedi**.

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Neda Muzaffar is a new technician in the MacPherson lab.

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Lakishia Smith is a new administrative assistant in the front office, and **Valerie Butler** has joined BioEYES as the new outreach educator.

The 2010 Math for America fellows arrived this summer. They take a break in the administration library.
Image courtesy Bianca Abrams

Ellen Cammon,

a technician in Doug Koshland's lab, retired on Aug. 31 after 24 years, 8 months, and 16 days of service. Ellen started in the glass-washing and animal facilities in 1985 and became a research technician in 1997. She prepared media and solutions for the lab, maintained their stock of transfer velvets and pipets, and poured thousands of plates for colony transfers. She plans to spend more time with her grandchildren, traveling, and volunteering.

Shown are Doug Koshland (left) and Ellen Cammon (right), and Ellen (center) with her family.

RICHARD E. PAGANO,

a staff member in the Department of Embryology from 1972-1994, died of complications from lymphoma September 22, 2010. He received his B.A. from Johns Hopkins, his Ph.D. in biophysics from the U. of Virginia, and carried out post doctoral training at NIH and then at the Weizmann Institute of Science in Israel. Pagano was an expert in the cell biology of membranes using the biophysical properties of synthetic lipids as a tool. While at Carnegie he pioneered the synthesis of lipid molecules with fluorescent side chains. The Pagano lab used these synthetic lipid probes to identify novel membrane transport pathways. He found that they were incorporated into living cells and could be followed microscopically as they moved through cells to membranes or cell compartments. He determined specific sub cellular organelles in lipid metabolism that showed how cholesterol and glycosphingolipids organize membranes into microdomains that control cell signaling. His work using fluorescent lipid analogs also provided insights into the diagnosis and treatment of sphingolipid storage disorders. Pagano developed systems to detect the defective membrane trafficking found in these diseases. These same assay systems are being used to screen for drugs that reverse the defect.

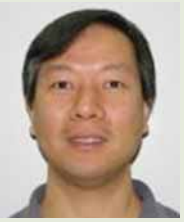
In 1994 Pagano was appointed professor in the Department of Biochemistry and Molecular Biology with a joint appointment as professor of medicine in the Division of Pulmonary and Critical Care Medicine at the Mayo Clinic in Rochester, Minnesota.

Two Winners

At the Aug. 2010 meeting of the Society for Developmental Biology held in Albuquerque, Maxine Singer received the Viktor Hamburger Outstanding Educator Prize. Steve Farber collected the John Doctor Best Education Poster Award on behalf of Jamie Shuda and other members of the BioEYES outreach group for their poster titled "Impacting K-12: What makes Project BioEYES work?"

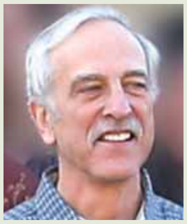
Carnegie president emerita Maxine Singer (left) and Steve Farber received awards at the Society for Developmental Biology meetings.

❹ Director of the Geophysical Laboratory Russell Hemley



❺ Wenge Yang

❻ Lin Wang



❼ Joe Berry

❽ Ken Caldeira

❾ Greg Asner (second from left) meets with Peruvian Minister of Environment Antonio Brack (third from left).

Image courtesy Greg Asner

GEOPHYSICAL LABORATORY

❹ **Russell J. Hemley** gave the following invited talks: "Chemistry of materials under extreme conditions," UC-Berkeley High Energy Density Workshop, May 12-13; "Materials and pressure: atoms, molecules, and energy landscapes in new domains." A tribute to Roy G. Gordon, Roy Gordon Symposium, Harvard U., May 1; "The Deep Carbon Observatory (DCO)," Lawrence Livermore National Laboratory, May 13; "The Deep Carbon Observatory," Los Alamos National Laboratory, May 14; "New findings in simple molecular systems under pressure," "Melting behavior of hydrogen at megabar pressures," and "The Deep Carbon Observatory" CC-2010, 8th Conference on Cryocrystals and Quantum Crystals—School of Young Scientists, Chernogolovka, Russia, July 26-31; "The Deep Carbon Observatory," Inst. of Geology in Moscow and Inst. of High-Pressure Physics in Troitsk, Moscow, July; "New findings in simple molecular systems under pressure," Kick-Off Conference on Pressure Effects on Materials, ICMR at the U. Santa Barbara, Aug. 24. He also participated in the organization of the DCO Workshop in Houston, TX, on July 21-22.

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Robert Hazen presented the opening plenary lecture on mineral evolution at the International Mineralogical Association meeting in Budapest, presentations on mineral-molecule interactions, and on the DCO. He presented the Bradley Lecture at the Geological Society of Washington, the Sigma Xi lecture at Loyola Marymount U. in Los Angeles, and invited talks at the Geochemical Society Goldschmidt Conference in Knoxville, TN, and at the Japan Geoscience Union Meeting in Tokyo.

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Ho-kwang Mao presented an invited talk, "Catalyst-free synthesis of transparent, mesoporous diamond monoliths from periodic mesoporous carbon" at the 4th International Conference on New Diamond and Nano Carbons, May 16-20, in Suzhou, China. He also presented two plenary lectures: "High-pressure science and technology of the 21st century" at the 48th EHPRG International Conference, Uppsala, Sweden, July 25-29, and at the ICMR Kick-Off Conference on Pressure Effects on Materials in Santa Barbara, CA, Aug. 22-28. He also presented an invited talk, "Energy frontier research in extreme environments" at the 14th High Pressure Semiconductor Physics International Conference in Changchun, China, Aug. 1-4.

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Douglas Rumble attended the Isotopomer 2010 Conference in Amsterdam in June. He spent July through mid-Aug. at Dartmouth Coll., where he gave a seminar, led a field trip, worked on the tandem mass spectrometer project, and wrote journal articles.

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Reinhard Boehler was an invited speaker at the Kick-Off Conference on Pressure Effects on Materials in Santa Barbara, CA, Aug. 23-27. He was the keynote speaker at the Geophysics Conference "Multiple-Scale Geodynamics of Continental Interiors" in Wuhan, China, May 16-21.

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Nabil Boctor attended the Meteoritical Society meeting in New York City in July and presented a paper.

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In May postdoctoral associate **David Baker** conducted fieldwork at the Perry Inst. for Marine Science lab at Lee Stocking Island in the Bahamas. In early June he presented "Stable isotopes reveal the biogeochemistry of a coral disease," at the Ecology and Evolution of Infectious Disease meeting at Cornell U. in Ithaca, NY. On July 7 he gave a talk at the Dept. of Global Ecology, hosted by Ken Caldeira, entitled "From cells to ecosystems: how stable isotopes improve our understanding of coral physiology and global change." On Aug. 9 he attended the seventh Stable Isotope Ecology Meeting (ISOECOL VII), where he gave a talk on "Stable isotopes and coral reef ecology, a two-part tale." On Aug. 29 he began fieldwork at the Smithsonian Tropical Research Inst. in Bocas del Toro, Panama.

High Pressure Collaborative Access Team (HPCAT)

Beamline scientist **Paul Chow** mentored four students this summer: **Alex Wang** and **Peter Shyu** from Naperville North High School and **Claire Lee** and **Ike Swetlitz** from Naperville Central. He introduced them to X-ray scattering and emission spectroscopy, and characterizing the emission analyzers.

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Summer intern **Alaina Beres** spent her last summer at HPCAT before beginning student teaching at Carl Sandburg High School. She developed a new Web page and expanded outreach for HPCAT.

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Margaret (Maggie) Liu, a high school student from Washington State, spent several weeks at HPCAT converting old 2-D drawings to 3-D models for the HPCAT beamline enclosures. She wants to be an engineer.

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

❺ **Wenge Yang** gave an invited talk titled "Novel high pressure synchrotron radiation techniques and applications to semiconductor nanowires" in the "Low-Dimensional System" session of 14th International Conference on High Pressure Semiconductor Physics in Changchun, China, Aug. 1-4 and chaired the session "Wide band gap materials."

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❻ **Lin Wang** has been promoted from postdoctoral researcher to research scientist.

GLOBAL ECOLOGY

❼ **Joe Berry** presented talks at the 15th International Congress on Photosynthesis held in Beijing Aug. 22-27, and a satellite meeting on C4 photosynthesis held at the Chinese Academy of Sciences, Plant Physiology Laboratory, in Shanghai Aug. 17-20.

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Scholars Wrap Up Successful Summer

On Wednesday, Aug. 4, the 12 participants in this year's Carnegie Summer Scholars Program presented the results of their work in the Greenewalt Lecture Hall at the Broad Branch Road campus. Projects included mineral physics, seismology, astronomy, organic geochemistry, high-pressure chemistry, and the origins of life. The Summer Scholars have now returned to their home institutions, but many will be presenting their results at national meetings in the coming year. The Carnegie Summer Scholars Program is jointly funded by the National Science Foundation/Research Experiences for Undergraduates program and the Air Force Office of Scientific Research.

The 2010 Carnegie Summer Scholars front row (left to right): Michael Wong (UC-Berkeley), Rachel Maxwell (U. of AZ), Bethany Chidester (U. of Toledo), and Rachel Hoover (U. of CO). Middle row: Kathryn Kumamoto (Williams College), Jennifer Moses (Franklin & Marshall College), Breana Hashman (Dickinson College), and Benjamin Horkey (Woodrow Wilson High School, DC). Back row: Amanda Lindoo (Augustana College), Byron Kelly (Memorial U. of Newfoundland), Donald Plattner (Centre College), and Melissa McMillan (U. of AZ).

LEONARD SEARLE, **astronomer and director emeritus of Carnegie Observatories, died at his home on July 2, 2010, in Pasadena, CA. He was born on October 23, 1930, in the London suburb of Mitcham. He received his bachelor of science degree from U. of Saint Andrews in Scotland, and his Ph.D. from Princeton, where he met his future wife, Eleanor Millard. She died in 1999.**

Searle joined the U. of Toronto in 1953 and in 1960 became a senior research fellow at Caltech. In 1963 Searle left Caltech to join the faculty of the Mount Stromlo Observatory in Australia. Then in 1968 he returned to Pasadena to join the staff of Carnegie. He became director in 1989 and retired in 1996. One of his most important research areas was understanding the abundance of helium by studying stars in the very early universe, and later certain small galaxies, for estimates of helium-to-hydrogen abundance ratio. With Wallace Sargent, he devised the "simple model" of chemical evolution. Later, with Robert Zinn he developed a scheme to assemble the Milky Way Galaxy from "primordial fragments." It has been quoted more than 1,000 times since it was published in 1978.

❿ (Top) Members of the spectranomics team go to work in a canoe. (Bottom) The spectranomics team poses in Maquipucuna, Ecuador.

Images courtesy the Asner lab

⓫ Wendy Freedman poses with President Piñera of Chile (center) and director of Las Campanas Miguel Roth at the signing of several MOUs, at UCLA, between Chile and California regarding innovation and technology.

Image courtesy Miguel Roth

❽ **Ken Caldeira** attended a steering committee meeting of the Global Carbon Project June 15-17 at U. East Anglia in Norwich, UK. On June 18 he visited the Royal Society of London to discuss a meeting to be planned for the autumn. On June 21 he flew to Bonn, Germany, to speak at the Deutsche Welle Global Media Forum. From July 27-29 he was in Urbino, Italy, at the Urbino Summer School for Paleoclimatology.

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Greg Asner gave an invited symposium talk on forest carbon emissions at the annual meeting of the Association for Tropical Biology in Bali, Indonesia. **Robin Martin** presented work from the spectra-nomics project at the same meeting.

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❾ **Guayana Paez** and **Greg Asner** provided a public presentation on a large-scale demonstration project to reduce emissions from deforestation and forest degradation to the Peruvian Ministry of Environment and other government agencies in Lima.

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Field lab's **Nona Chiariello** and summer interns **Safiyyah Abdul-Khabir** and **Christina Feng** presented their research about native grass restoration in plots of the Jasper Ridge Global Change Project.

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Field lab's **Luis Fernandez** spoke at the UNEP conference "International Symposium of Renewable Energy and Economic Competitiveness," in Praia, Cape Verde, regarding carbon reductions through the use of renewable energy in the developing world May 17-21. He was invited by the Angolan government to testify at the Ministry of Energy in Luanda, Angola, on the potential deforestation and carbon benefits of establishing Angola's first national renewable energy law May 24-28. June 8-13 he was in Goias Velho, Brazil, to judge the XII Brazil International Environmental Film Festival. June 14-16 he worked with collaborator Laerte Ferreira and his graduate students at the Federal U. of Goias (UFG) in Goiana, Brazil, regarding a joint DGE-UfG project that studies the impacts of biofuels development on land use and carbon stocks in the Brazilian Cerrado.

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Carolyn Snyder of the Field lab received her doctorate in June and is now the director of clean energy and climate policy for the state of Delaware in their Dept. of Natural Resources and Environmental Control.

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Caldeira lab's **Julia Pongratz** attended the AIMES Open Science Conference on Global Change, Climate, and People in Edinburgh, UK, May 10-13, and gave the talk "Biophysical versus carbon cycle effects of anthropogenic land cover change."

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❿ The Asner's lab's spectranomics team, including **Greg Asner**, **Loreli Carranza**, **Alberto Escudero**, **Nestor Jarmillo**, **Robin Martin**, **Paola Martinez**, **Felipe Sinca**, and **Raul Tupayachi**, completed biodiversity field campaigns in Peru and Ecuador.

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Asner's Carnegie Airborne Observatory (CAO) team, including **Ty Kennedy-Bowdoin** and **James Jacobson,** completed airborne mapping flights over Madagascar and South Africa.

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Jim Kellner, **Kyla Dahlin**, and **Kealoha Kinney** presented CAO-related research at the annual meeting of the Ecological Society of America in Pittsburgh.

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The Asner CLASlite team, including **Guayana Paez** and **John Clark**, completed training workshops in Brazil, Venezuela, and Suriname.

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Berry lab's **Adam Wolf** attended a two-week workshop Aug. 16-31 that was organized by the Office of Tropical Studies at La Selva, Costa Rica, on "Expanding the frontiers of tropical ecology through Wireless Sensor Networks."

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Arrivals and Departures: New arrivals in the Field lab include lab technician **Shane Easter** and summer interns **Julia Morrison**, **Priscilla Ngo**, and **Rebecca Nguyen**. **Katharine Mach**, postdoc from Stanford U., joined the Technical Support Unit for the IPCC Working Group II. **Loreli Carranza-Jimenez** was hired as an Asner lab assistant. **Joe Mascaro** joined the Asner lab as a postdoctoral fellow. **Ruth Emerson** left the Asner lab to pursue graduate studies at UC-Berkeley.

OBSERVATORIES

⓫ In early June **Wendy Freedman** hosted a visit with Patty Stonesifer, chair of the board of regents at the Smithsonian Institution and others at Las Campanas Observatory. They peered through the eyepiece of the Clay telescope and learned about the Magellan telescopes and the Giant Magellan Telescope. She attended a conference entitled "Darkness Visible" at U. Cambridge in early Aug. On Aug. 30 she served as lead for the astrophysics and physics section for the W. M. Keck Foundation's Science and Engineering program evaluation committee, conducted by the NAS.

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⓬ Staff astronomer **Andrew McWilliam** gave an invited review of chemical evolution at the Nuclei in the Cosmos XI conference in Heidelberg, Germany, on July 19.

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Staff astronomer **Michael Rauch** gave a talk in June on "High redshift dwarf galaxies" at the conference "A Universe of Dwarf Galaxies" in Lyon, France, and visited the Institute of Astronomy, U. Cambridge, in Aug.

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In June staff associate **Jeff Crane** attended the SPIE Astronomical Telescopes and Instrumentation conference to present information on the Planet Finder Spectrograph. In Aug. he gave an invited talk about PFS at the Astronomy of Exoplanets with Precise Radial Velocities workshop at Penn State U.

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Carnegie Fellow **Janice Lee** lectured at Texas A&M U., Spitzer Science Center (Caltech), UCLA, and attended the annual meeting of the Gemini Telescopes U.S. Science Advisory Committee at NOAO in Tucson.

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NSF Fellow **Karín Menéndez-Delmestre** visited NRAO in Charlottesville, VA, and presented a lunch talk after being a reviewer for the HST Cycle 18 at STScI. She attended the Extreme Starbursts workshop at the end of June in Granada, Spain, where she presented the first study of high-redshift submm-selected galaxies using an integral field spectrograph with adaptive optics (OSIRIS/Keck). She attended Career Day at the Sandburg Middle School in Glendora, CA, as a guest speaker and gave two workshops at the 16th annual conference Adelante Mujer Latina, a daylong career and educational conference for young Hispanic women.

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Carnegie Fellow **Joshua Simon** gave an invited talk, "The nature of the least luminous galaxies" at the Darkness Visible conference at U. Cambridge on Aug. 5.

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Postdoctoral research associate **Christopher Burns** attended the 2010 Aspen Center for Physics Workshop, "Taking Supernova Cosmology into the Next Decade."

⓬ Andrew McWilliam

PLANT BIOLOGY

⓭ **Wolf Frommer** received an EAGER grant to develop biosensors using a microfluidic platform developed by Steve Quake, Stanford U. He was an invited speaker at ICAR in Yokohama on June 15-18, giving a talk on "High throughput analysis of membrane/signaling protein interactions in *Arabidopsis*."

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⓮ **Winslow Briggs** and **Bill Eisinger**, a visiting researcher, gave an invited talk at the American Society of Plant Biologists meeting in Montreal early in Aug. on cytoskeletal changes in guard cells during stomatal opening and closing.

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On June 1-2 **Arthur Grossman** attended a meeting of the Porphyra Genome Group held at Rutgers U. in New Jersey. During June 20-25 he was in Volterra, Italy, to attend the Plant Anaerobiosis meeting and gave a symposium talk titled "Metabolic circuits associated with anaerobic metabolism in *Chlamydomonas reinhardtii*." On Aug. 22-27 he attended the 15th International Congress of Photosynthesis held in Beijing and presented a symposium talk.

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Kathy Barton gave a plenary lecture titled "Understanding the network that controls ad/abaxial development in *Arabidopsis*" at the International Conference on *Arabidopsis* Research held in Yokohama on June 6-10. She also gave an invited talk on "Understanding the network that controls ad/abaxial development in *Arabidopsis*" and was session chair at the FASEB conference on plant development in Saxton's River, VT.

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Sue Rhee gave a plenary talk at 21st International Conference on Arabidopsis Research held on June 6-10 in Yokohama, titled "Integration of metabolomics, metabolic network, and gene function network for systematic gene function identification."

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⓯ **Zhiyong Wang** gave a talk on May 22 at the National Plant Proteomics symposium, Wuhan, China, titled "Proteomic studies of brassinosteroid signal transduction." On June 25, at the Institute of Plant Physiology and Ecology, CAS, Shanghai, he presented a talk, "Brassinosteroid signaling from a receptor kinase to a thousand target genes and plant growth." On June 30 he gave a plenary talk at the 20th International Plant Growth Substance Association (IPGSA) Conference, Tarragona, Spain, titled "Brassinosteroid signaling and plant growth regulation." In July he gave two talks, one on July 14 at the Chinese U. of Hong Kong on "Brassinosteroid signaling" and on July 15 a seminar at Hong Kong Baptist U., "Proteomic studies of brassinosteroid signal transduction." On Aug. 17 he attended the FASEB Conference on Mechanisms in Plant Development in VT and gave a talk, "Brassinosteroid signaling from a receptor kinase to a thousand target genes and many developmental processes."

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On June 6-10 **Eva Huala**, **Philippe Lamesch**, and **Donghui Li** attended the International Conference on *Arabidopsis* Research held in **Yokohama,** where Huala gave an invited talk on "New data and tools at TAIR (the Arabidopsis Information Resource)." On July 31-Aug. 4 **Kate Dreher** and **Philippe Lamesch** of the TAIR group attended Plant Biology 2010 held in Montreal.

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In July **Devaki Bhaya** was appointed to serve on the 2010 advisory board of the Metacyc database at the Stanford Research Inst. in Menlo Park, CA, and in Aug. she was appointed to the 2010 advisory committee on the Optogenetics Innovation Laboratory at BioX at Stanford U. In July she was an invited speaker at the 3rd annual meeting on Clustered Regularly Interspaced Short Palindromic Repeats and bacteriophage resistance held at UC-Berkeley. On June 13-18 she was an invited speaker at the Gordon Conference on Environmental Bioinorganic Chemistry held in Newport, RI.

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Tong-Seung Tseng, a postdoc in the Briggs's lab, presented a poster on factors interacting with phototropin 2, and Eisinger gave a poster on the stomatal studies. Briggs gave an invited lecture on June 25 at a retirement symposium for Eberhard Schäfer at U. Freiburg, Germany.

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Two Grossman lab graduate students, **Katherine Rose Marie Mackey** and **Wirulda (Nik) Pootakham**, successfully defended their Ph.D. theses. Pootakham left the lab shortly after for a research scientist position in the National Research Institution in Bangkok.

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Arrivals: Yongxian Lu joined the Evans lab on July 1 as a postdoctoral research associate from U. Maryland. The Frommer lab had two new arrivals: postdoctoral research associate **Nabila Aboulaich** (Linkoping U., Sweden) on June 1, and on July 1 **Fanglian He** (U. Pennsylvania) as a Carnegie Fellow.The Huala's TAIR group welcomed back two former members: **Aung-Kyaw Chi** returned on July 16 as a part-time curator and **Raymond Chetty** returned Aug. 3, after a stay in Japan, to resume his position as a programmer.

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Departures: Ken-Ichiro Hibara, a postdoctoral fellow funded by the Japanese government and a visiting researcher in the Barton lab, returned to Japan on June 17. Ph.D. student **Leonardo Magneschi** spent a year in the Grossman lab and returned to Italy on Aug. 30 to finish his degree with Pierdomenico Perata at Scuola Superiore. **Min Yuan**, a graduate student from Hebei Normal U., China, completed her term in the Wang lab and returned to China to complete her degree on Aug. 30. Also leaving the lab, student **Hui Yang**, returned to Gansu Academy of Sciences, China, on June 9. **Zhiping Deng**, a senior researcher in the lab, departed on June 22 to take up his new position in China. **David Gonzalez-Ballester**, a postdoctoral research associate in the Grossman lab, left on May 28 to take up his new position as a postdoctoral researcher at Cordoba U., Spain. **Thomas Meyer**, a software engineer in the TAIR group, left on Apr. 30 for *On Live* in Palo Alto. **Pinar Mutluoglu**, assistant to the director, departed on July 14.

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Plant Biology had a successful summer intern program welcoming high school students and undergraduate and graduate students from various colleges and universities. The Frommer lab welcomed **Paul Hichwa** in June and **Chloe Peters** in July; the Barton lab received **Jarrod Nixon** and **Steven Muenzen** in June and **Kimberly Pham** in July; Sue Rhee's lab trained **Julian Huang**, **Cherise Lau**, a returning intern from last year, and **Nathaniel Leu**, all starting in July; the Evans lab shared their space with **Duncan Oja**, **Sejal Parekh**, and **Jennifer Telschaw** starting in June; the Grossman lab welcomed **Daniele Ikoma**; and the Wang lab made room for **Andrew Ma**, another returning

FourStar Send-Off!

The FourStar near-infrared imager left for Magellan on August 18, 2010. Scott Rubel and Rob Pitts cut wood for bracing while Steve Wilson and Vince Kowal tied down crates and Robert Storts and Greg Ortiz were lining up the next items to load. It all took less than five hours.

Earl Harris and Sharon Kelly arranged to have the shipping container and a large forklift delivered on time and removed a day earlier than planned. Andy Monson wrote the manifest and devised the packing arrangement, and Greg built his usual fine boxes.

FourStar arrived in Chile about a month later and was on the mountain a few days after that. Telescope installation is scheduled for December 2010 after reassembly and testing.

Eris Persson (foreground) and Scott Rubel start the disassembly process.

Greg Ortiz and Scott Rubel lift the FourStar vacuum off the truck.

Images courtesy Andy Monson

⓭ Wolf Frommer

⓮ Winslow Briggs

⓯ Zhiyong Wang

⓰ Alan Boss

⓱ Paul Butler

intern from last year. The intern program was wrapped up by a very successful session of talks and poster presentations by the interns.

TERRESTRIAL MAGNETISM

Director **Sean Solomon** chaired a three-day meeting of the MESSENGER Science Team, held in June at MIT, and participated in a Systems Integration Review for the GRAIL mission to measure the lunar gravity field, held at Lockheed Martin Corp. in Denver that same month. In July he co-convened three special sessions on Mercury, and gave a presentation on MESSENGER mission results, at the 38th COSPAR Scientific Assembly held in Bremen, Germany. Later that month he delivered the Barringer Invitational Lecture at the American Museum of Natural History, as part of the 73rd Annual Meeting of the Meteoritical Society, held in New York City. In Aug. he attended a GRAIL Science Team meeting in Woods Hole, MA. In Sept. he participated in two MESSENGER Orbital Readiness Reviews held at the Applied Physics Laboratory in Laurel, MD, and he co-convened three special sessions on Mercury, and gave a presentation, at the 5th European Planetary Science Congress, held in Rome, Italy.

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⓰ In July **Alan Boss** reported to the NASA Advisory Council's Science Committee at NASA Headquarters on the Astrophysics Subcommittee meeting he chaired earlier that month. In Aug. Boss was interviewed on CBS Radio News about the discovery of an extrasolar planetary system that appears to have at least seven planets, and he spoke on National Public Radio's *Morning Edition* program about recent discoveries by NASA's Kepler Space Telescope. In Sept. Boss attended the 50th-anniversary celebration of the first search for extraterrestrial intelligence (SETI), undertaken with the 85-foot Tatel radio telescope in Green Bank, WV, named after DTM staff member Howard Tatel. Boss also was the moderator for a panel discussion on "Life in the Milky Way" at the SETI workshop.

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⓱ Traveling between Chile, Australia, and Hawaii, **Paul Butler** observed at a variety of telescopes including the Magellan, Anglo-Australian, and Keck. In Sept. he was interviewed for two episodes of *Sci Fi Science* on the Discovery Science Channel.

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John Chambers attended the National Capital Area Disks meeting at NASA Goddard Space Flight Center in June and presented a talk, "Stellar elemental abundances and planet formation."

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In June **Larry Nittler** taught a short course on presolar grains at the Universitat Politècnica de Catalunya in Barcelona, Spain. In July he was elected a fellow of the Meteoritical Society and gave a talk at the 11th Conference on Nuclei in the Cosmos in Heidelberg, Germany.

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Several DTM geochemists (**Rick Carlson**, **Jonathan O'Neil**, **Steve Shirey**) attended and presented talks at the Annual Meeting of the Geochemical Society, held this year in Knoxville, TN, June 14-18.

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On June 29 **Rick Carlson**, **Steve Shirey**, and **Tim Mock** hosted the Smithsonian-led Earth's History and Global Change Academy for K-12 teachers. About 15 teachers spent the afternoon at DTM listening to talks about the age of the Earth and its mineral resources and in a hands-on demonstration of age dating of the mineral zircon using the DTM laser ablation mass spectrometer.

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Jonathan O'Neil traveled to the 3.8-billion-year-old rocks in Isua, Greenland, for sampling and comparison with his study area of 4.3-billion-year-old rocks in northern Quebec. The two areas are composed of similar rock types likely representing some of the Earth's oldest oceanic crust.

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Rick Carlson, **David James**, and **Nick Schmerr** participated in the final High Lava Plains workshop held in Bend, OR, Sept. 13-15. This project involved installation of 106 seismometers in eastern OR to image the mantle structures that have given rise to the voluminous volcanism in this area over the past 40 million years. Following the workshop, Carlson and colleagues **Anita Grunder** of Oregon State U. and **Randy Keller** of U. Oklahoma traveled to Burns, OR, to give a presentation on the project at the Burns Public Library. Approximately 30 to 40 local citizens, out of a total population of 3,000, attended the presentation and stayed for an hour afterward to ask questions.

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Postdoctoral fellow **Nick Moskovitz** traveled to Taiwan, where he presented a poster on "Formation and evolution of differentiated planetesimals" in Taipei at the Western Pacific Geophysical Meeting. Not far off in Zhongli, Taiwan, he visited National Central U. and gave an additional invited talk focused on evidence for and formation of differentiated planetesimals.

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In Sept. postdoctoral fellow **Jonathan O'Neil** and staff member **Steve Shirey** gave invited talks at the 5th International Archean Symposium in Perth, Western Australia, which is a meeting held once every decade. Afterward they joined a postconference field trip across the Yilgarn Craton, looking at minerals and rocks whose ages range from 2.7 to 4.4 billion years.

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Visiting Investigator **Tetsuo Takanami** traveled to Japan in May to attend the Japan Geoscience Union Meeting 2010 and spoke on "A strain event related to aftershock activity following the 2003 Tokachi-oki earthquake (M8.0)" in collaboration with **Selwyn Sacks** and **Alan Linde**. In Aug. he visited the Inst. of Statistical Mathematics in Tokyo to talk on data processing for Sacks-Evertson strainmeters.

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At the 2010 Goldschmidt Conference, held in Knoxville, TN, in June, several DTM staff and postdoctoral fellows presented papers, including **Rick Carlson**, **Steve Shirey**, postdoctoral associate **Jonathan O'Neil**, and postdoctoral fellow **Nick Moskovitz**, who gave an invited talk on differentiated planetesimals.

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The 73rd Annual Meeting of the Meteoritical Society was held in New York City in July. DTM presenters included **Sean Solomon**, **Conel Alexander**, **Larry Nittler**, and postdoctoral fellows **Frank Gyngard** and **Ming-Chang Liu**.

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Visitors to the DTM geochemistry laboratory included students **Luc Doucet** from St. Etienne U. in France, who analyzed the Re-Os system in mantle xenoliths from a Siberian kimberlite, and **Gina Mosely**, who works with former DTM postdoc **Maria Schonbachler**, now a professor at U. Manchester. Ms. Mosely measured the Mn-Cr systematics of a variety of meteorites and their mineral components.

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Arrivals: Postdoctoral fellows **Lydie Bonal**, who received her Ph.D. from the Laboratoire de Planétologie de Grenoble, and **Christopher Stark**, who received his Ph.D. from U. Maryland, arrived at DTM in Aug. Arriving in Sept. were postdoctoral associate **Christian Miller**, who received his Ph.D. from the WHOI/MIT Joint Program, and postdoctoral fellow **Susan Benecchi**, who received her Ph.D. from MIT. **Eloise Gaillou**, formerly of the Smithsonian Inst., arrived as a visiting investigator in June and will transition to postdoctoral fellow in January 2011. **Tyler Bartholomew** began in June as a machinist apprentice. In Sept. **Stacey Santiago** joined DTM as administrative assistant.

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Departures: In Aug. postdoctoral fellow **Jessica Warren** left DTM to take an assistant professor post at Stanford, and postdoctoral fellow **Ming-Chang Liu** started a position as a visiting scientist at the Centre de Recherches Pétrographiques et Géochimiques in Nancy, France. In Sept. postdoctoral fellow **Nick Schmerr** began an ORAU Fellowship at NASA Goddard Space Flight Center, and **Natalia Gómez-Pérez** departed DTM to take a faculty position at the Universidad de los Andes in Colombia. Administrative assistant **Alicia Case** also departed in Sept. to pursue writing and teaching opportunities. ☐

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Whiter Clouds Could Mean Wetter Land

Image courtesy Ken Caldeira

Ken Caldeira

White clouds reflect more light than gray clouds. That's what makes them white, and that is also what has attracted the interest of researchers hoping to find a way to combat global warming. If the Earth's cloud cover were whiter, the planet would absorb less solar radiation, which could mitigate the warming driven by rising levels of greenhouse gases in the atmosphere.

Clouds become whiter when the water droplets that make them up get smaller. "Rain clouds, which have big droplets, tend to be gray and absorb sunlight, whereas clouds with smaller droplets tend to be white and fluffy and reflect more sunlight to space," said Ken Caldeira of the Department of Global Ecology. "In practice this could be done by shooting a fine spray of seawater high into the air, where the tiny salt particles would create condensation nucleii to form small cloud droplets."

But many researchers have been concerned that a cloud-whitening geoengineering scheme might wreak havoc with global rainfall patterns and cause widespread droughts. To test this possibility, Caldeira and Carnegie colleagues Long Cao, George Ban-Weiss, and Ho-Jeong Shin, with two other collaborators, used a global climate simulation in which atmospheric carbon dioxide was set at approximately twice present-day concentrations. Cloud droplets over the oceans in the model were made smaller to make the clouds more reflective. Clouds over land were unaltered. As expected, the whitened clouds reflected sunlight and offset the greenhouse warming from the high CO_2.

What surprised the researchers, however, was that the whitened oceanic clouds made the land surface wetter on average, not drier. Previous climate simulations had suggested that reducing solar radiation would reduce precipitation on land. "The drying of the continents has been a major concern with regard to geoengineering," says Caldeira. But in the model the runoff from the continents increased by 7.5% globally, with the effect being strongest in the tropics.

Why would more clouds over the oceans cause more rain on the continents? The researchers concluded that the whiter clouds changed large-scale air circulation patterns, creating patterns similar to the monsoons that control rainfall in much of Asia. "Monsoons occur when air masses over land are warmer than air masses over the ocean, and this draws in cool, moist air from over the ocean which then drops rain over the land," said Caldeira. In the simulations, the reflective oceanic clouds preferentially cooled the air over the oceans relative to land, setting up a monsoonal air flow.

Caldeira stresses that their study simulated an idealized situation and cannot be used to predict the actual rainfall patterns that geoengineering might produce. "An actual deployment would be much patchier than in our study, and the result would therefore be somewhat different. But our basic result calls into question previous assumptions about the impact of this geoengineering scheme. It merits further investigation." □

Geoengineering schemes that enhance reflective white clouds over the oceans could counteract global warming. New research suggests that such schemes could also cause some land areas to become wetter.