CarnegieScience

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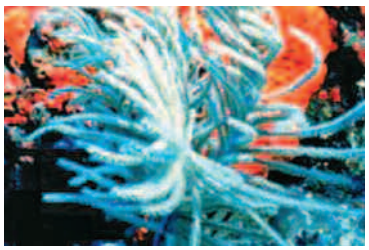
EMBRYOLOGY □ GEOPHYSICAL LABORATORY □ GLOBAL ECOLOGY □ THE OBSERVATORIES □
PLANT BIOLOGY □ TERRESTRIAL MAGNETISM □ CASE: CARNEGIE ACADEMY FOR SCIENCE EDUCATION

On the Inside



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LETTER FROM THE PRESIDENT

EMBRYOLOGY TURNS 100!

The Department of Embryology turns 100 years old this year and, in September, I had the pleasure of attending a symposium celebrating this important milestone. The department used the occasion to look back on its history and accomplishments. In true Carnegie style, however, the talks focused more on the future than the past. Speakers excitedly described their latest findings and their newest ideas, stimulating discussion that continued informally throughout the meeting.

Past Embryology researchers and those at the former Department of Genetics not only were giants in their respective fields, they defined those fields. The department's first director, Franklin Mall, established the still-classic Carnegie embryo collection—the foundation for embryological research around the world. Elizabeth Ramsey made unprecedented studies of the interactions among the fetus, the placenta, and the mother. A host of remarkable accomplishments were achieved by other Carnegie staff, including Nobel laureates Alfred Hershey and Barbara McClintock. And the remarkable advances continue to the present day. In 2006, former Carnegie investigator Andy Fire shared a Nobel prize for his work at Carnegie on RNA interference.

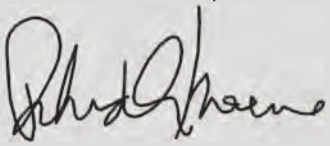
It is a wonder that the intentionally small scientific staff at Embryology, now nine individuals, has delivered a completely outsized impact. The department's success is a validation of Andrew Carnegie's vision that exceptional individuals, if given support and scientific freedom, would accomplish exceptional things. Over the century, the department has hired creative and skilled scientists and provided them with the environment and the encouragement to pursue bold new ventures that were off the beaten track. The results are nothing short of astounding.

I was particularly struck by the contagious enthusiasm of the 200 or so alumni and staff who attended the centennial celebration. Almost to a person, they recounted that their experience at Carnegie molded them and shaped their careers. Former Carnegie researcher Doug Koshland, now a professor at UC-Berkeley, remarked that Carnegie is distinctive both in the quality of the science and in the quality of its people. Former postdoc Shannon Fisher, now at the University of Pennsylvania, explained that Carnegie's atmosphere encouraged her to be adventurous in the pursuit of interesting questions. Geraldine Seydoux, now a Johns Hopkins professor, said that many of the wonderful things that have happened in her life started with a letter inviting her to join Carnegie. Nipam Patel, a Carnegie staff associate in the 1990s and now at UC-Berkeley, noted that the best decision he ever made was to follow advice from Gerry Rubin, a former Carnegie staff member now running HHMI's Janelia Farm, that he should join Carnegie.

As reflected by the attendees, the alumni of the department are highly regarded researchers at many prestigious institutions, including Stanford, NIH, Yale, UC-Berkeley, and elsewhere. Former director Don Brown observed that he had learned to take comfort in the fact that Carnegie staff were always being recruited by other institutions. Director Allan Spradling, in turn, remarked that the department could be thought of as a stem cell, its graduates as transit amplifying cells, and their students and colleagues as downstream cells.

I believe that Andrew Carnegie would be pleased to see that his vision of support for exceptional individuals has served to strengthen science well beyond our borders. He would be profoundly proud to see that his institution has indelibly influenced great minds around the world.

Richard A. Meserve, *President*



Superconducting Surprise

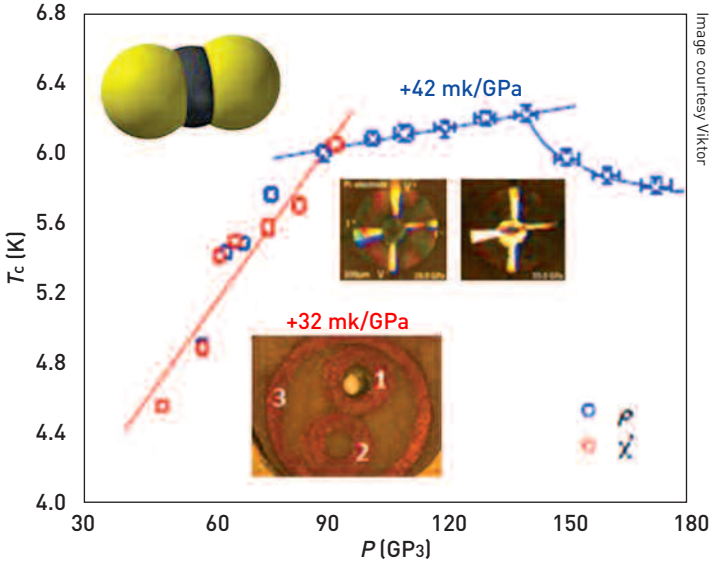


Image courtesy Viktor

Electrical contacts (inset in the middle) and electromagnetic coils (inset at the bottom) measured pressure dependence of the transition temperature to a superconducting state of a metal created by the team from a carbon disulfide molecule (top left).

Superconductivity is a rare physical state in which matter is able to conduct electricity, i.e., maintain a flow of electrons, without any resistance. This phenomenon is only found in certain materials under specific low-temperature and high-pressure conditions. Research to create superconductors at higher temperatures has been ongoing for two decades, with the promise of significant impact on electrical transmission.

Research from a team including Carnegie's Viktor Struzhkin, Takaki Muramatsu, and Stanislav Sinogeikin found unexpected superconductivity in the solid form of a compound called carbon disulfide, CS_2 which is sometimes used in liquid form as a chemical solvent or insecticide. The research could help scientists better understand the structural changes that create this rare phenomenon.

The team found that carbon disulfide enters a superconducting state at about -449°F (6.2°K) at pressures ranging from about 493,000 to about 1,698,000 times normal atmospheric pressure (50 to 172 gigapascals).

Their findings seem counter to the understanding of how superconductivity normally works. Usually, but not always, superconductivity is present in highly ordered molecular structures. But superconductivity in carbon disulfide arises from a highly disordered state. Even more surprising, this disordered structure is preceded by a magnetically ordered state, which disappears when the material undergoes a structural change into the disorganized configuration and superconductivity starts. □

Proceedings of the National Academy of Sciences published their work.

The National Science Foundation's Division of Materials Research, the Defense Threat Reduction Agency, the Deep Carbon Observatory's Extreme Physics and Chemistry, and the Department of Energy's Basic Energy Sciences supported this work.

Trustee News

Flying Tours

The Carnegie Airborne Observatory (CAO) team, led by Global Ecology's Greg Asner, hosted two days of tours for supporters and friends. The guests were treated to an airborne demonstration flight over the San Francisco Bay area to show how the CAO collects data to uncover the chemistry and structure of the ecosystem below. □

▲ Carnegie trustee Will Hearst (back right), long-time supporter of the CAO, enjoyed the demonstration with trustee Mike Long (front left).

◀ Supporter Len Baker (back right) asks questions about the CAO's operations.

◀ Greg Asner (left) describes some of what goes into the airborne observatory with Carnegie friend and supporterTom Steyer (right) and Steyer's colleague Ted White (middle).

Images courtesy Greg Asner, CAO

No Stem Cells for New Eggs

Female mammals ovulate throughout their reproductive lifetimes, placing significant demands on their ovaries to produce eggs. The question of whether mammals generate new eggs in adulthood using stem cells has been controversial. If true, these "germ-line stem cells" might allow novel treatments for infertility and other diseases. New research from Carnegie's Lei Lei and Allan Spradling surprisingly shows that adult mice do not use stem cells to produce new eggs. The *Proceedings of the National Academy of Sciences* published this work in April.

Before birth, mouse and human ovaries contain an abundant supply of germ cells, some of which will develop into the eggs that will ultimately be released from follicles during ovulation. Around the time of birth these germ cells have formed a large reserve of primordial follicles—each containing a single immature egg. Evidence of new follicle production is absent after birth, so researchers have long believed that the supply of follicles is fixed at birth and eventually runs out, leading to menopause.

During the last decade, some researchers have claimed that primordial follicles in adult mouse ovaries turn over and that females use adult germ-line stem cells to constantly resupply the follicle pool and sustain ovulation. These claims were based on subjective observations of ovarian tissue and on the behavior of extremely rare ovarian cells following extensive growth in tissue culture, a procedure that is capable of "reprogramming" cells.

Lei and Spradling used a technique that allows individual cells and their progeny within a living animal to be followed over time by marking the cells with a new gene. This general approach, known as lineage tracing, has been a mainstay of classical developmental biology research and has greatly clarified knowledge of tissue stem cells during the last decade.

Lei and Spradling's research shows that primordial follicles are highly stable and that germ-line stem cell activity cannot be detected, even in response to the death of half of the existing follicles. Their research placed a stringent upper limit on stem cell activity that could exist in the mouse ovary and escape detection—no more than one stem cell division every two weeks, which is an insignificant level.

What about the rare stem-like cells generated in cultures of ovarian cells? According to Spradling, these cells "likely arise by dedifferentiation in culture," and "the same safety and reliability concerns would apply as to any laboratory-generated cell type that lacks a normal counterpart" in the body. □

Lei Lei

Allan Spradling

"The question of whether mammals generate new eggs in adulthood using stem cells has been controversial."

The Howard Hughes Medical Institute provided funding for this research.

Saving Reefs: Major Changes Needed

Ricke and Caldeira's research shows that there is a good possibility that in 100 years no ocean conditions will remain hospitable to shallow-water coral reefs, such as this one in the Florida Keys National Marine Sanctuary.

Deep cuts in carbon dioxide emissions are required to prevent coral reefs around the world from dying off, according to a study from Carnegie's Katharine Ricke and Ken Caldeira. They found that all existing coral reefs will be engulfed by inhospitable ocean chemistry conditions by the end of the century if civilization continues along its current emissions trajectory.

Coral reefs are havens for marine biodiversity, and they underpin the economies of many coastal communities. But these reefs are very sensitive to changes in ocean chemistry resulting from greenhouse gas emissions, as well as to coastal pollution, warming waters, overdevelopment, and overfishing. Ricke and Caldeira focused on the acidification of open ocean water surrounding coral reefs and how it affects a reef's ability to survive.

Coral reefs use a mineral called aragonite to make their skeletons. This mineral is a naturally occurring form of calcium carbonate, $CaCO_3$. When the ocean absorbs carbon dioxide, CO_2, from the atmosphere, it forms carbonic acid—making the ocean more acidic and decreasing the ocean's pH levels. This increase in acidity makes it more difficult for many marine organisms to grow their shells and skeletons and threatens coral reefs the world over.

Coral reefs such as this one in Fiji are havens for marine biodiversity and underpin the economies of many coastal communities.
Images by Julie Bedford courtesy NOAA

Ken Caldeira

Katharine Ricke

Ricke, Caldeira, and their co-authors worked with results from simulations that were conducted using an ensemble of sophisticated models. They calculated ocean chemical conditions that would occur under different future scenarios and determined whether or not these chemical conditions could sustain coral reef growth.

Their results show that if our current emissions path continues then by the end of the century there will be no water left in the ocean with the chemical properties that have supported coral reef growth in the past. They can't say with 100% certainty that all shallow-water coral reefs will die, but they think this is a likely result.

Deep cuts in emissions are necessary in order to save even a fraction of existing reefs, according to the team's results. Chemical conditions that can support coral reef growth can be sustained only with very aggressive cuts in carbon dioxide emissions. □

Environmental Research Letters published their work in July.

The U.S. Department of Energy provided support to the World Climate Research Programme's Coupled Model Intercomparison Project, which developed a software infrastructure in partnership with the Global Organization for Earth System Science Portals.

Artist's conception of a blazar
Image used courtesy NASA/JPL-Caltech

BEFUDDLING BLAZAR

Michele Fumagalli

Blazars are the brightest of active galactic nuclei, and many emit very high-energy gamma rays. New observations of a blazar known as PKS 1424+240 show that it is the most distant known source of very high-energy gamma rays. But its emission spectrum is highly unusual.

A team including Carnegie's Michele Fumagalli used data from the Hubble Space Telescope to set a lower limit for the blazar's redshift ($z \geq 0.6035$). An object's redshift value is a measurement of how much the wavelength of its light that reaches the Earth is stretched by the expansion of the universe; it reveals the object's age and distance. This blazar's redshift corresponds to a distance of at least 7.4 billion light-years.

Researchers thought that such high-energy gamma-ray sources could not be seen at such great distances. Extragalactic background light (EBL) is the diffuse radiation from all stars and galaxies, a dim but pervasive glow that fills the universe. When a high-energy gamma-ray photon collides with a lower-energy EBL photon, they annihilate each other and create an electron-positron pair. The farther the gamma rays have to travel, the more likely they are to be absorbed by this mechanism. This limits the distance to which sources of very high-energy gamma rays can be detected.

Considering PKS 1424+240's distance, a substantial proportion of its gamma rays should be absorbed by the EBL. The team's findings may indicate something new about the emission mechanisms of blazars, the EBL, or the propagation of gamma-ray photons over long distances. Their research should allow scientists to better understand cosmological models that predict the EBL.

Measuring the EBL directly is extremely difficult because there are many bright sources of light in our immediate neighborhood. In addition to estimates based on cosmological models, astronomers have used galaxy counts to set a lower limit for the EBL. Using a model close to this lower limit to calculate the expected absorption of very high-energy gamma rays from PKS 1424+240, the team derived an intrinsic gamma-ray emission spectrum for the blazar. The results, however, deviate from the expected emission based on current blazar models, which are thought to result from a relativistic jet of particles powered by matter falling onto a supermassive black hole at the center of the host galaxy. □

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The Astrophysical Journal Letters published their work.

NASA provided support through grants awarded from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., for NASA; the National Science Foundation award PHY-0970134; NASA grants NNX08AC146 and NAS5-98043 to the University of Colorado at Boulder; NASA/Fermi grants GO-31089 and NNX12AF12GA; NSF grant AST-1211916; the Christopher R. Redlich Fund; the TABASGO Foundation; and NASA Hubble Fellowship grant HF-51305.01-A.

The Katzman Automatic Imaging Telescope and its ongoing operation are made possible by donations from Sun Microsystems, Inc., the Hewlett-Packard Company, AutoScope Corporation, the Lick Observatory, the National Science Foundation, the University of California, the Sylvia and Jim Katzman Foundation, and the TABASGO Foundation.

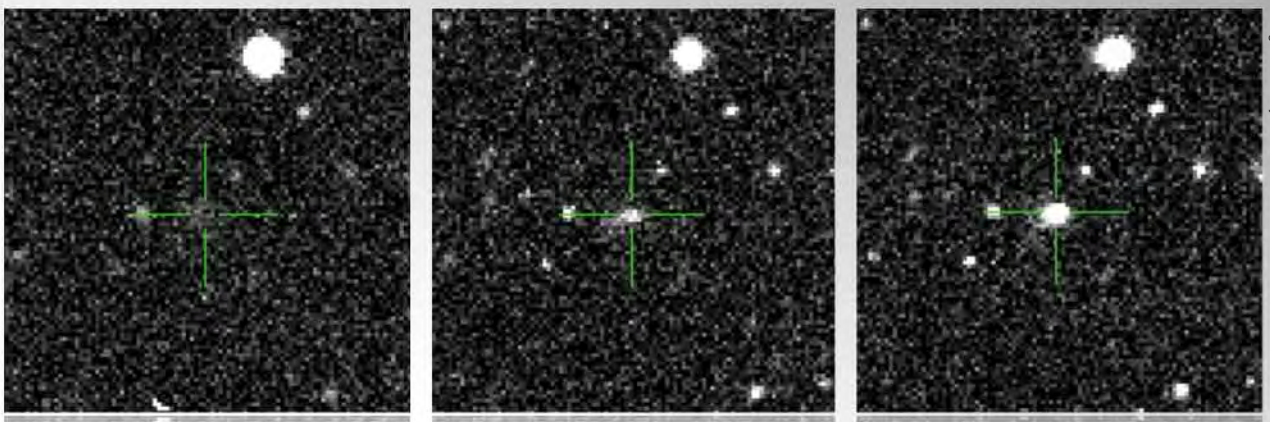


Image courtesy Mansi Kasliwal

These images depict three stages in a supernova's life—quiet, eruption, and explosion.

Caught in the Act

Type II supernovae are formed when massive stars collapse, initiating giant explosions. Researchers believe that stars emit a burst of mass as a precursor to that explosion. A better understanding of that emission process could help scientists predict and study supernova events in their earliest stages. Several models for the supernova creation process predict pre-explosion outbursts, but it has been difficult for scientists to directly observe this process.

Mansi Kasliwal

Researchers believe emission lines that radiate from Type IIn supernovae represent interactions between the mass ejected during and prior to the star's explosion. New observations from a team of astronomers including Carnegie's Mansi Kasliwal show a remarkable mass-loss event about a month before the explosion of a Type IIn supernova.

The Palomar Transient Factory team, including Kasliwal, observed an energetic outburst from Type IIn supernova SN2010mc that radiated at least 6×10^{40} joules of energy and released about 2×10^{28} kilograms (one hundredth of a solar mass). This mass-loss was observed 40 days before the supernova exploded.

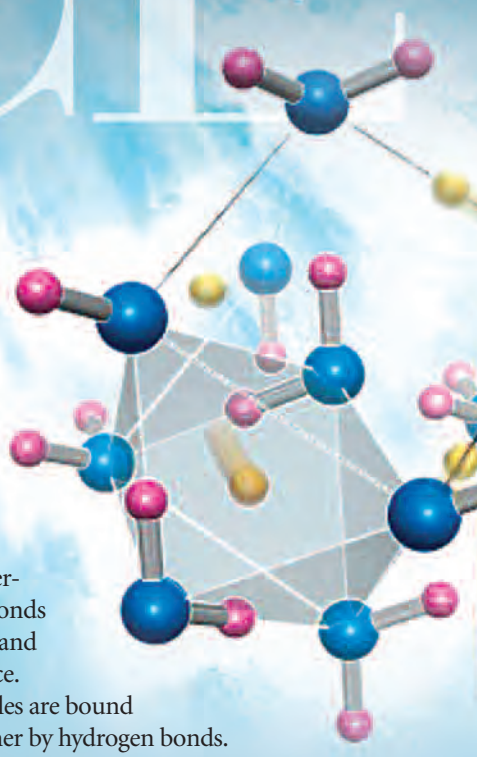
Probability modeling showed that there was only a 0.1 percent chance that the outburst was due to random chance, indicating that the outburst and the explosion were likely causally related. At the very least, such outbursts are two orders of magnitude more likely to occur in the immediate run-up to the star's explosion than at other times in a star's life.

The team compared their observations to three proposed models for the mechanism by which this mass is ejected. They found one model that provided the best match: The high velocities lend credence to the idea that the mass is driven out to the envelope that forms the star's atmosphere by the propagation and dissipation of excited gravity waves. More work is necessary to confirm this model. □

Nature published their work in February.

The Very Large Array is operated by the National Radio Astronomy Observatory, a facility of the National Science Foundation (NSF) operated under cooperative agreement by Associated Universities, Inc. This paper is based on observations obtained with the Samuel Oschin Telescope as part of the Palomar Transient Factory project. The authors acknowledge support from the Arye Dissentshik Career Development Chair; the Helen Kimmel Center for Planetary Science; the Israeli Ministry of Science, Technology, and Space; the Royal Society; NSF; the Israel Science Foundation; the German-Israeli Foundation for Scientific Research and Development; European Research Council; the U.S. Department of Energy; Gary and Cynthia Bengier; the Richard and Rhoda Goldman Fund; the Christopher R. Redlich Fund; and the TABASGO Foundation.

ICE Under Pressure



In this fragment of the crystal structure of the new ice, the oxygen atoms are blue and the molecular hydrogen atoms pink. Hydrogen atoms that have been pulled off the water molecules are gold. These appear to locate in polyhedral voids in the oxygen lattice (one of which is shaded light grey). Previously, these voids were believed to remain even after the water molecule broke up under enormous pressures.
Image courtesy Oak Ridge National Laboratory

Malcolm Guthrie is working in the Oak Ridge National Laboratory facility.

Image courtesy Malcolm Guthrie

Using revolutionary new techniques, a team led by Carnegie's Malcolm Guthrie has made a striking discovery about how ice behaves under pressure, changing ideas that date back almost 50 years. Their findings, published in the *Proceedings of the National Academy of Sciences*, could alter our understanding of how the water molecule responds to conditions found deep within planets and could have implications for energy science.

When water freezes into ice, its molecules are bound together in a crystalline lattice held together by hydrogen bonds. Hydrogen bonds are highly versatile and, as a result, crystalline ice reveals a striking diversity of at least 16 different structures.

In all of these forms of ice, the simple H_2O molecule is the universal building block. In 1964 researchers predicted that, under sufficient pressure, the hydrogen bonds could strengthen to the point where they might actually break the water molecule apart. The possibility of directly observing a disassociated water molecule in ice has lured scientists and driven extensive research for the last 50 years. In the mid-1990s several teams, including a Carnegie group, observed this transition using spectroscopic techniques. However, they were indirect and only revealed part of the picture.

A preferred method is to "see" the hydrogen atoms, or protons, directly. This can be done by bouncing neutrons off the ice and then carefully measuring how they are scattered. However, applying this technique at high enough pressures to see the water molecule dissociate had simply not been possible in the past. Guthrie explained, "you can only reach these extreme pressures if your samples of ice are really small. But, unfortunately, this makes the hydrogen atoms very hard to see."

In 2006 the Spallation Neutron Source opened at Oak Ridge National Laboratory in Tennessee, providing a new and intensely bright supply of neutrons. By designing a new class of tools that were optimized to exploit this unrivalled flux of neutrons, Guthrie and his team—Carnegie's Russell Hemley, Reinhard Boehler, and Kuo Li, as well as Chris Tulk, Jamie Molaison, and António dos Santos of Oak Ridge National Laboratory—obtained the first glimpse of the hydrogen atoms themselves in ice at unprecedented pressures of over 500,000 times atmospheric pressure.

"The neutrons tell us a story that the other techniques could not," said Hemley. "The results indicate that dissociation of water molecules follows two different mechanisms. Some of the molecules begin to dissociate at much lower pressures and via a different path than was predicted in the classic 1964 paper."

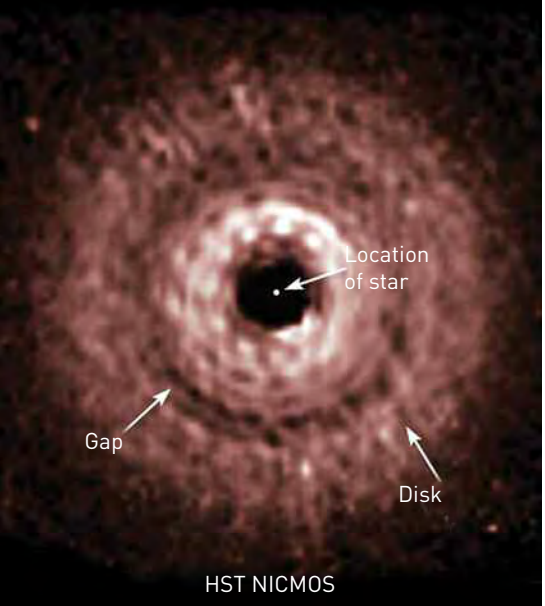
"Our data paints an altogether new picture of ice," Guthrie commented. "Not only do the results have broad consequences for understanding bonding in H_2O, the observations may also support a previously proposed theory that the protons in ice in planetary interiors can be mobile even while the ice remains solid." □

The group is part of Energy Frontier Research in Extreme Environments (EFree), an Energy Frontier Research Center headquartered at Carnegie's Geophysical Laboratory. EFree is funded by the U.S. Department of Energy (DOE), Office of Science, Office of Basic Energy Sciences (BES). The Scientific User Facilities Division, Basic Energy Sciences, DOE supported the research conducted at the Spallation Neutron Source, Oak Ridge National Laboratory.

Exoplanet Formation Surprise

A team of researchers has discovered evidence that an extrasolar planet may be forming particularly far from its star—about twice the distance between Pluto and the Sun. The planet lies inside a dusty, gaseous disk around the small red dwarf star TW Hydrae, which has about 55% of the Sun's mass. This discovery adds to the ever-increasing variety of planetary systems in our galaxy.

This dusty protoplanetary disk is the closest one to us, some 176 light-years away in the constellation Hydra. The astronomers used the Hubble Space Telescope to observe it over a wide range of wavelengths and modeled the color and structure of the disk in a way that has not been done before. They found a partial gap in the disk, at about 80 astronomical units (AU) (1 AU is the distance between Earth and the Sun). Their models indicate that this depression is about 20 AUs wide, just slightly wider than necessary for a planet-opening gap and consistent with a planet of between 6 and 28 Earth masses. The feature is seen at all wavelengths; the team believes it is a planet-formation gap.



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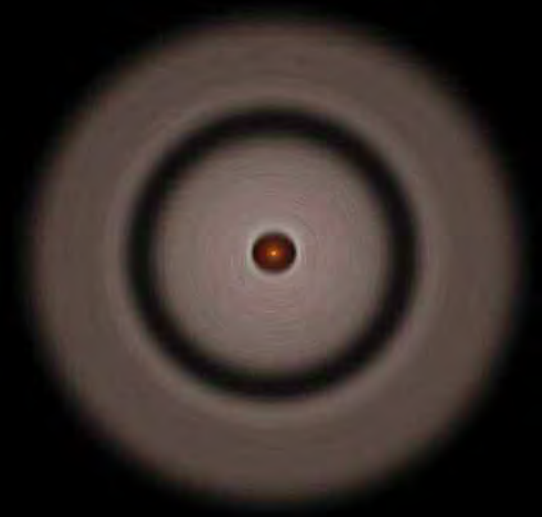


Illustration

TW Hydrae Disk
Hubble Space Telescope - NICMOS

This NASA image and artwork shows the location of a gap, believed to be from a forming planet that is collecting the material in the disc around the small red dwarf star TW Hydrae. It is the farthest-forming planet from its star thus far found.
Images courtesy NASA/ESA

"TW Hydrae is between 5 and 10 million years old; it should be in the final throes of planet formation before its disk dissipates," remarked Carnegie coauthor Alycia Weinberger, principal investigator of the observations. "It is surprising to find a planet only 5% to 10% of Jupiter's mass forming so far out. Planets should form faster closer in. In all planet formation scenarios, it's difficult to make a low-mass planet far away from a low-mass star."

Carnegie's Alycia Weinberger was the principal investigator for the observations.
Image courtesy Alycia Weinberger

The astronomers' goal was to understand whether planets have formed, what conditions can result in planet formation, and what chemicals are available for new planets. Models by coauthor Hannah Jang-Condell, a former Carnegie postdoctoral researcher, showed that the disk was brighter than expected, which indicates that very small dust grains are being lifted high above the midplane. This is surprising because observations with radio telescopes have previously shown that the disk contains dust that has conglomerated into pebbles.

Weinberger designed the observations to be able to detect large water ice grains in the surface layer of the disk. These grains weren't seen, which probably means that they have grown and sunk to the midplane of the disk where they can aggregate into water-rich planets.

Planet formation far away from a small parent star is at odds with conventional planet-making dogma. Under the most accepted scenario, planets form over tens of millions of years from the slow accretion of dust, rocks, and gas. That happens most easily close to the central star, where orbital timescales are short. Even under a disk instability scenario, in which planets can collapse quickly from the disk, it's not clear such a low mass planet could form.

Carnegie astrophysicist Alan Boss, who works on disk instability models, said, "If the mass of this suspected planet is as low as it seems to be, this presents a real puzzle. Theory would say that it cannot exist!"

Lead author of the study, John Debes of the Space Science Telescope Institute and also a former Carnegie postdoctoral researcher remarked, "Typically, you need pebbles before you can form a planet. So, if there is a planet in the gap and there is no dust larger than a grain of sand farther out, we have provided a challenge for traditional planet-formation models." □

The *Astrophysical Journal* published this research, authored by John Debes, Hannah Jang-Condell, Alycia Weinberger, Aki Roberge, and Glenn Schneider. NASA, through the Space Telescope Science Institute, operated by the Association of Universities for Research in Astronomy, Inc. under contract NAS 5-26555, provided support for this work. Debes, Jang-Condell, and Roberge are all former Carnegie postdoctoral fellows.

The brainchild behind the Carnegie Airborne Observatory is Greg Asner. He is posing with instrumentation aboard the craft.
Image courtesy CAO

FIRST NATIONAL CARBON MAP

Image courtesy Robin Kempster

For the first time, a team of researchers led by Greg Asner has mapped in high fidelity the aboveground carbon density of an entire country. The team integrated field data with satellite imagery and high-resolution airborne Light Detection And Ranging (LiDAR) data to map the vegetation and to quantify carbon stocks throughout the Republic of Panama. This nation has complex landscapes, with variable topography, and diverse ecosystems (ranging from grasslands and mangroves to shrublands and dense forests). As a result, Panama is an ideal laboratory to develop and test a method for quantifying aboveground carbon.

The researchers' results are the first maps that report local carbon stocks in areas as small as a hectare (2.5 acres). Their system has the lowest demonstrated uncertainty of any carbon-counting approach yet—a carbon-estimation uncertainty of only about 10% in each hectare overflown with LiDAR, as compared to field-based estimates. Importantly, the approach can be used across a wide range of vegetation types worldwide and can access millions of hectares in a short time.

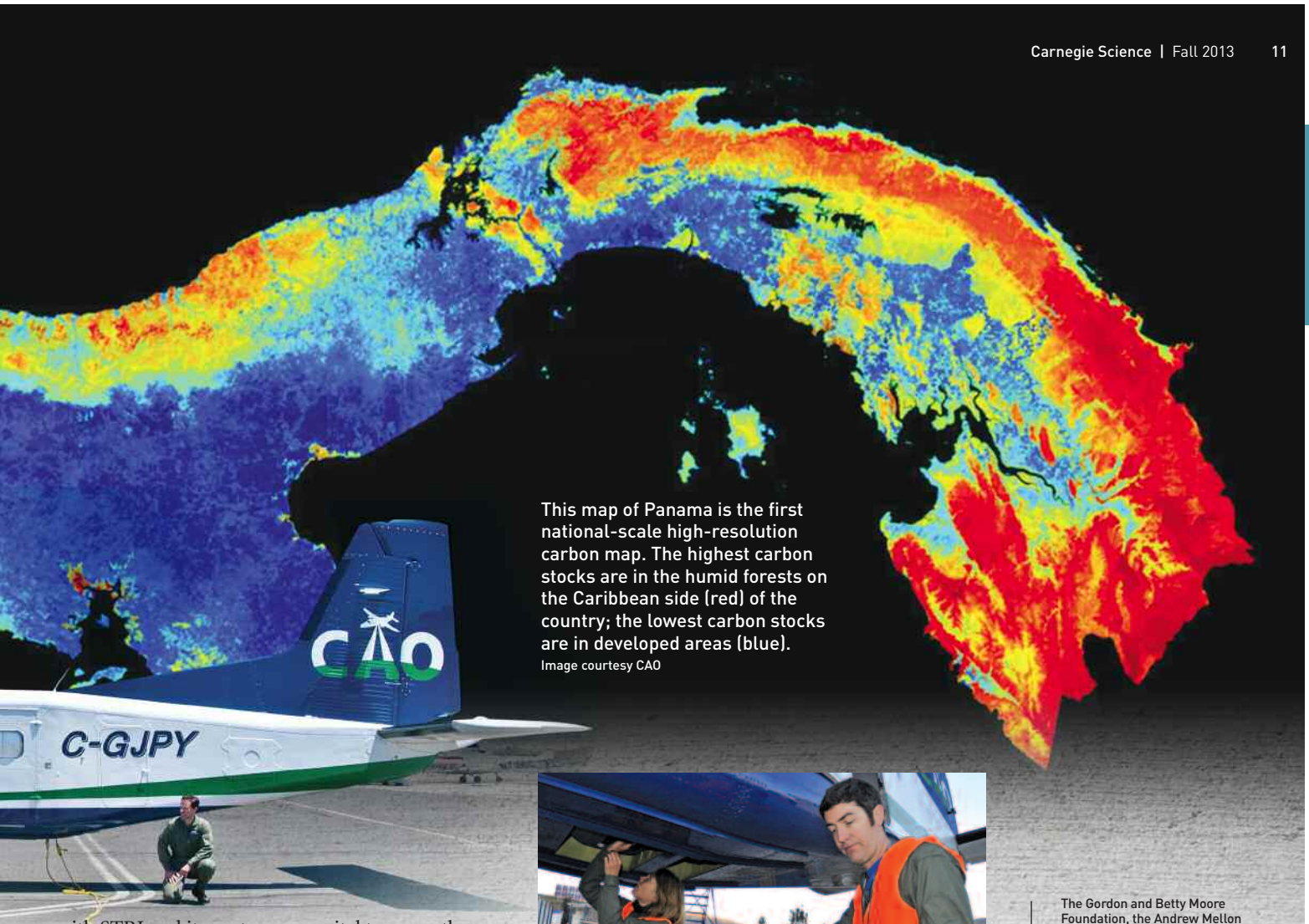
This new mapping system, described in *Carbon Balance and Management,* will greatly boost conservation and efforts to mitigate climate change through carbon sequestration. It will also help our understanding of how carbon storage can be used to assess other fundamental ecosystem characteristics, such as hydrology, habitat quality, and biodiversity. The approach provides much-needed technical support for carbon-based economic activities, such as the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD) program in developing countries.*

Asner, commented: "Three things make this national-scale study unique. First, Panama is an outstanding place for testing carbon-mapping approaches due in part to the long-term forest studies that have been undertaken by our partners at the Smithsonian Tropical Research Institute (STRI). Second, we have applied the very latest techniques using high-performance instrumentation, resulting in demonstrably high accuracy at fine spatial resolution. And third, the partnership permitted us to estimate our errors in a novel way, and we did so over every point on Panamanian soil."

Carnegie and STRI researchers worked with scientists from McGill University and the University of California-Berkeley to combine measurement methods—an extensive and essential network of ground-based plot sampling, satellite imagery, and LiDAR measurements from the Carnegie Airborne Observatory—to achieve this unprecedented accuracy.

LiDAR uses reflected laser light to image vegetation canopy structure in 3-D. The scientists calibrated the LiDAR measurements—taken at one-meter resolution throughout nearly one million acres (390,000 hectares)—to the known carbon density of 228 regional field plots, as established and sampled by the collaborating scientists. They used 91other plots to validate the LiDAR's aboveground carbon density estimates.

"Rarely has such a large number of field plots been available to validate LiDAR calibration independently," remarked Asner. "Our collaboration



This map of Panama is the first national-scale high-resolution carbon map. The highest carbon stocks are in the humid forests on the Caribbean side (red) of the country; the lowest carbon stocks are in developed areas (blue).
Image courtesy CAO

with STRI and its partners was vital to assess the accuracy of what we achieved from the air."

Traditional carbon monitoring has relied upon on-the-ground sampling of field plots, but this approach usually represents just small areas of land and is time-consuming. "There has been growing interest in using satellite imagery to cover larger areas, but it is low resolution both spatially and in terms of the structural information about the vegetation," described Carnegie author Joseph Mascaro. "In some parts of Panama, different global methods disagree by more than 100% at square-kilometer scale."

This is where the airborne LiDAR comes in: It directly probes the ecosystem's physical structure, which Carnegie scientists have repeatedly proven to be tightly linked to tropical carbon stocks. These measurements are the bedrock for mapping and estimating the amount of carbon locked up in plants, from dense forests to shrublands. The researchers were able to scale up the plot and LiDAR data with freely available satellite data on topography, rainfall, and vegetation to model carbon stocks at the national level.

The LiDAR and satellite combination was able to account for variations in the carbon pattern arising from differences in elevation, slope, climate, and

The observatory's instruments are mounted so that they can peer through a hole in the bottom of the airplane.
Image courtesy CAO

fractional canopy cover over the entire country. For instance, the scientists found that the highest carbon levels are in humid forests on the Caribbean side of Panama, often exceeding 110 tons of carbon per hectare. In contrast, large regions were deforested to very low carbon levels, such as in the developed regions outside the protected watershed of the Panama Canal.

Human activity is the overwhelming driver of carbon stock patterns in Panama.

"Panama is one of the first UN-REDD partner countries, and these new maps put the country at the forefront of high-resolution ecosystem management," said co-author and STRI's director Eldredge Bermingham. "The new carbon mapping approach could be the model for other tropical nations." □

The Gordon and Betty Moore Foundation, the Andrew Mellon Foundation, the Grantham Foundation for the Protection of the Environment, the Avatar Alliance Foundation, the John D. and Catherine T. MacArthur Foundation, the W. M. Keck Foundation, the Margaret A. Cargill Foundation, Mary Anne Nyburg Baker and G. Leonard Baker, Jr., William R. Hearst III, and Tom Steyer and Kat Taylor make the Carnegie Airborne Observatory (CAO) possible. The research reported in this article was based on funding to the CAO and a Grantham Foundation for the Protection of the Environment grant to the Smithsonian Tropical Research Institute (STRI), in addition to Grantham funding for the CAO, SIGEO/ForestGEO funds from the Smithsonian Institution and STRI, and support to the CAO Panama project from William R. Hearst III.

*The objective of UN-REDD is to create a financial incentive for developing countries to protect their forest resources in order to offset increasing carbon emissions. By creating financial value for the carbon stored in trees, the aim is to protect standing forests.

Watch the Carnegie Airborne Observatory make the world's highest resolution carbon map of Panama in less than one minute at **http://www.youtube.com/watch?v=_fQwv4coRR8**

▲ Dianne Williams peers through a microscope in the museum that was set up for the festivities. A recreated historical sketch from one of the early *Contributions to Embryology* volumes accompanies the exhibit.

▲ Carnegie alumnus and senior trustee Steven McKnight (right) chats with other participants at a coffee break during the symposium.

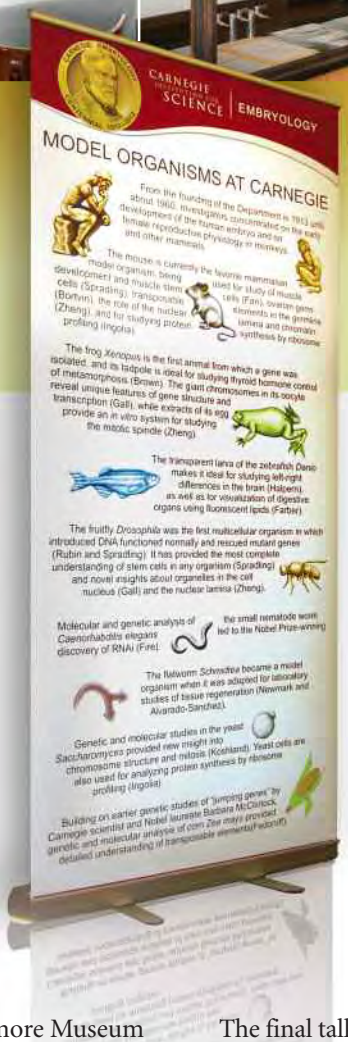


Image courtesy Christine Pratt

Embryology's Maxine Singer Building was decorated with panels showcasing their history. Choosing the right model organisms was a topic at the symposium and featured on this poster.

▲ A symposium participant looks at the embryo model exhibit set up for the centennial at the Maxine Singer Building.

▲ A celebratory cake featured words that alumni thought represented their experience at Embryology, including "bold," "unconventional," and "inspiring."

A Century of Discovery at Embryology

by TAGIDE DECARVALHO

To celebrate their 100th anniversary, the Department of Embryology annual mini-symposium was expanded into a two-day event. Traditionally the symposium is organized by postdoctoral fellows who invite scientists at the forefront of diverse fields. This year, the 31st symposium—the "Biology of Sex," was preceded by a special alumni symposium to commemorate the centennial.

The centennial symposium took place at the Baltimore Museum of Art. Carnegie president, Richard Meserve, and former president, Maxine Singer, gave opening remarks. Then, Embryology alumni spoke about choosing the "right" biological system to answer their questions. Joseph Gall, staff member emeritus, talked about his research spanning six decades with over 50 different organisms. Using the roundworm, Geraldine Seydoux, professor at The Johns Hopkins University School of Medicine, described how a fertilized egg determines which cells become specialized reproductive germ cells. UC- Berkeley's Douglas Koshland uses yeast genetics to understand desiccation tolerance, while Igor Dawid, investigator at the National Institute of Child Health and Human Development (NICHD), spoke of gene expression in the African clawed frog during his term from 1962-1978.

Later, Shannon Fisher, assistant professor at the University of Pennsylvania, and staff associate Christoph Lepper, recounted their experience as trainees who were encouraged to develop independent research programs, the hallmark of "Carnegie Style Science."

The afternoon session focused on new technology with ties to the department. Gerald Rubin, director of Janelia Farm Research Campus, showed how transgenic fruit flies provide insights into the brain, while Jennifer Lippincott-Schwartz, investigator at NICHD, discussed engineered fluorescent proteins for imaging cells. Senior trustee Steven McKnight, chairman of the Biochemistry Department at UT-Southwestern, discussed protein regions that can trap molecules.

The final talks were from alumni who forged new research fields. Philip Beachy, professor at Stanford University School of Medicine, discovered a cell-signaling pathway. Haifan Lin implicated molecules of small RNAs in stem cell self-renewal. Both projects could lead to new cancer therapies.

For insights into the evolution of development, Alejandro Sánchez-Alvarado, professor at the University of Utah, probes the highly regenerative flatworm, and Nipam Patel, professor at UC-Berkeley, examines diverse crustacean species. Donald Brown, a staff member since 1960 and director from 1977-1993, ended the day with a perspective.

The Maxine Singer Building showcased the department's history and its current programs. A temporary museum displayed artifacts on loan from the National Museum of Health and Medicine including specimens and plaster models demonstrating the stages of human development. The centennial was capped by a dinner at the Scottish Rite Masonic Center in Baltimore. □

Where is the MOON'S Water From?

Water is perhaps the most important molecule in our solar system. Figuring out where it came from and how it was distributed within and among the planets can help scientists understand how planets formed and evolved. Research from a team including Carnegie's Erik Hauri demonstrates that water from the interiors of the Earth and Moon has a common origin.

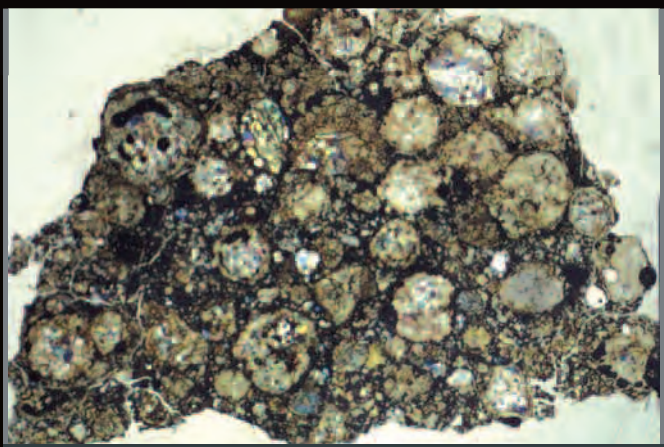
The Moon is thought to have formed from a disc of debris left after a Mars-sized object hit the Earth 4.5 billion years ago, forming the Moon in an event called the Giant Impact. Scientists have estimated that the heat from an impact of that size would cause hydrogen and other volatile elements to boil off into space, meaning the Moon must have started off completely dry. But recently, NASA spacecraft and new research on samples from the Apollo missions have shown that the Moon actually has water, both on its surface and beneath.

Hauri and his teammates looked for evidence of this water's origin by homing in on the element hydrogen and its heavier isotope deuterium. (Isotopes are atoms of the same element with different numbers of neutrons.) The ratio of these isotopes can tell scientists about the water's origin. They determined the deuterium-hydrogen ratio for water trapped in extremely primitive volcanic glass samples from the Moon, which were brought back to Earth by the Apollo 15 and 17 missions. The measurements revealed that the hydrogen isotopes matched those from a type of meteorite called carbonaceous chondrites.

Because the deuterium in Earth's water is also matched by carbonaceous chondrites, the two bodies likely obtained their water from the same source. This suggests that the Earth was already wet at the time of the Moon-forming collision and that the water within the Moon was inherited from proto-Earth's water, which survived the impact. □

Science Express published their work.

Erik Hauri



Hauri's research demonstrates that lunar water samples likely came from the proto-Earth and were transferred during the giant impact that formed the Moon.

Hauri's research shows the Moon and Earth's water both likely originated from carbonaceous chondrites shown left.
Image courtesy Harold C. Connolly, Jr., CUNY-Kingsborough College

NASA's Cosmochemistry and LASER programs, along with the Brown/MIT NASA Lunar Science Institute, funded this research.

PLANTS Are Our Future

An international team of 12 leading plant biologists, including Carnegie's Wolf Frommer, says their discoveries could have profound implications for increasing the supply of food and energy for our rapidly growing global population. All of their work focuses on the mechanisms that plants use for transporting small molecules across their membranes and for controlling water loss, resisting toxic metals and pests, increasing salt tolerance, and storing sugar.

The group has discovered details about the biochemistry and genetics of plant transport proteins that could have a profound impact on global agriculture. In a perspective piece published by *Nature*, the team argues that the application of their findings could help the world meet its increasing demand for food and fuel, as the global population grows from seven billion people to an estimated nine billion by 2050.

Frommer, director of Carnegie's Department of Plant Biology, has worked on plant transporters for over two decades and has identified many of the key nutrient transporters in plants. He and his colleagues state that many recent discoveries are below the radar, known only to a small group of other plant biologists. By widely disseminating their findings, the team hopes to educate policymakers and speed the eventual application of their discoveries to global agriculture.

"Of the present global population of seven billion people, almost one billion are undernourished and lack sufficient protein, fats, and carbohydrates in their diets," the paper says. Another billion are malnourished, which has an enormous negative impact on global health, increasing susceptibility to infection and diseases and significant mental impairment. Upcoming climate change and population growth will impose further pressures on agricultural production.

Simply increasing current practices will not increase yield or environmental sustainability, but will rather increase ecological damage. The paper continues, "Increasing food production on limited land resources for sustainable production has to rely on innovative agronomic practices coupled to the genetic improvement of crops."

Another recent discovery has the potential to allow crops to grow on the 30% of the Earth's soil that is otherwise too acidic. Acid soils damage the root tips, inhibit growth, and impair water and nutrient uptake. By understanding how transport proteins control this process, agricultural scientists could engineer crops accordingly.

Other recent transport protein developments could improve crop salt tolerance, while still others could increase iron and zinc storage and thereby improve nutrition. Research from one member of the team has already allowed agricultural scientists to engineer wheat plants that are more tolerant to salt in the soil, boosting wheat yields by a whopping 25% in field trials.

The scientists discovered plant transporters that allow crops to use phosphate more efficiently and to increase the uptake of nitrogen fertilizers, which are costly to produce and wasteful—only 30% to 50% of applied nitrogen is used by plants. The leftover can yield nitrous oxide, a greenhouse gas.

The biologists said crops could be made more drought resistant via transport proteins that regulate the pores on the surface of leaves. Plants lose some 90% of their water through these pores.

Two other major agricultural goals are increasing the carbohydrate content and pest-resistance of crops. A recent discovery in the Frommer lab, the identification of SWEET sugar transporters, has been used to develop pest-resistant rice plants, providing a novel way to simplify the engineering of crops for both high yields and pest resistance. □

Wolf Frommer

"…the team hopes to educate policymakers and speed the eventual application of their discoveries to global agriculture."

Julian Schroeder, a professor of biology at U.C.-San Diego, brought together the research team. In addition to Schroeder and Frommer, the co-authors of the paper are Emmanuel Delhaize of CSIRO in Canberra, Australia; Mary Lou Guerinot of Dartmouth College; Maria Harrison of the Boyce Thompson Institute for Plant Research in Ithaca, N.Y.; Luis Herrera-Estrella of the Center for Research and Advanced Studies of the National Polytechnic Institute in Iraputo, Mexico; Tomoaki Horie of Shinshu University in Nagano, Japan; Leon Kochian of Cornell University; Rana Munns of the University of Western Australia in Perth; Naoko Nishizawa of Ishikawa Prefectural University in Japan; Yi-Fang Tsay of the National Academy of Science of Taiwan; and Dale Sanders of the John Innes Center, Norwich Research Park in the U.K.

InBrief

❶ President Richard Meserve (middle) talks with director of Embryology Allan Spradling (left) and Janelia Farm Research Campus executive director Gerry Rubin.
Image courtesy Christine Pratt

❷ Yingwei Fei received the Geochemistry Fellow award at the 2013 VM Goldschmidt Conference.
Image courtesy Yingwei Fei

❸ Doug Rumble organized this group to examine graphite and collect samples at the Kearsarge graphite mine in New Hampshire.
Image courtesy Doug Rumble

ADMINISTRATION AND TRUSTEES

❶ Carnegie president **Richard A. Meserve**, with trustees **Michael Long**, **William Hearst**, **III**, and others, flew on the Carnegie Airborne Observatory on July 8-9 from San Carlos, CA. Meserve provided a presentation at the rollout of a report issued by the Center for Strategic and International Studies on nuclear power on July 11 in Washington, DC, and participated in council meetings of the National Academy of Engineering on Aug. 4-5 in Woods Hole, MA, and on Oct. 4-5 in Washington, DC. He attended the GMT partner retreat in Tucson, AZ, on Aug. 23. He attended a meeting sponsored by the American Academy of Arts and Sciences to prepare a report on new models for US science and technology policy on Sept. 4-5 in Washington, DC, and attended a meeting of the Secretary of Energy Advisory Board on Sept. 12-13. He participated on a visiting committee to the MIT Nuclear Science & Engineering Department on Sept. 24-25 in Cambridge, MA. He and president emerita Maxine Singer provided remarks at Embryology's centennial celebration on Sept. 26 in Baltimore, MD.

EMBRYOLOGY

After participating in BioEyes, a local high school teacher **Takisha Reece** wanted to do research to better teach her students about what scientists do. **Steve Farber** offered her a summer position. During her time, she applied for and received an APS Research Teacher Fellowship, which provides a stipend, funds to attend the Experimental Biology meeting, and online professional development to help her. She also applied for a free zebrafish tank system for her classroom use, which she also received—a tribute to the success of BioEyes!

GEOPHYSICAL LABORATORY

Russell Hemley gave the annual Flygare Lecture at the U. of Illinois on May 8. On May 28, he presented an invited talk at the Royal Swedish Academy of Science's Molecular Frontiers Symposium. He gave two invited talks at the Stewardship Science Academic Programs Symposium in Albuquerque, NM, on June 28, on the Carnegie/DOE Alliance Center and about HPCAT and DCS at APS. In July, he co-organized a symposium on the "Deep Carbon Budget" at the APS-SCCM/AIRAPT Joint Conference in Seattle, WA, and presented a talk. He stepped down as director in Oct. **George Cody** is acting director.

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Ronald Cohen received a European Research Council Advanced Grant to expand his research to include activities at U. College London (UCL), the London Centre for Nanotechnology, and the Thomas Young Center for the Theory and Simulation of Materials. He will maintain his theory of materials program at GL.

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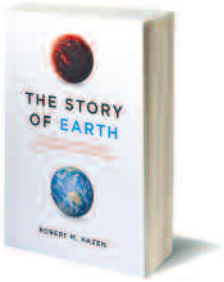
❷ **Yingwei Fei** gave an invited talk on the processes and chemistry of the deep Earth at the first GSC-GSA Joint Meeting in Chengdu, China, in June. He gave an invited talk on terrestrial planetary cores at the APS-SCCM/AIRAPT Joint Conference in July in Seattle, WA. In Aug., he attended the VM Goldschmidt Conference in Florence, Italy, where he received the 2013 Geochemistry Fellow award.

—

Robert Hazen's recent book *The Story of Earth* was selected for the Phi Beta Kappa Book Award in Science short list, the Royal Society Winton Prize for Science Books long list, and the Kirkus Reviews list of top 25 nonfiction books of 2012. Hazen gave a keynote lecture at the Industrial Diamond Association's convention in Baltimore. He lectured on carbon at the extremes at a Nobel Symposium in Stockholm, and he presented lectures on mineral evolution and origins of life as a visiting professor at U. Milan, Italy. Hazen presented the plenary lecture at the VM Goldschmidt Conference in Florence, Italy. He was featured in six lectures on a *Scientific American* cruise to the Norwegian fjords in July.



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Bjørn Mysen gave the keynote lecture at JpGU in Tokyo, Japan, in May. In June, he presented two invited lectures in the Graduate School of Science at Tohoku U. and one invited lecture at the World Premier Institute-Advanced Institute for Materials Research at Tohoku U.

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❸ **Douglas Rumble** organized a field trip with a group of scientists, including GL postdoctoral fellow **Matthieu Galvez**, to study graphite hydrothermal deposits in New Hampshire in July.

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On July 21, postdoctoral fellow **Celia Dalou** gave an invited talk at the IAVCEI Conference in Kagoshima, Japan, on the effect of H_2O on F and Cl solubility and solution mechanisms in aluminosilicate melts at high pressure and high temperature.

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Postdoctoral fellow **Xiaoming Liu** went to the ESWN workshop on leadership training at Brown U. in May and attended the CIDER Summer Program at UC-Berkeley in July. She gave a talk at the VM Goldschmidt Conference in Florence, Italy, in Aug. NSF awarded Liu an ExTerra travel grant in Aug.

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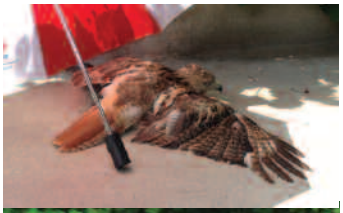
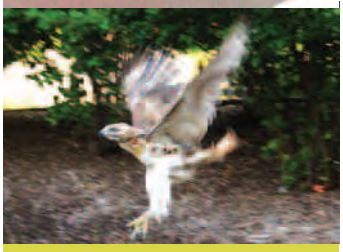
Stable isotope lab manager **Roxane Bowden** presented a talk about sulfur-bearing samples for $\delta^{34}S$ and $\Delta^{33}S$ on June 4 at the Advances in Stable Isotope





Images courtesy Zehra Nizami and Zheng-an Wu

Hawk Rescue

Staff at Embryology have enjoyed the company of red-tailed hawk in their area for some time. It was found with severe head trauma outside the building in July (top). The bird was rescued by the Phoenix Wildlife Center, where she made a full recovery. They released her Aug. 27 outside the building, where she flew right to her perch (bottom). □

Jamieson Award

During the July SCCM/AIRAPT Joint Conference, postdoctoral fellow **Duck Young Kim** received the 2013 Jamieson Award. He presented a plenary talk about new prediction and synthesis of materials under pressure and an invited talk. □

Images courtesy Duck Young Kim

The DCO delegation and Petrobras scientists pose, from left to right: Magali Ader (Institut de Physique du Globe de Paris, France), Craig Schiffries (GL), Max Coleman (JPL-Caltech), Peter Szatmari (Petrobras), David Cole (Ohio State U.), Alina Stadnitskaia (Royal Netherlands Institute for Sea Research), Maria Jose Resende Oliveira (Petrobras).

The Deep Carbon Observatory (DCO) had a large presence at the VM Goldschmidt Conference on Aug. 25-30 in Florence, Italy, where **Robert Hazen** (GL) gave a plenary lecture on "Earth's Carbon Through Deep Time." **Dionysis Foustoukos** and **Andrea Mangum** (GL) participated in the DCO Bioreactor Sandpit Workshop: Designing and Building Pressure Tools for Worldwide Biological Investigations in Veyrier-du-Lac, France, on Aug. 26-29. **Douglas Rumble** and **Matthieu Galvez** (GL) participated in a field trip on July 29-30 to hydrothermal graphite deposits in New Hampshire for the initiative on tectonic fluxes. **Celia Dalou** (GL), **Marion Le Voyer** (DTM), and **Diana Roman** (DTM) attended the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly on July 19-24 in Kagoshima, Japan. **Craig Schiffries** (GL) participated in a DCO delegation to Rio de Janeiro, Brazil, on Aug.13-15 to develop DCO partnerships with Petrobras and universities in Brazil. □

❹ Two of the IPCC team members, Mike Mastrandrea and Katie Mach, are shown here.

❺ Joe Berry

❻ Carnegie Airborne Observatory's senior technician David Knapp

❼ Ken Caldeira

❽ Anna Michalak

Images 4-9 courtesy Robin Kempster

Techniques and Applications workshop in Calgary, Canada.

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On Aug. 26, microbeam specialist **Katherine Crispin** was appointed to the organizing committee for the IUMAS-6 meeting Aug. 2-7 in Hartford, CT. She was the social media outreach coordinator for the meeting.

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John Armstrong and Katherine Crispin attended the Microscopy & Microanalysis 2013 Meeting in Indianapolis, IN, from Aug. 5-8. They presented three papers regarding examining geological materials using high-resolution electron microprobe and doing SEM analysis with field emission instruments.

—

Predoctoral fellow **Derek Smith** defended his Ph.D. thesis, submitted his dissertation, and received an Agouron Institute Postdoctoral Fellowship in Geobiology from Caltech.

—

HPCAT

HPCAT hosted a Paris-Edinburgh Cell Workshop on May 23-24. **Changyong Park**, **Yoshio Kono**, and **Guoyin Shen** from HPCAT and **Yanbin Wang** from GSE-CARS organized the event; HPCAT, COMPRES, and CDAC sponsored the event; Changyong Park, Yoshio Kono, and **Curtis Kenney-Benson** from HPCAT and **Tony Yu** from GSE-CARS gave hands-on training; and **Freda Humble** provided administration. Changyong Park and Yoshio Kono presented beamline posters at the COMPRES Annual Meeting in Lake Geneva, WI, on June 17-20.

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Yoshio Kono, Changyong Park, Curtis Kenney-Benson, Guoyin Shen, and **Hongping Yan** presented posters at the APS-SCCM/AIRAPT Joint Conference in Seattle, WA, on July 7-12.

—

Changyong Park and **Dmitry Popov** hosted a group of 12 graduate students for 2013 Neutron and X-ray School on Aug. 14-15 at HPCAT. The students received hands-on training for high-pressure X-ray diffraction experiments and data analysis during the two-day class.

—

SNS

In May, associate beamline scientist **Jesse Smith** presented a poster describing HPCAT's recent development of rapid compression-decompression techniques and apparatus at the APS/CNM/EMC Users Meeting at Argonne National Laboratory. In Aug., he presented an invited talk at the ORNL Neutron and Nano User Meeting.

GLOBAL ECOLOGY

❹ **Chris Field** and his IPCC crew, **Mike Mastrandrea**, **Katie Mach**, **Monalisa Chatterjee**, **Yuka Estrada**, **Eric Kissel**, and **Eren Bilir**, traveled to Bled, Slovenia, for a lead-author meeting in July.

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❺ **Joe Berry** attended the 16th International Congress on Photosynthesis in St. Louis, MO. He talked about measuring photosynthesis from space.

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❻ **Greg Asner** talked at the TEDGlobal conference in Edinburgh, Scotland, on June 11. In July, the Carnegie Airborne Observatory team, including **Chris Anderson**, **Asner**, **David Knapp**, **Robin Martin**, **Elif Tasar**, **Raul Tupayachi**, and **Nick Vaughn**, began mapping in the western Peruvian Amazon.

—

Carnegie's spectranomics team, including **Katie Kryston** and Peruvian members **Nestor Jaramillo** and **Felipe Sinca**, climbed hundreds of Amazonian trees in Peru for chemical information for the CAO.

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❼ In Apr., **Ken Caldeira** and **Ivana Cvijanovic** attended a sea ice workshop at Columbia U. Caldeira spoke at Harvard U. in Apr. and at UC-Santa Cruz in May. He participated in a public debate on geoengineering at UC-Berkeley in May and a panel discussion at Carnegie headquarters in Sept.

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❽ **Anna Michalak** gave invited presentations at the 2013 NASA Terrestrial Ecology meeting in San Diego, the Joint Statistical Meetings of the American Statistical Association in Montreal, the UC-Davis Statistical Science Symposium 2013, the Workshop on Large-Scale Inverse Problems and Quantification of Uncertainty: Big Data Meets Big Models in Santa Fe, and the International Space Science Institute in Berne, Switzerland.

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Jennifer Johnson of the Field and Berry labs defended her Ph.D. dissertation on Aug. 27.

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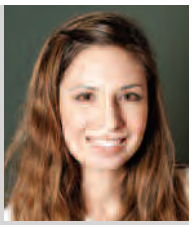
❾ Field lab's **William Anderegg** successfully defended his Ph.D. dissertation on June 7. He is now a postdoctoral fellowship at Princeton U. **Rebecca Hernandez**, a Ph.D. student, was awarded several fellowships: a McGee grant from Stanford U. to support plant-soil biogeochemistry in the Sonoran Desert, a Graduate Summer Research Fellowship from Stanford's Center for African Studies for soil microbial ecology in Senegal, Stanford's Diversifying Academia, Recruiting Excellence Doctoral Fellowship, and the Jean Langenheim Fellowship from the national Graduate Women in Science organization. **Emily Solly** and **Jakob Zscheischler**, Ph.D. students from the Max Planck Institute for Biogeochemistry,

Chris Field was awarded one of Germany's most prestigious prizes, the Max Planck Research Prize, with Markus Reichstein "because they have significantly increased our knowledge of how life on Earth responds to climate change and what reactions can be anticipated between the biosphere and the atmosphere." □

Image courtesy Robin Kempster

Marschner Young Scientist Award

Postdoctoral fellow **Rubén Rellán-Álvarez** received the Marschner Young Scientist Award from the International Plant Nutrition Colloquium for "outstanding Ph.D. students and early-career researchers with the potential to become future research leaders." □



❾ Rebbeca Hernandez

❿ Linda Longoria (pink) opens a gift at her retirement party.

⓫ Michael Rauch

⓬ Andrew Benson

⓭ Mansi Kasliwal

⓮ Li-Qing Chen

⓮ Davide Sosso

⓯ Tingting Xiang

visited the Field and Michalak labs.

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On Aug. 13, **Katharine Ricke** of the Caldeira lab presented a webinar to Chevron on geoengineering.

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On July 11, Michalak lab's **Dan Obenour** defended his Ph.D. dissertation and began a postdoctoral position at NOAA Great Lakes Environmental Research Laboratory. **Jeff Ho** was awarded the Natural Sciences and Engineering Research Council of Canada Postgraduate Scholarship for Doctoral Study. **Yuanyuan Fang**, **Vineet Yadav**, and **Yoichi Shiga** presented their work at the 9th International Carbon Dioxide Conference in Beijing, in June. In July and Aug., **Yuanyuan Fang** was an invited participant in the 12th Atmospheric Chemistry Colloquium for Emerging Senior Scientists, the Gordon Research Conference: Atmospheric Chemistry, and the National Center of Atmospheric Research Advanced Study Program summer research colloquium.

—

Asner lab graduate student **Dana Chadwick** did fieldwork in the Los Amigos Conservation Concession in the Peruvian Amazon, studying soils and forest structure. Postdoctoral researcher **Claire Baldeck** was selected to be a Barbara McClintock Fellow.

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Summer interns arrived this year under the Summer Undergraduate Research in Geoscience and Engineering (SURGE) program at Stanford U. for non-Stanford students and the School of Earth Sciences Undergraduate Research (SESUR) program for Stanford undergraduates. The interns were **Tera Johnson** (SURGE), **Tefiro Serunjogi** (SURGE), **Michael Sojka** (SESUR), **Beti Girma** (SESUR), **Catie Mong** (SESUR), **Makulumy Alexander-Hills** (SESUR), and **Rosemary Mena-Werth** (SESUR/SURGE). Johnson, Mena-Werth, and Serunjogi presented their work at the School of Earth Science's symposium on Aug, 15.

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Jizhong Zhou spent the fall on sabbatical leave from U. Oklahoma.

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Arrivals: Ivana Cvijanovic, Ph.D. from Copenhagen U., joined the Caldeira lab as a postdoctoral research associate in May. Arrivals to the Michalak lab were Ph.D student **Eva Sinha** in June and postdoctoral research associate **Chao Li** in July. The IPCC welcomed graphic artist **Leslie White** in June, Stanford U. summer interns **Beti Girma** and **Ian Sparkman**, and ISSME high school teacher **Catherine Lemmi**. **Abby Bethke** began work in June as operations specialist.

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❿ **Departures: Ty Kennedy-Bowdoin** left the Asner lab on July 30 for a start-up company in the Bay Area. **Matt Colgan** took a postdoctoral position at U. Colorado and U. Florida but will continue working in the Asner lab. **Joe Mascaro** left for a position with USAID. **Linda Longoria** retired at the end of June after 10 years as the department administrator. **Shouren Zhang** returned to the Chinese Institute of Botany in Bejing.

OBSERVATORIES

Director **Wendy Freedman** participated in a panel discussion about the Planck results for cosmology at the 47th ESLAB Symposium in Noordwijk, The Netherlands, in Apr. She gave a lecture on Apr. 22 at U. Pennsylvania as part of the Elon Musk Public Lecture 2013 series. On Apr. 27-30, she attended the NAS 150th Annual Meeting in Washington, DC. In May, she served as Chair of the Gruber Cosmology Prize Advisory Board for the 2013 prize. In June, Freedman was awarded an honorary doctorate from her alma mater U. Toronto. She delivered an invited convocation to the U. College graduating class. She spoke at the Planck Workshop at CERN in Geneva and gave an invited plenary talk at the Cosmo Probes 2013 Conference in Lausanne, Switzerland, in June.

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Staff astronomer **Luis Ho** attended an editorial board meeting of the *Astrophysical Journal* in Saskatoon, Canada. He gave an invited talk at the Second China-U.S. Workshop on Radio Astronomy Science and Technology workshop in Shanghai.

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⓫ Staff astronomer **Michael Rauch** participated in workshops at the CGM-Galaxy Interface Workshop in Leiden, The Netherlands, and in a workshop on galactic outflows in Santa Barbara, CA. He spoke at the conference "The Physical Link between Galaxies and their Halos" in Garching, Germany, and presented a seminar at the Institute of Astronomy, Cambridge.

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Josh Simon gave a colloquium at Geneva Observatory on May 21 and a colloquium at UC-Riverside on June 4. On Aug. 9, he gave a public lecture at Santa Monica Amateur Astronomy Club. He gave a colloquium at Pontificia Universidad Católica de Chile on Sept. 3. In mid-Sept., he attended the workshop "Exploring Future Directions of Stellar Spectral Analysis at Low and High Resolution" at UC-Santa Cruz.

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⓬ Staff associate and Hale Scholar **Andrew Benson** gave a talk "Constraints on Outflows from Population Statistics" at UC-Santa Barbara in Aug.

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⓭ Hubble-Carnegie-Princeton Fellow **Mansi Kasliwal** gave a colloquium at Caltech in Feb. and an invited talk at the International Meeting on Transients and Timing in Pune, India, in Mar. Her talk opened the Carnegie Lecture Series in Pasadena in Apr. She gave an invited review at the American Physical Society Meeting in Boulder, CO, and an invited review at the 2nd PANDA Symposium on Multi-Messenger Astronomy in Xi'an, China, both in Apr. In May, she attended the Astrophysics Seminar at UC-Irvine, gave a colloquium at UC-Berkeley, and gave an invited talk at the Locating Astrophysical Transients workshop in Leiden, The Netherlands. She attended the AAS plenary talk in Indianapolis, IN, in June.

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Postdoctoral research associate **Rik Williams** gave the invited colloquium "Galaxy Assembly in the Thermal Era" at U. Alabama on Apr. 15.

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On July 19, postdoctoral research associate **Joshua Adams** gave a talk at the AAS conference "Probes of Dark Matter on Galaxy Scales."

PLANT BIOLOGY

On May 6-8, **Wolf Frommer** chaired a panel at the AIPI meeting at Cornell U. He was invited to Syngenta in Durham, NC, on May 9-10, to speak about nutrient transporters. On June 14, he spoke at the Mitochondrial Medicine 2013 conference in Newport Beach, CA, about optical sensors and in vivo biochemistry. On June 16-21 he spoke at the Gordon Research Conference: Mechanisms of Membrane Transport at Mount Holyoke College, MA. On June 24, he spoke about sugar transporters at the Garvan Institute of Medical Research in Darlinghurst, Australia. On June 24-29, he attended the 24th International Conference on Arabidopsis Research, Sydney, Australia, where he lectured and gave a workshop on biosensors. On June 28, he talked about the transporters in seeds at U. Newcastle-Callaghan, Australia.

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On July 10, **Winslow Briggs** lectured at the postdoc seminar "Scientific Talks: Is Yours Boring and Incomprehensible, or Exciting and Informative?" In May, he led a field trip about plant regeneration after a wildfire for Jasper Ridge Biological Preserve docents.

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Arthur Grossman gave the plenary lecture at the Carbon Concentrating Mechanism Meeting in New Orleans, LA, on May 27-30. On July 28-Aug. 2, he gave a symposium about the evolution of organelles at the International Congress of Protistology in Vancouver, Canada. Grossman served as a member of the

⓰ Elizabeth Freeman

⓱ From left to right: Alberto Behar, Linda Elkins-Tanton, and James Tanton are on a fumarole in Iceland with a BENTO box, which measures volcanic gases and weather conditions.
Image courtesy Linda Elkins-Tanton

⓲ From left to right: Alan Boss, Willy Benz (U. Bern), Larry Nittler, and Rhonda Stroud attended a CHEOPS exoplanet mission event at the Swiss Embassy.
Image courtesy Catherine Boss

With Stanford U., Plant Biology ran a large internship program for 25 high school students, undergraduates, and international students from May through Aug. The interns performed hands-on lab work and attended weekly seminars. The program wrapped up with a pizza and poster session where the interns presented their projects. □

Richard Carlson was inducted into the National Academy of Sciences at their annual meeting in Apr. In May, he was awarded the 2013 Arthur L. Day Medal, which was presented at the 2013 GSA Annual Meeting in Denver, CO, in Oct. □

EPSCoR RII Track-1 external review panel at U. Nebraska on Aug. 22-23. He was appointed to the scientific advisory board of the Boyce Thompson Institute for Plant Research.

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Zhiyong Wang gave a seminar on integrated plant signals at Chung-Ang U., Korea, on May 13. He gave the same talk at the International Symposium on Plant Cell Signaling and Systems Biology in Gwangju, Korea, on May 15. At IPGSA's 21st International Conference, held in Shanghai on June 18-22, he spoke on proteomic and genomic strategies for hormone research. On July 21-24, he presented a plenary talk on plant hormonal and environmental signals at ASPB's annual conference in Providence, RI. During July 28-Aug. 2, he co-chaired the Gordon Research Conference: Posttranslational Modification Networks in Hong Kong and gave a talk.

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May 29-31, **José Dinneny** gave a talk on environmental cues at the 30th Annual Interdisciplinary Plant Group Symposium "Root Biology" in Columbia, MO. In June, he gave an invited talk about plant environmental responses at UC-Riverside. He attended IPGSA's 21st International Conference, held in Shanghai, on June 18-22, giving a seminar about local water and root pattern development. On July 20-24, he spoke on the same topic at ASPB's annual conference, and he held a similar seminar at a FASEB conference in Saxtons River, VT, on Aug. 11-16.

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⓮ Frommer postdoctoral members **Jonas Danielson**, **Cheng-Hsun Ho**, **Li-Qing Chen**, and **Davide Sosso** attended ASPB's Western Section Meeting at UC-Davis, CA. Postdoctoral researcher **Alexander Jones** spoke about membrane-based interactomes.

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⓯ On May 11-26, Grossman lab postdoctoral researcher **Dimitri Tolleter** presented talks on photosynthesis and coral bleaching at U. Pierre and Marie Curie, Paris, and Institut de Biologie Environnementale et de Biotechnology, CEA, Cadarache, France. On Aug. 11-16, he spoke at the 16th Photosynthesis Congress in St. Louis, MO, on a similar topic. Graduate students **Rick Kim** and **Tyler Wittkopp** presented posters at the congress. In June, postdoctoral researcher **Wenqiang Yang** gave several talks while in China. On June 18, he presented a seminar at Tsinghua U. on anoxic metabolism. On June 20, 25, and 27, Yang spoke on related subjects at different institutes of the Chinese Academy of Sciences. Postdoctoral researcher **Tingting Xiang** spoke about glucose and coral bleaching at the 10th International Phycological Congress held in Orlando, FL, on Aug. 4-10.

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Dinneny lab postdoctoral researcher **Ruben Rellan** talked about a platform for analysis of root structure and physiology in soil at the 30th Annual Interdisciplinary Plant Group Symposium "Root Biology" in Columbia, MO, on May 29-31.

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⓰ Jonikas graduate student **Elizabeth Freeman** presented a poster about the FRET nanosensor for inorganic carbon at CCM8: The VIIIth International Symposium on Inorganic Carbon Utilization by Aquatic Photosynthetic Organisms meeting at Loyola U., New Orleans.

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The following researchers presented posters at the July ASPB meeting: **Winslow Briggs**, **David Ehrhardt**, Briggs' senior researchers **Rajnish Khanna** and **Tong-Seung Tseng**, postdoc **Zhiping Den**, and Briggs' former postdoc **David Nelson**.

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The department hosted 7th and 8th grade students from East Palo Alto Academy for an outreach program run by Stanford, who worked with José Dinneny to organize the event. The program was centered on revealing plant biology using various microscopy techniques; at the end, students presented pictures they had taken.

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Arrivals: Frommer lab postdoctoral researcher **Lily Cheung** arrived from Princeton on July 2, and senior researcher **Roberto De Michele** arrived on July 22 from Institute of Plant Genetics-Palermo, Italy. The Rhee lab welcomed intern/lab assistant **Lessley Peterson** on Apr. 15 and postdoctoral researcher **Jue Fan** from Clark U. on May 13. Postdoctoral researcher **Renate Weizbauer**, from Washington U. in St. Louis, joined the Ehrhardt lab on June 1. On July 22, **Rebecca Yue** arrived from UC-Berkeley as a laboratory technician in the Jonikas lab. **Richard Jorgensen** arrived on Aug. 19 as an advancement consultant. **Theo van de Sande** joined both Plant Biology and Global Ecology on Apr. 22 as facilities manager.

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Departures: Shruti Manoj Kumar, lab technician in the Frommer lab, left on July 24. On Aug. 30, Grossman lab postdoctoral researcher **Mark Heinnickel** left for Matrix Genetics in Seattle, WA.

TERRESTRIAL MAGNETISM

⓱ Director **Linda Elkins-Tanton** attended the June 2-7 Gordon Research Conference: Interior of the Earth and the June 23-28 Gordon Research Conference: Origin of Solar Systems at Mount Holyoke College, MA. Also in June, she debuted the Discovery mission proposal to orbit the asteroid Psyche at the Low-Cost Planetary Missions Conference at Caltech, and she attended student Benjamin Black's Ph.D. thesis defense at MIT. In July, Elkins-Tanton and Alberto Behar installed a BENTO box to measure volcanic gases and weather conditions on Hengill volcano in Iceland. In Aug., she and James Tanton conducted a weeklong Earth and space science education workshop for high-school teachers at U. Massachusetts-Amherst, and she attended a Psyche mission planning meeting at JPL in Pasadena, CA. Elkins-Tanton presented two keynote talks at the VM Goldschmidt Conference in Florence, Italy, in Aug., and she attended a Committee on Astrobiology and Planetary Science meeting at NAS in Washington, DC, in Sept.

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On June 29, a symposium was held in honor of the scientific contributions of senior fellow **Selwyn Sacks**. Invited speakers included Ragnar Stefansson (Iceland), Kiyoshi Suyehiro (Japan), Alessandro Bonaccorso (Italy), former DTM fellows Arthur Snoke and Fred Pollitz, and staff scientists **David James** and **Alan Linde**.

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⓲ In June, **Alan Boss** chaired a NASA review panel in Washington, DC, about developing space telescope technology to directly image extrasolar planets. He also participated in a workshop at Wallops Island, VA, on developing a new roadmap for NASA's Astrobiology Program. On June 25, Boss attended a Swiss Embassy event featuring the CHEOPS exoplanet mission, with **Larry Nittler** and Rhonda Stroud (NRL). In July, Boss chaired a review sub-panel for

Pioneering Research

On May 17, the American Physical Society presented a plaque to senior fellow **Vera Rubin** and former DTM staff scientist **Kent Ford**, Jr., "in recognition of the pioneering research" they conducted at DTM that provided evidence for the existence of dark matter. □

⓳ Larry Nittler attended a MESSENGER meeting to discuss a map of Mercury's composition projected onto a visualization wall at Case Western Reserve U.
Image courtesy Larry Nittler

NASA on proposals for membership in the Solar System Exploration Research Virtual Institute. In Sept. in London, he gave a talk about the orbital migration of protoplanets in marginally gravitationally unstable disks at the European Planetary Science Congress 2013.

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Richard Carlson presented an invited talk about turning measurements into 4-D structures at the Gordon Conference: Interior of the Earth in June. He hosted three representatives from the Geochemical Society of Japan for the first planning meeting for the 2016 VM Goldschmidt Conference to be held in Yokohama, and he presented an invited talk on the use of short-lived radionuclides to understand early Solar System history at the Geological Society of London. In July, he taught at the CIDER Summer Program at UC-Berkeley. Carlson attended the VM Goldschmidt Conference in Florence, Italy, in Aug., and he presented a plenary. He participated in the "Origin of the Moon" conference at the Royal Society in London in Sept.

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Steve Shirey spoke in June on his diamond research at headquarters' "Lunch and Learn." He also spoke about scientific research to teachers at Friendship Collegiate Academy for CASE. In July, Shirey, **Tim Mock**, and postdoctoral fellows **Terry Blackburn** and **Hanika Rizo** hosted 22 teachers for a lecture and laboratory practicum as part of the Smithsonian Science Education Academy for Teachers. In Aug., he attended the VM Goldschmidt Conference in Florence, Italy.

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In July, **Conel Alexander** attended the Meteoritical Society meeting in Edmonton, Canada.

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⓳ **Larry Nittler** attended a June MESSENGER Science Team Meeting at Case Western Reserve U. in Cleveland. In July, he presented a paper at the annual meeting of the Meteoritical Society, in Edmonton, Canada. In Aug., he presented a keynote talk at the VM Goldschmidt Conference in Florence, Italy.

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In June, **John Chambers** attended the Gordon Conference: Origin of Solar Systems at Mount Holyoke College, MA.

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Diana Roman conducted fieldwork at Mt. Etna, Italy, in July and gave two talks at the IAVCEI General Assembly in Kagoshima, Japan, which was also attended by Alan Linde and Carnegie fellow **Christelle Wauthier**. In Sept., she conducted fieldwork at Telica and San Cristobal volcanoes, Nicaragua, and presented a department seminar at U. North Carolina-Chapel Hill.

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In Apr., astronomy Carnegie fellow **Susan Benecchi** gave a public talk and a student seminar for the Outer Planets Colloquium Series at U. Nebraska-Lincoln. In June, she observed at the Las Campanas Observatory, Chile. In July, she talked at the Pluto Science Conference hosted at APL. From Jan. through the beginning of July, Benecchi hosted a variety of speakers from U. Maryland, STScI, Princeton, APL, GSFC, Howard U., and The Johns Hopkins U. as part of the department's astronomy seminar series.

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MESSENGER fellow **Paul Byrne** gave a plenary presentation at the 30th MESSENGER Science Team Meeting in Cleveland, OH, in June. In July, he attended the New Horizons conference at APL. He came in first in the online heats of the 2013 FameLab competition in Aug.

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In May, Vera C. Rubin fellow **Joleen Carlberg** gave an astronomy talk at the Pontificia Universidad Católica de Chile in Santiago while visiting former DTM fellow Julio Chaname. In June, she presented a talk at the Sloan Digital Sky Survey-III collaboration meeting in Baltimore, MD, and received the AAS International Travel Grant to attend the "400 Years of Stellar Rotation" meeting to be held in Natal, Brazil, in Nov. Carlberg has been participating in an outreach program at the National Air and Space Museum.

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In June, MESSENGER fellow **Christian Klimczak** presented at the 30th MESSENGER Science Team Meeting in Cleveland, OH. In July, he conducted fieldwork in the Bohemian Cretaceous Basin, studying the nature and distribution of deformed sandstones along the German/Czech border.

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DCO postdoctoral associate **Marion Le Voyer** participated in Career Day on Apr. 26 at Samuel Ogle Middle School in Bowie, MD. On May 6, she gave a talk at LDEO about volatiles in basaltic systems as part of their geosystems series of seminars. She also presented an outreach talk on ocean floor geology at the Shepherd's Center of Annandale, VA, on May 22. She chaired a session and presented a talk at the IAVCEI conference, Kagoshima, Japan, on July 19-25.

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NSF associate **Ryan Porter** and field seismologist **Steven Golden** installed a seismic network around Sunset Crater near Flagstaff, AZ, in June and July, as part of the Sunset Seismic Experiment in collaboration with Arizona State U. Porter also presented at the May EarthScope National Meeting held in Raleigh, NC.

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In July, electronic design engineer **Brian Schleigh** and IT/IS manager/systems engineer **Michael Acierno** traveled to Montserrat to upgrade the data loggers for the strainmeter network in collaboration with Pyiko Williams of the Montserrat Volcano Observatory and Wade Johnson of UNAVCO.

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In Mar., web coordinator **Kasey Cunningham** covered the 44th Lunar and Planetary Science meeting held in Houston for the DTM Web site.

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Arrivals: In May, predoctoral student **Tarzan Kwadiba** (U. of the Witwatersrand) arrived to work on his Ph.D. thesis with **David James**. Other May visitors included **Sandy Faber** (UC Observatories) and **Jack Wisdom** (MIT). In June, Merle A. Tuve Senior Fellow **David Bercovici** returned to present his Tuve seminar. Also in June, former fellow and current visiting investigator **Chin-wu Chen** returned for a two-week visit, coinciding with the Sacks Symposium. In July, former postdoctoral fellow **Liping Qin** (U. Science and Technology, Hefei, China), and her students **Jia Liu** and **Jiuxing Xia**, arrived to collaborate with Rick Carlson and Conel Alexander. **Valentina Taranovic** (Ph.D. student from Indiana U.-Bloomington) arrived to do some analyses on the mass spectrometer. In Aug., **Doug Wiens** (Washington University, St. Louis) began his visit as a Merle A. Tuve Senior Fellow. **Grant Bybee**, a Ph.D. student from the U. of the Witwatersrand, also arrived.

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Departures: Carnegie fellow **Frances Jenner** left for a position at The Open U. in Milton Keynes, UK, and astronomy fellow **Christopher Stark** joined Goddard Space Flight Center in Greenbelt, MD. In Aug., web coordinator and administrative assistant **Kasey Cunningham** departed for a multimedia journalist position at WECT TV6 in Wilmington, NC, and temporary assistant **Hayley Johnson** left for a position in NY. □

Angela Schad (U. Delaware), a former summer scholar at GL, interned in the DTM-GL library this summer. She catalogued photographs of historic scientific instruments in the two departments' archives and developed a Web site about the collection. □

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Moody's

Moody's Affirms Carnegie's AAA Rating

In July, Moody's Investors Service affirmed Carnegie's AAA ratings of Carnegie's 2010 Series A Bonds issued through the California Educational Facilities Authority (CEFA) and Series 2010 Bonds issued through the Maryland Health and Higher Education Facilities Authority (MHHEFA), affecting $65.1 million of rated debt. The AAA rating is Moody's highest and is based on Carnegie's "strength of its reputation and balance sheet." The rating agency determined the institution's outlook is stable.

The AAA rating incorporates the significant reliance on grants and contract revenues and investment income to support operations, which made up 85% of FY 2012 operating revenues. The stable outlook reflects the expectation that balance sheet growth will continue to be healthy with sound investment practices. "Carnegie's conservative fiscal practices and planning, high-caliber primary investigators, and diverse sources of research funding we expect will mitigate expected pressures on operations from stagnant or declining federal research funding and future financial commitments." □