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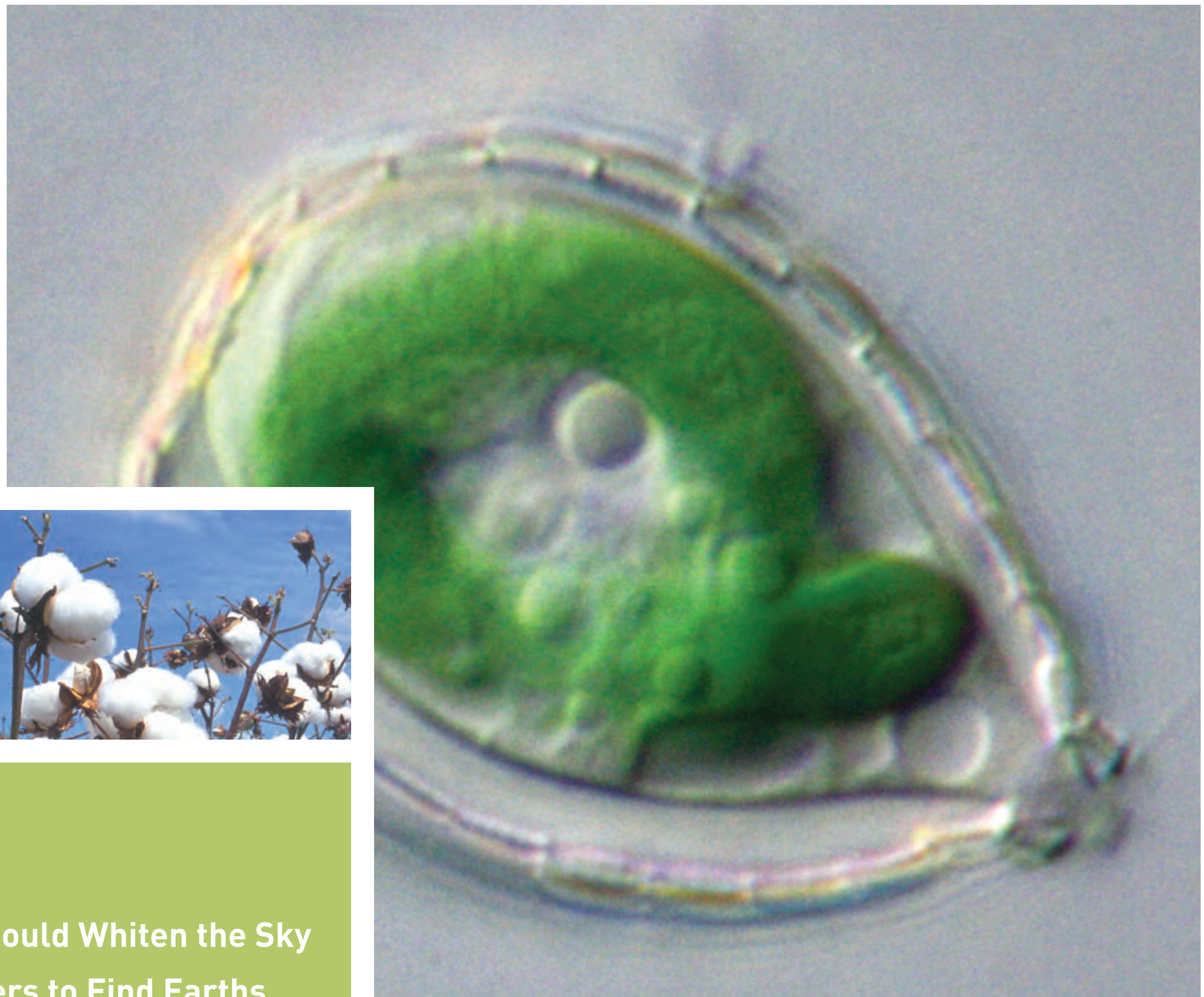
CarnegieScience

The Newsletter of the Carnegie Institution

FALL 2012

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 CHAIRMAN

Why Invest in Science?

There is no more critical time to support science than now. The world is in a period of great uncertainty and change. The economy continues to waver as anxiety permeates global markets. And governments, corporations, foundations, and individuals are carefully husbanding their resources. Yet despite this widespread unease, investing in the scientific enterprise offers us, perhaps, the best way to get back on course.

Since World War II, science and technology have been the driving force for about half of the growth of the U.S. economy. Vannevar Bush, president of the Carnegie Institution from 1939-1955 and a chief architect of postwar U.S. science policy, recognized this potential. His influential 1945 report requested by President Roosevelt entitled *Science: The Endless Frontier* argued that federal investment in basic research is necessary for economic progress and stability. He was right. This endeavor paved the way for the establishment of the National Science Foundation—a vital government agency that has supported decades of discoveries—and laid the foundations for the support of basic research throughout the government.

Today, some three-quarters of U.S. economic growth can be attributable to innovation, which of course, stands on the shoulders of scientific and technological breakthroughs. Recently, science, technology, engineering, and math—the so-called STEM subjects—have become the war cry for a better economic future. Carnegie's basic research and educational programs are well positioned to contribute to our nation's economic progress and to tackle some of the world's other fundamental challenges.

To address some of these challenges, Carnegie plant scientists, for instance, are unraveling the genetics to develop plants adaptable to saltier, drier, and hotter conditions. Our climate researchers have invented high-resolution, airborne techniques to understand carbon and nutrient cycling and to provide tools to help combat climate change. Carnegie's high-pressure investigators have a long history of creating new materials with potential industrial and energy applications. And our biologists are discovering the genes and processes behind diseases, including cancer, with the promise of providing a pathway to eventual cures.

It does not stop there. A strong research program can spawn countless, unanticipated spin-offs—satellite phones, cordless tools, and the chips that power an interconnected world, to name a few. Today, China, Korea, India, and other countries are accelerating their investments in science and technology, providing tough competition for innovation dominance. The U.S. needs to respond to the reality that others would like to emulate and surpass our remarkable engine for economic growth and technological advance.

No one can predict what the future holds. But Carnegie's solid record of extraordinary achievements for the last 110 years underscores the vital contribution we are making to advance humankind. Continued investment in basic science will help perpetuate this legacy and that in turn will help the nation remain competitive.

Michael E. Gellert, *Chairman*

The president and the chairman of the board alternate roles in presenting an introductory letter.

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Trustee News

Senior Trustee **Jaylee Mead** Dies

Senior trustee and retired Goddard Space Flight Center astronomer Jaylee Mead died at home from congestive heart failure on September 14, 2012, at the age of 83. Mead joined the Carnegie board in 1999. She was a dedicated member of the Development and Research committees. She became a senior trustee in 2008.

Mead was born in North Carolina. Her teachers and parents encouraged her to seek higher education. She attended the University of North Carolina at Greensboro and received a bachelor's degree in mathematics in 1951. She went on to Stanford University and obtained a master's in education in 1954.

Mead went on to work for the State Department in Washington, D.C. In 1959 she was recruited by NASA. Later she attended Georgetown University, where she studied with Carnegie's Vera Rubin, the astronomer who confirmed the existence of dark matter. Mead received her doctorate in astronomy in 1970.

In addition to her many other contributions, Mead established the Vera Rubin Fellowship to honor her former mentor. Thus far, eight researchers have benefitted from her generosity. She and her husband Gilbert, a geophysicist, were members of the Hubble Society. Members of the Hubble Society have contributed between $1 million and $10 million to Carnegie science. □

Senior trustee Jaylee Mead (above) and her mentor, Carnegie astronomer Vera Rubin (left).

Honing in on Supernovae Origins

Astronomers use Type Ia supernovae, massive exploding stars, to measure the expansion of the universe, but they know embarrassingly little about the stars they come from and how their explosions are initiated. New research from a team including Carnegie scientists could help explain at least some of their origins.

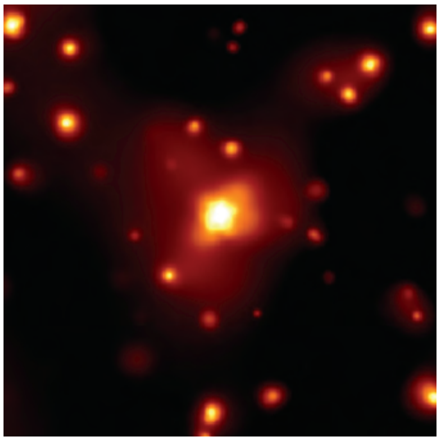
Type Ia supernovae are believed to be thermonuclear explosions of a white dwarf star that is part of a binary system—two stars that are physically close together and orbit around a common center of mass. There are two possible explanations for the creation of Type Ia supernovae from this type of binary system.

In the so-called double-degenerate model, the orbit between two white dwarf stars gradually shrinks until the lighter star gets so close to its companion that it is ripped apart by tidal forces. Some of the lighter star's matter is then absorbed into the primary white dwarf, causing an explosion. In the competing single-degenerate model, the white dwarf slowly accretes mass from an ordinary nonwhite dwarf star until it reaches an ignition point.

Previous research has been unable to shed light on which model is correct. Carnegie scientists Josh Simon, Chris Burns, Nidia Morrell, and Mark Phillips were part of a Harvard University-led team that examined 23 Type Ia supernovae. The team looked for signatures of gas, which should be present only in single-degenerate systems, and found that the more powerful explosions did indeed tend to come from "gassy" systems, or systems with outflows of gas. However, only a fraction of supernovae show evidence of outflows; hence the remainder likely come from double-degenerate systems.

This finding may help astronomers tell the two types of Ia supernovae apart, thus leading to greater accuracy in measuring the expansion of the universe. □

Images courtesy NASA/Swift/S. Immler



This Type Ia supernova was detected in 2005 and is dubbed Supernova 2005ke. It is shown here exploding at optical, ultraviolet, and X-ray wavelengths.

Funding for this research was provided in part by a Clay Fellowship, the International Science Foundation, the Minerva Foundation, the Lord Sieff of Brimpton Fund, CONICYT, the Millennium Center for Supernova Science, and the National Science Foundation. The Hobby-Eberly Telescope is a joint project of the University of Texas at Austin, Pennsylvania State University, Stanford University, Ludwig-Maximilians-Universität München, and Georg-August-Universität Göttingen. The HET is named in honor of its principal benefactors, William P. Hobby and Robert E. Eberly.

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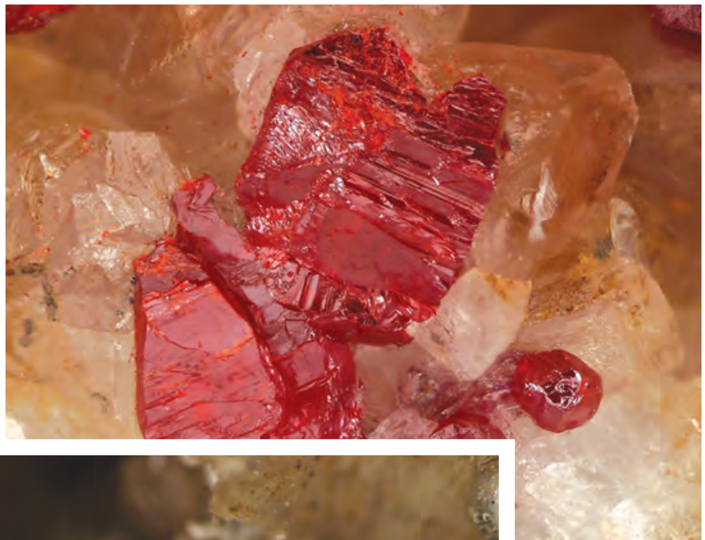
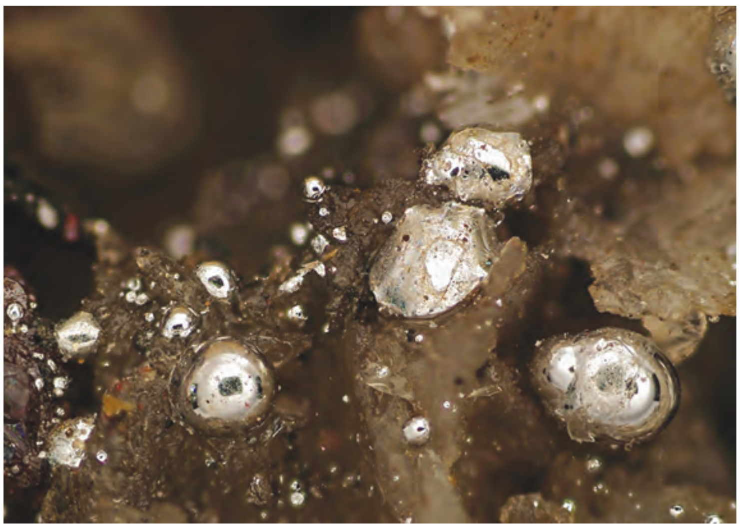
Mercury Mineral Count Rising



This is a picture of cinnabar–or mercury sulfide–the most common mercury mineral, from Sonoma County, California.



The silver spheres are native mercury from San Luis Potosi, Mexico.

Images courtesy Bob Hazen

Mineral evolution posits that Earth's near-surface mineral diversity gradually increased through an array of chemical and biological processes. The dozen different species in interstellar dust particles that formed the Solar System evolved to more than 4,500 species today. Previous work from Carnegie's Bob Hazen demonstrated that up to two-thirds of the known types of minerals on Earth can be directly or indirectly linked to biological activity. More recently, Hazen has focused specifically on minerals containing the element mercury and their evolution on our planet as a result of geological and biological activity. His work, published in *American Mineralogist*, demonstrates that the creation of most minerals containing mercury is fundamentally linked to several episodes of supercontinent assembly over the last 3 billion years.

Mineral evolution is an approach to understanding Earth's changing near-surface geochemistry. All chemical elements were present from the start of our Solar System, but at first they formed comparatively few minerals—perhaps no more than 500 different species in the first billion years. As time passed on the planet, novel combinations of elements led to new minerals. Although as much as 50% of the mercury that contributed to Earth's accretion was lost to volatile chemical processing, 4.5 billion years of mineral evolution led to the at least 90 different mercury-containing minerals now found on Earth.

Hazen and his team examined the first documented appearances of these 90 different mercury-containing minerals on Earth. They were able to correlate much of this new mineral creation with episodes of supercontinent formation—periods when most of Earth's dry land converged into single landmasses. They found that of the 60 mercury-containing minerals that first appeared on Earth between 2.8 billion and 65 million years ago, 50 were created during three periods of supercontinent assembly. Their analysis suggests that the evolution of new mercury-containing minerals followed periods of continental collision and mineralization associated with mountain formation.

By contrast, far fewer types of mercury-containing minerals formed during periods when these supercontinents were stable or breaking apart. One striking exception to this trend is the billion-year-long interval that included the assembly of the Rodinian supercontinent approximately 1.8 to 0.8 billion years ago, which saw no mercury mineralization anywhere on Earth. Hazen and his colleagues speculate that this hiatus could have been due to a sulfide-rich ocean, which quickly reacted with any available mercury and thus prevented mercury from interacting chemically with other elements.

The role of biology is also critical in understanding the mineral evolution of mercury. Although mercury is rarely directly involved in biological processes—except in some rare bacteria—its interactions with oxygen came about entirely due to the appearance of the photosynthetic process. Mercury also has a strong affinity for carbon-based compounds that come from biological material, such as coal, shale, petroleum, and natural gas products. □

Bob Hazen poses while doing fieldwork.

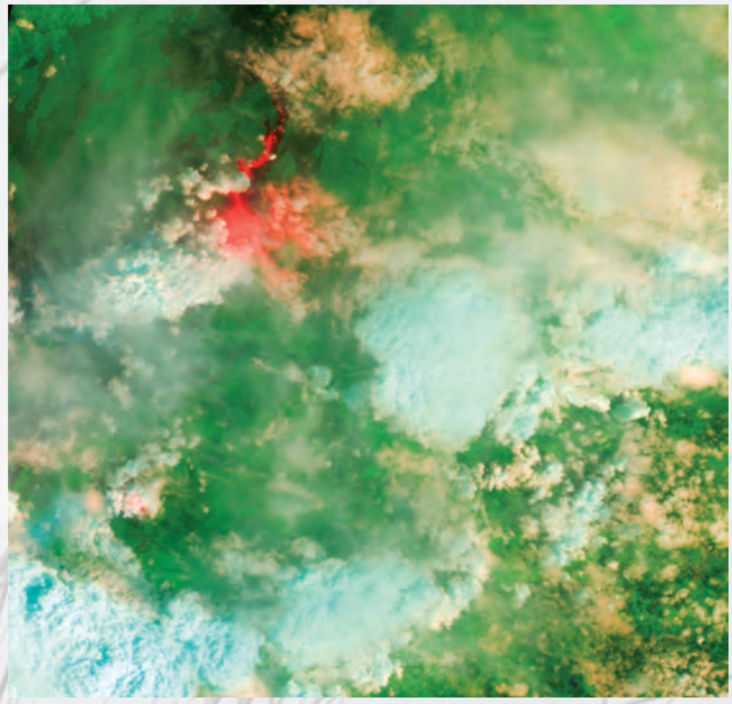
The Alfred P. Sloan Foundation and the Deep Carbon Observatory awarded grants to in part support the Mineral Evolution Database. This work was supported by the NASA Astrobiology Institute, an NSF-NASA Collaborative Research Grant to The Johns Hopkins University and the Carnegie Institution for Science, a DOE grant, and a U.S. National Science Foundation grant to the University of Maine.

Pictured right is a light sky over long grass. Kravitz and Caldeira's research indicates that although a geoengineered sky would still be blue, it would be a lighter shade than is usually seen now outside urban areas.

Image courtesy Alice Birkin, PublicDomainPictures.net

Africa's Nyamuragira Volcano, shown below, began to erupt along a new fissure in November 2011. Geoengineering is intended to mimic the cooling effect caused by major volcanic eruptions releasing particles into the stratosphere.

Image courtesy Jesse Allen, NASA Earth Observatory



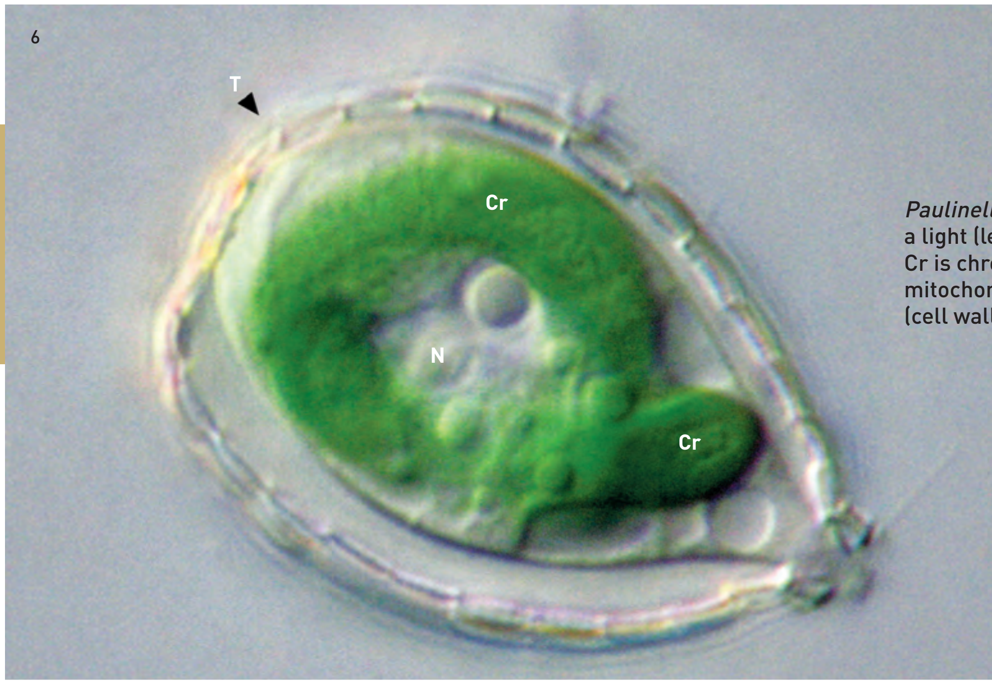
Geoengineering Could Whiten the Sky

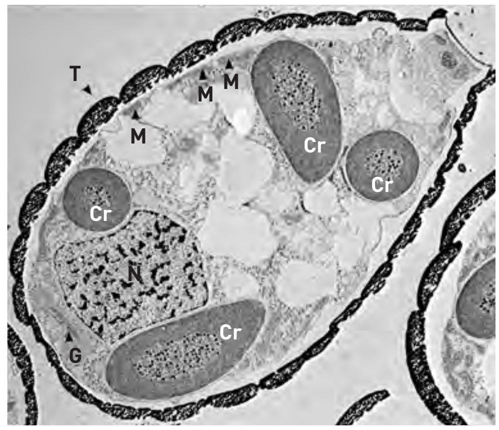
One idea for fighting global warming is to increase the amount of aerosols in the atmosphere, which would scatter incoming solar energy away from the Earth's surface. But scientists theorize that this solar geo-engineering could have the side effect of whitening the daytime sky. Research from a team including Carnegie's Ben Kravitz and Ken Caldeira indicates that blocking 2% of the Sun's light would make the sky three to five times brighter, as well as whiter.

Carbon dioxide emissions from the burning of coal, oil, and gas have been increasing over the past decades, causing the Earth to get hotter and hotter. Large volcanic eruptions cool the planet by creating lots of small particles in the stratosphere, but the particles fall out within a couple of years, and the planet heats back up. The idea behind solar geoengineering is to constantly replenish a layer of small particles in the stratosphere, mimicking this volcanic aftermath by scattering sunlight back into space. Using advanced models, Kravitz and Caldeira examined changes in sky color and brightness produced by using sulfate-based aerosols in this way. They found that, depending on the size of the particles, the sky would whiten during the day and sunsets would have afterglows.

Their models predict that the sky would still be blue, but a lighter shade than that to which most people are accustomed. Further, the research team's work shows that skies everywhere could look like those often seen over urban areas—hazy and white.

The group's findings have several larger environmental implications too. Because plants grow more efficiently under diffuse light such as that produced by solar geoengineering, global photosynthetic activity could increase, pulling more of the greenhouse gas carbon dioxide out of the atmosphere. On the other hand, the effectiveness of solar power could be diminished, as less sunlight would reach solar-power generators. The work was published in June 2012 by *Geophysical Research Letters*, a journal of the American Geophysical Union. □





Paulinella chromatophora as viewed through a light (left) and electron (bottom) microscope. Cr is chromatophore; G is golgi; M is mitochondrion; N is nucleus; and T is theca (cell wall composed of silica scales).

Image courtesy Eva Nowack

Can Amoeba Explain Photosynthetic Evolution?

The major difference between plant and animal cells is the photosynthetic process, which converts light energy into chemical energy. The cellular organelle responsible for this process is the chloroplast. Research, published in the *Proceedings of the National Academy of Sciences,* by Carnegie's Eva Nowack and Arthur Grossman has opened a window into the early stages of chloroplast evolution.

Arthur Grossman

Eva Nowak

It is widely accepted that chloroplasts originated from photosynthetic, single-celled bacteria called cyanobacteria. More than 1.5 billion years ago these cyanobacteria were engulfed by a more complex, non-photosynthetic cell. While the relationship between the two organisms was originally symbiotic, over evolutionary time the cyanobacterium transferred most of its genetic information to the nucleus of the host organism, transforming the original cyanobacterium into a chloroplast organelle no longer able to survive without its host. To sustain the function of the organelle, proteins encoded by the transferred genes are synthesized in the cell's interior and then imported into the organelle.

Clearly the events that gave rise to chloroplasts changed the world forever. But it is difficult to research the process by which this happened because it took place so long ago. One strategy used to understand this process's evolution involves identifying organisms where events that resulted in the conversion of a bacterium into a host-dependent organelle occurred more recently.

Nowack and Grossman focused their research on the amoeba *Paulinella chromatophora*. This type of amoeba contains two photosynthetic compartments that also originated from an endosymbiotic cyanobacterium, but that represent an earlier stage in the formation of a fully evolved organelle. These compartments, called chromatophores, transferred more than 30 of the original cyanobacterial genes to the nucleus of the host organism.

The Carnegie team honed in on three of the *P. chromatophora* transferred genes that encode proteins involved in photosynthesis, a process localized to the chromatophore. They set out to determine whether these proteins are synthesized in the cytoplasm of the amoeba and whether the mature proteins become localized to the chromatophore. They were able to determine that these three proteins are indeed synthesized in the cytoplasm and then transported into the chromatophores, where they assemble together with other internally encoded proteins into working protein complexes that are part of the photosynthetic process.

Interestingly, the process by which these proteins are transported into chromatophores may also be novel and involve transit through an organelle called the Golgi apparatus prior to becoming localized to the chromatophore. This suggests the occurrence of an initial, rudimentary process for proteins to cross the envelope membrane of the nascent chloroplast—a process that ultimately evolved into one that is potentially more sophisticated and that uses specific protein complexes for efficient transport. □

This research was supported by Michael Melkonian, Deutsche Forschungsgemeinschaft, and the National Science Foundation.

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Looking for Jupiters to Find Earths

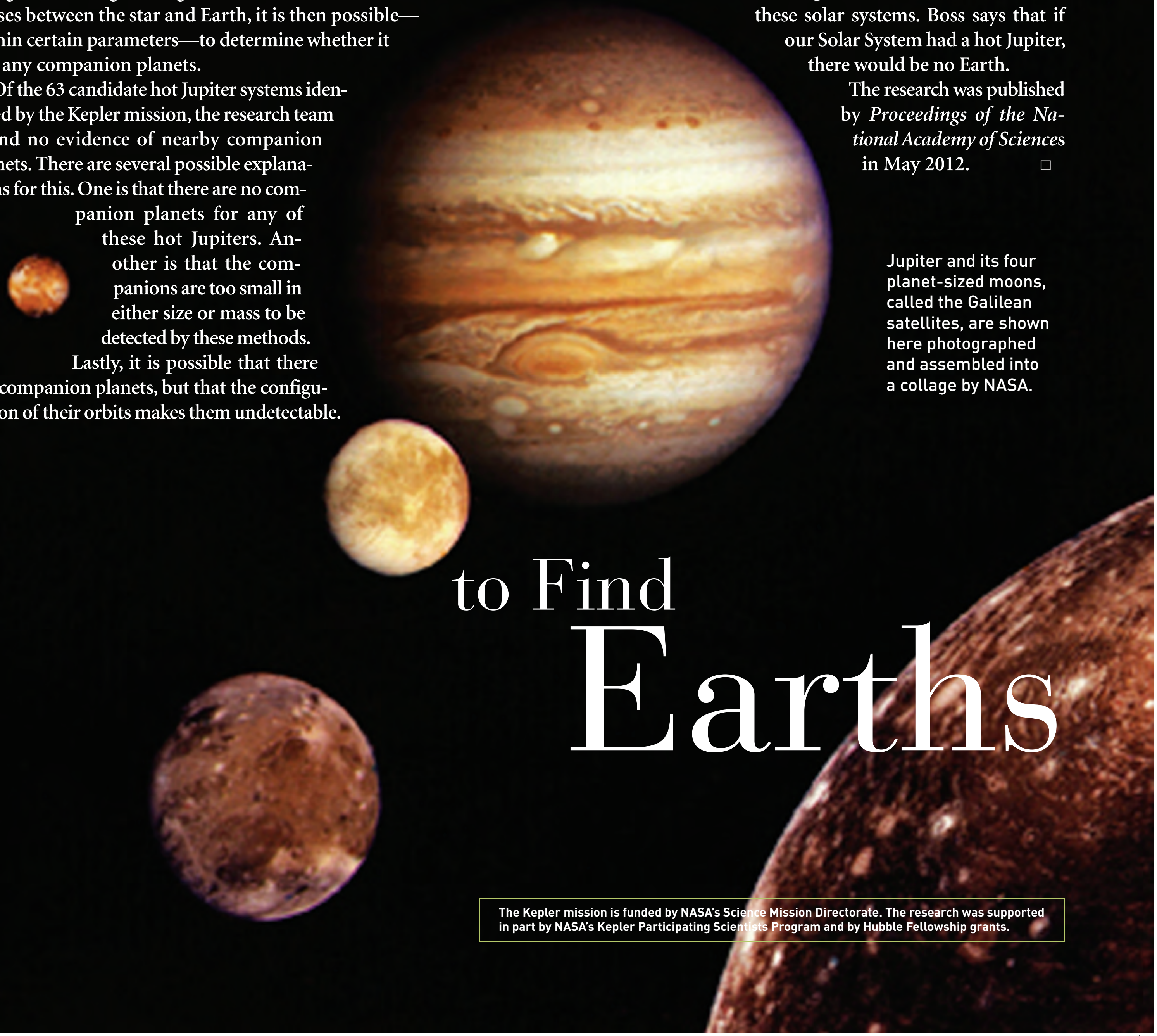
In the search for Earth-like planets, scientists look for clues and patterns that can help them narrow down the types of systems where potentially habitable planets are likely to be discovered. A team including Carnegie's Alan Boss narrowed down the search for Earth-like planets near Jupiter-like planets, indicating in the process that the early postformation movements of so-called hot Jupiter planets probably disrupted the formation of Earth-like planets. The team used data from NASA's Kepler mission to look at hot Jupiters—roughly, Jupiter-sized planets with orbital periods of about three days. If a hot Jupiter planet has been discovered by a slight dimming of brightness in the star it orbits as it passes between the star and Earth, it is then possible—within certain parameters—to determine whether it has any companion planets.

Of the 63 candidate hot Jupiter systems identified by the Kepler mission, the research team found no evidence of nearby companion planets. There are several possible explanations for this. One is that there are no companion planets for any of these hot Jupiters. Another is that the companions are too small in either size or mass to be detected by these methods. Lastly, it is possible that there are companion planets, but that the configuration of their orbits makes them undetectable.

However, when expanding the search to include systems with either Neptune-like planets (known as hot Neptunes) or "warm Jupiters" (Jupiter-sized planets with slightly larger orbits than hot Jupiters), the team found some potential companions. Of the 222 hot Neptunes, there were two with possible companions, and of the 31 warm Jupiters, there were three with possible companions.

These findings imply that systems with Earth-like planets form differently from systems with hot Jupiters. It is believed that hot Jupiters form farther out from their suns and then migrate inward. But this migration could disrupt the formation of Earth-sized planets closer to the center of these solar systems. Boss says that if our Solar System had a hot Jupiter, there would be no Earth.

The research was published by *Proceedings of the National Academy of Sciences* in May 2012. □



Jupiter and its four planet-sized moons, called the Galilean satellites, are shown here photographed and assembled into a collage by NASA.

The Kepler mission is funded by NASA's Science Mission Directorate. The research was supported in part by NASA's Kepler Participating Scientists Program and by Hubble Fellowship grants.

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Images courtesy Peter Kratochvil, PublicDomainPictures.net

Preindustrial Emissions Count, Too

Today's modern traffic, such as in Beijing shown here, will have effects on the climate well into the future.

When evaluating the historic contributions made by different countries to the greenhouse gases found in Earth's atmosphere, calculations generally go back no further than the year 1840. Research from Carnegie's Julia Pongratz and Ken Caldeira shows that carbon dioxide contributions from the preindustrial era still impact today's climate. The burning of fossil fuels that came with industrialization released massive amounts of carbon dioxide emissions into the atmosphere, causing global warming. But clearing forests and other wild areas for agricultural purposes also contributes to atmospheric carbon dioxide, and these releases have been happening since before industrialization.

The relatively small amounts of carbon dioxide emitted many centuries ago continue to affect atmospheric carbon dioxide concentrations and our climate today, though to a small extent. But looking into the past illustrates that the relatively large amount of carbon dioxide that we emit today will continue to impact the atmosphere and climate for centuries into the future.

Moreover, the effect of accounting for preindustrial emissions can have important consequences for the amount of climate change attributed to certain regions. In some regions, such as North America, preindustrial clearing is only a small part of the total carbon picture because of the massive quantities released by burning fossil fuels. But in other regions, particularly China and India, the ratio of preindustrial to industrial emissions is high.

The world's population increased about five-fold between 800 and 1850 A.D., and half that growth occurred in China and India. This led to substantial deforestation in the preindustrial era. On the other side of the coin, cumulative postindustrial fossil fuel carbon emissions for these nations are relatively low, reaching substantial levels only in recent years.

Using advanced models, Pongratz and Caldeira determined that accounting for preindustrial emissions shifts attribution of global temperature from industrialized nations to developing nations by up to 3%. For example, the study found that considering emissions from preindustrial land-use change increases the amount of total global warming that can be attributed to emissions from South Asia (a region that includes India) from 5.1% to 7%–an increase of 37% in the amount previously attributed to this region. Emissions from North America, Europe, and the former Soviet Union have caused more than half of all global warming, even though fewer people live in those regions combined than live in India alone.

Julia Pongratz (left) and Ken Caldeira (right) of Global Ecology conducted the study.

Images courtesy Ken Caldeira and Julia Pongratz

The researchers note that their work is not intended to increase the blame on people living today in the developing world for our current climate problems based on what their ancestors did centuries ago, particularly considering the much larger climate impact being made by modern industrialized nations on a daily basis.

Pongratz and Caldeira's work was published in *Environmental Research Letters.* □

Solving Mantle Mysteries

Scientists have long speculated about why there is a large change in the strength of rocks that lie at the boundary between two layers immediately under Earth's crust: the lithosphere and the underlying asthenosphere. Understanding this boundary is central to our knowledge of plate tectonics and thus the formation and evolution of our planet.

A new technique for observing this transition area, particularly in the portion of Earth's mantle that lies beneath the Pacific Ocean basin, has led Carnegie and Goddard Space Flight Center scientist Nick Schmerr to new insights into the origins of the lithosphere and asthenosphere. Schmerr's work was published in the March issue of *Science*.

The lithosphere-asthenosphere boundary, or LAB, represents the transition from the hot, convecting mantle asthenosphere to the overlying cold, rigid lithosphere. The oceanic lithosphere thickens as it cools over time, eventually sinking back into the mantle at Earth's so-called subduction zones where one tectonic plate slides under another.

Studies of seismic waves traveling across the LAB show higher wave speeds in the lithosphere and lower speeds in the asthenosphere. In some regions, seismic waves indicate an abrupt 5 to 10% decrease in wave speeds between about 20 to 75 miles (35 to 120 km), forming a boundary known as the Gutenberg discontinuity. In many cases the depth of the Gutenberg discontinuity is roughly coincident with the expected depth of the LAB, leading to the suggestion that the two boundaries are closely interrelated.

However temperature alone cannot fully explain the abrupt change in the mechanical and seismic properties that have been observed at the Gutenberg discontinuity. This has led many scientists to suggest that other factors—such as the presence of molten rock, water, and/or a decrease in the grain size of minerals—may also play important roles.

Older techniques made imaging seismic discontinuities shallower than 60 miles (100 km) quite difficult. But an innovative observation technique—one that incorporates seismic waves that sample beneath remote regions of the Earth at higher frequencies—and new signal processing techniques enabled Schmerr to hone in on the Gutenberg discontinuity.

Schmerr discovered that the seismic discontinuity is not a Pacific-wide phenomenon but rather is only detectable beneath regions with recent surface volcanism. He also found the Gutenberg discontinuity appears to become deeper beneath older crust, confirming the discontinuity is indeed related to the LAB.

Schmerr proposes that the Gutenberg discontinuity is formed by partially molten rock produced in the asthenosphere that collects and ponds at the base of the lithosphere. Decompression of hot rock at small-scale upwellings or hot mantle plumes is responsible for generating the melt. The plumes thermally reheat the lithosphere, making it shallower than would be expected underneath older crust. □

Funding was provided by the Carnegie Institution for Science Department of Terrestrial Magnetism Postdoctoral Fellowship and the NASA Postdoctoral Program. The facilities of the IRIS Data Management Center were used to access the data required in this study.

The generation of partially molten rock locally sharpens the lithosphere-asthenosphere boundary (LAB), allowing seismic waves to reflect from the interface. Shear waves from an earthquake (star) travel through the Earth and reflect from the surface, and also where melt has ponded at the base of the lithosphere. The waves are recorded by seismometers (blue inverted triangle) deployed around the globe, providing a complete view of the LAB beneath the Pacific. Regions without melt will not produce a deeper reflection, signifying that melt is not the primary mechanism for weakening of rock in the asthenosphere.

Image courtesy Nick Schmerr

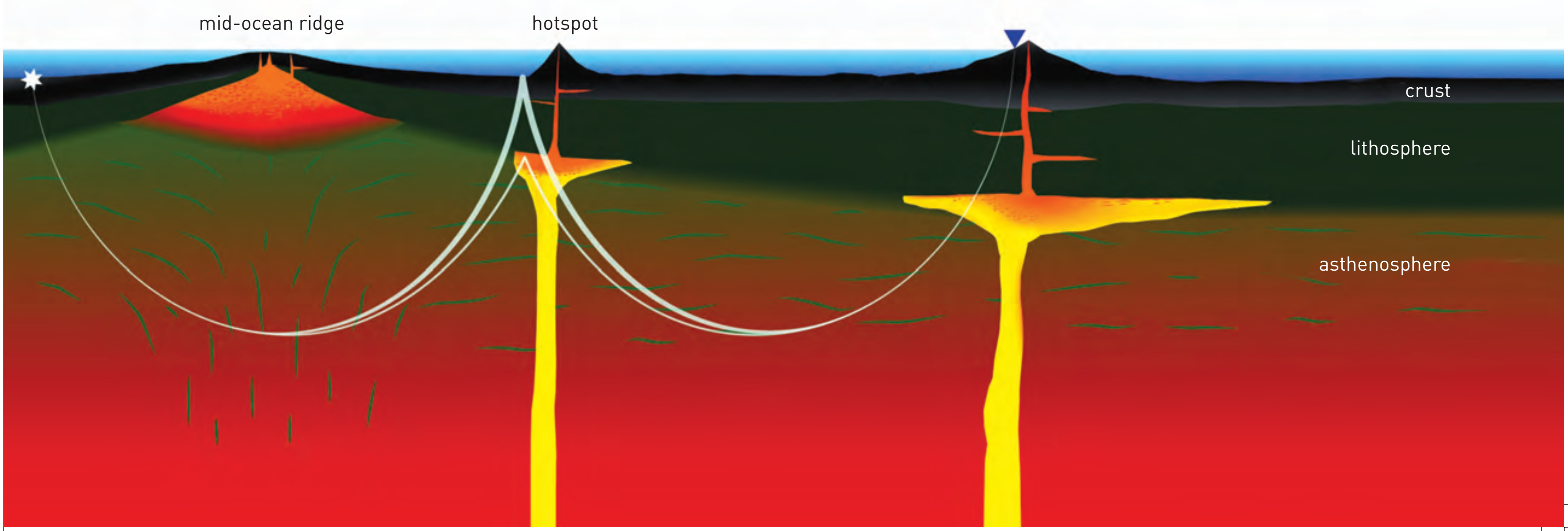

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Image courtesy NASA Image Exchange

Old Star, New Trick

Ian Roederer

The Big Bang produced lots of hydrogen and helium and a smidgen of lithium. Over the last 13.7 billion years stars have produced all of the heavier elements found on the periodic table. Astronomers analyze starlight to determine the chemical makeup of stars, the origin of the elements, the ages of stars, and the evolution of galaxies and the universe. Now, for the first time, astronomers co-led by Carnegie's Ian Roederer have detected the presence of arsenic and selenium in an ancient star in the faint stellar halo that surrounds the Milky Way. Arsenic and selenium are elements at the transition from light to heavy and had not been found in old stars before. This research was published in May in *The Astrophysical Journal.*

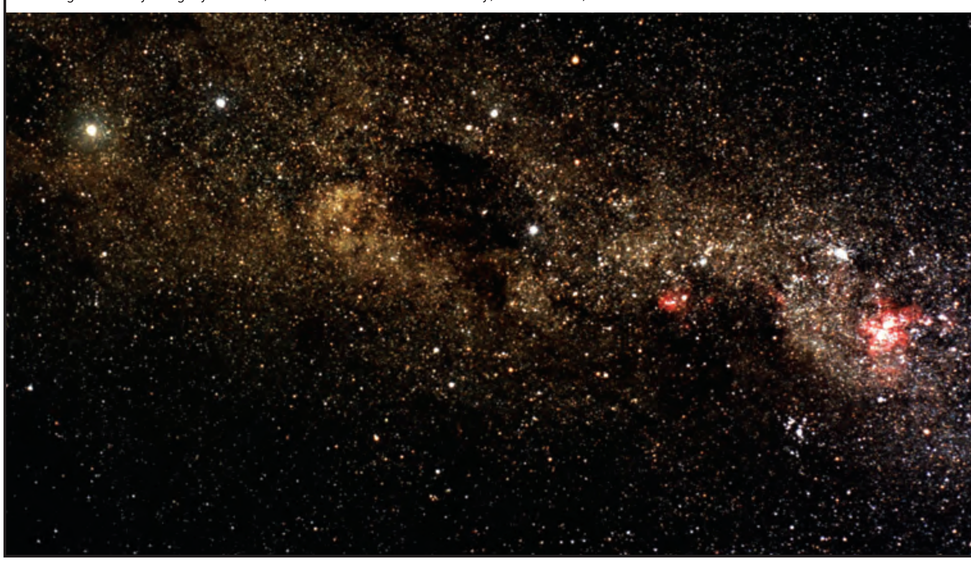
Stars like our Sun can produce elements on the periodic table up to oxygen. More massive stars can synthesize heavier elements—those with more protons in their nuclei—up to iron by nuclear fusion, which is the process in which atomic nuclei fuse and release lots of energy. Most of the elements heavier than iron are made by a process called neutron capture nucleosynthesis. Although neutrons have no charge, they can decay into protons after they're in the nucleus, producing elements with larger atomic numbers. One method is by exposure to a burst of neutrons during the violent supernova death of a star. This rapid process (r-process) can produce elements at the middle and bottom of the periodic table—from zinc to uranium—in the blink of an eye.

Roederer looked at an ultraviolet spectrum from the Hubble Space Telescope public archives to find arsenic and selenium in a 12-billion-year-old halo star dubbed HD 160617. These elements were forged in an even older star which has long since disappeared, and then—like genes passed on from parent to infant—they were born into the star we see today, HD 160617.

Stars like our Sun can produce elements on the periodic table up to oxygen.

The team also examined data about HD 160617 from the public archives of several ground-based telescopes and was able to detect 45 elements. In addition to arsenic and selenium they found rarely seen cadmium, tellurium, and platinum, all of which were produced by the r-process. This is the first time these elements have been detected together outside the Solar System. Astronomers cannot replicate the r-process in any laboratory since the necessary conditions are so extreme. The key to modeling the r-process relies on astronomical observations. □

Image courtesy Gregory J. Bock, Southern Astronomical Society, Queensland, Australia



In the panoramic image (above) from the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire project, a plethora of stellar activity in the Milky Way's galactic plane, reaching to the far side of our galaxy, is exposed.

The image at left shows the Milky Way Galaxy near the Southern Cross constellation. Roederer detected the presence of arsenic and selenium in an ancient star in the faint stellar halo that surrounds the Milky Way.

Ian Roederer is supported by the Carnegie Institution through the Carnegie Observatories Fellowship. Co-author James Lawler is supported by NASA grant NNX10AN93G.

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Image courtesy Michael Drummond, PublicDomainPictures.net

Image courtesy David Nance, USDA

(Top) Cellulose provides the structural support that allows plants, even giant trees, to withstand wind and weather.

(Bottom) The cotton harvested for human use has a high cellulose content.

Tough Stuff: Plant Cell Walls

Along with photosynthesis, the plant cell wall is one of the features that most sets plants apart from animals. New research from a team including Carnegie's David Ehrhardt and Ryan Gutierrez examines the structure of the wall's most crucial component, cellulose. Their research was published in February in *Proceedings of the National Academy of Sciences.*

Cellulose is synthesized in a semi-crystalline state that is essential for its function in the cell wall, but the mechanisms controlling its crystallinity are poorly understood. Cellulose is the primary constituent of the cell wall and as such is the most abundant biopolymer on the planet. It is also the key molecule providing the cell wall its essential mechanical properties.

A plant's cell wall serves several essential functions including mechanical support: Allowing the plant to withstand the onslaughts of wind and weather, permitting it to grow to great heights—hundreds of feet for trees like the giant redwood—and providing an essential barrier against invading pathogens. The cell wall is also a source of materials that have long been utilized by humans, including wood and cotton, in addition to serving as a potential source of biofuel energy.

Using a complex series of techniques, the research team was able to identify two mutations in the genes that encode certain cellulose making proteins, CESA1 and CESA3. Both of these mutations resulted in plant cell walls with defects in the structure of cellulose.

Normally, the individual sugar chains that make up cellulose bond to each other to make a semi-crystalline fiber. This crystalline structure gives cellulose its essential mechanical properties, such as rigidity and tensile strength. This structure is also responsible for cellulose's resistance to digestion, which provides a key barrier to utilizing cellulose as a source to produce liquid fuel.

The mutant CESA1 and 3 produced cellulose with lower crystallinity. This cellulose was also more easily digested, a process needed to liberate sugars from cellulose so they can be converted to useful fuels. □

This work was supported by the National Science Foundation and the Department of Energy. The Cornell High Energy Synchrotron Source is a national user facility supported by the National Science Foundation and the National Institutes of Health/National Institute of General Medical Sciences via the National Science Foundation.

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MARTIAN CARBON NOT BIOLOGICAL

Andrew Steele and his team analyzed evidence showing that carbon in some Martian meteorites formed on Mars and was not contamination from Earth.

Image courtesy NASA Image Exchange

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Molecules containing large chains of carbon and hydrogen—the building blocks of all life on Earth—have been the targets of missions to Mars from Viking to the present day. While these molecules have previously been found in meteorites from Mars, scientists have disagreed about how this organic carbon was formed and whether or not it came from Mars. Research by Carnegie's Andrew Steele provides strong evidence that this carbon did originate on Mars, although it is not biological. The work was published by *Science Express* in May 2012.

There has been little agreement among scientists about the origin of the large carbon macromolecules detected in Martian meteorites. Theories about their origin include contamination from Earth or other meteorites, chemical reactions on Mars, or that they are the remnants of ancient Martian biological life.

Steele's team examined samples from 11 Martian meteorites whose ages span about 4.2 billion years of Martian history. It detected large carbon compounds in 10 of them. The molecules were found inside grains of crystallized minerals. Using an array of sophisticated research techniques, the team was able to show that at least some of the macromolecules of carbon were indigenous to the meteorites themselves and were not the result of contamination from Earth.

Next the team looked at the carbon molecules in relation to other minerals in the meteorites to see what kinds of chemical processing these samples endured before arriving on Earth. The crystalline grains encasing the carbon compounds provided a window into how the carbon molecules were created. The findings indicate that the carbon was created during volcanism on Mars and show that Mars has been doing organic chemistry for most of its history.

In a separate paper published by *American Mineralogist,* Steele and his team studied a meteorite called Allan Hills 84001 that was reported to contain relicts of ancient biological life on Mars. The paper demonstrated that these supposed remnants could have been created by chemical reactions involving the graphite form of carbon, rather than by biological processes. Both of these papers reveal a pool of reduced carbon on Mars and will help scientists involved in future Mars missions distinguish these nonbiologically formed molecules from potential life. □

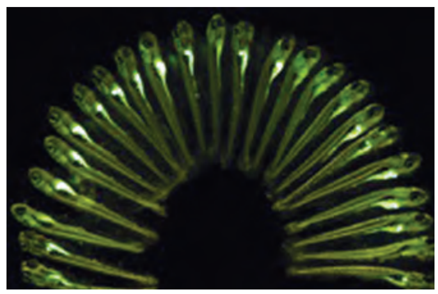
The research for the *Science Express* paper was funded by NASA, the W. M. Keck Foundation, the Natural Sciences and Engineering Research Council of Canada, and the Carnegie Institution for Science. The research for the *American Mineralogist* paper was supported by NASA.

A mature zebrafish

Fishy Fat Absorption

In mammals, most lipids—such as fatty acids and cholesterol—are absorbed into the body via the small intestine. The complexity of the cells and fluids that inhabit this organ makes it very difficult to study in a laboratory setting. New research from Carnegie's Steven Farber, James Walters, and Jennifer Anderson, published in *Chemistry & Biology*, has produced a technique that allows scientists to watch lipid metabolism in live zebrafish. This method enabled the researchers to describe new aspects of lipid absorption that could have broad applications for reducing the impact of diseases, such as diabetes, obesity, and cardiovascular disease.

The small intestine is composed of many types of cells. It is also where the agents that help digest and absorb food—microorganisms, bile, and mucus—are found. In this environment, dietary lipids are digested by enzymes and bile so that the body, via the enterocytes, or absorptive cells of the small intestine, can take in critical nutrients.



Images courtesy Steven Farber

The glowing guts of fluorescently tagged zebrafish larvae reveal their ability to digest lipids.

One type of lipid, cholesterol, is known to impact a number of highly prevalent human diseases and is absorbed by enterocytes. In zebrafish and humans, newly absorbed cholesterol combines with proteins to form lipoproteins, vehicles destined for the lymphatic system for subsequent distribution throughout the body.

Fatty acids, another lipid metabolic product, are also absorbed by enterocytes. Despite years of study, the physiological process by which proteins mediate the initial steps of fatty acid uptake is unclear. Once absorbed, the fatty acids are converted to triacyglycerides (fat) and are prepared either to be transported out of the cell or to be transformed into droplets of stored fat.

These processes involving fatty acids, triacyglycerides, and cholesterol influence each other in poorly understood ways. Enter Farber and his team's new research tool.

They developed a method for using fluorescently glowing forms of lipids to observe fat and cholesterol absorption in the small intestines of live zebrafish. Using this tool, they were able to demonstrate that the physiological processes regulating fatty acid absorption and cholesterol absorption are linked, and that a fatty acid called oleic acid increases the uptake of dietary cholesterol, among other things. □

This research was funded by the National Institutes of Health, the American Heart Association, the G. Harold and Leila Y. Mathers Charitable Foundation, and the Carnegie Institution for Science endowment.

Getting Extreme with Hydrogen

How hydrogen—the most abundant element in the cosmos—responds to extremes of pressure and temperature is one of the major challenges in modern physical science. Moreover, knowledge gained from experiments using hydrogen as a testing ground on the nature of chemical bonding can fundamentally expand our understanding of matter. New work from Carnegie's Chang-sheng Zha, Zhenxian Liu, and Russell Hemley has enabled researchers to examine hydrogen under pressures never before possible.

Observing hydrogen's behavior under very high pressures has been a great challenge for researchers because it is in a gas state under normal conditions. Hydrogen has three solid molecular phases. But the structures and properties of highest-pressure phases are unknown. For example, a transition to a phase that occurs at about 1.5 million times atmospheric pressure (150 gigapascals, GPa) and at low temperatures has been of particular interest. But there have been technological hurdles in examining hydrogen at these high pressures using static compression techniques.

Scientists speculate that under high pressures hydrogen transforms to a metal, which means it conducts electricity. It could even become a superconductor or a superfluid that never freezes—a completely new and exotic state of matter.

To explore hydrogen under these new extreme conditions, the team developed new techniques to contain hydrogen at pressures of nearly 3 million times normal atmospheric pressure (300 GPa) and temperatures ranging from -438°F (12 K) to close to room temperature and to probe its bonding and electronic properties with infrared radiation.

The team found that the molecular state was stable to remarkably high pressures, confirming extraordinary stability of the chemical bond between the atoms. Their work disproves the interpretations of experiments by other researchers reported last year indicating a metallic state under these conditions. The new study found evidence for semimetallic behavior in the dense molecular phase, but with electrical conductivity well below that of a full metal. Their work was published in *Physical Review Letters.*

Meanwhile, in another paper also published in *Physical Review Letters,* a team including Carnegie's Alexander Goncharov reported evidence for another phase of molecular hydrogen. They found this phase at the relatively high temperature of 80°F (300 K) and under pressures above 220 GPa. They suggest that the structure of hydrogen in this new phase is a honeycomb made of six-atom rings, similar to the carbon structure of graphene. □

Image courtesy iStockPhoto

The periodic table at left shows details of hydrogen.

Carnegie's Chang-sheng Zha (left) and Zhenxian Liu (right), with Russell Hemley, have examined hydrogen under pressures never before possible.

The research for the Zha paper was funded by the National Science Foundation and the Department of Energy. The research for the Goncharov paper was supported by the Engineering and Physical Sciences Research Council in the U. K.; the Institute of Shock Physics, Imperial College London; the Army Research Office; NASA Astrobiology Institute; and DOE's EFRee.

InBrief

❶ Carnegie president Richard Meserve

❷ Director of external affairs Susanne Garvey

Image courtesy Lisa Helfert

❸ From left to right: Sue Biggins, Sen. Ben Cardin (D-MD), and Yixian Zheng

❹ Steve Farber (right) poses with other awardees, Antonio Garcia-Bellido (left) and Cliff Tabin (middle).

❺ Eric Mills

❻ Peter Lopez

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Image courtesy Lisa Helfert

TRUSTEES AND ADMINISTRATION

Former Carnegie trustee and astronaut **Sally Ride** died of pancreatic cancer at the age of 61 in July.

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❶ Carnegie president **Richard A. Meserve** gave welcoming remarks at the Sixth International Symposium on Isotopomers on June 18 in Washington, DC. He moderated a discussion on nuclear disarmament with Special Envoy Ellen Tauscher on July 11 in Washington, DC, on behalf of the Foundation for Nuclear Studies. He participated in meetings of the Small Modular Reactor Subcommittee of the Secretary of Energy's Advisory Board on July 18-19 and was cospeaker for congressional staff concerning the report of the Blue Ribbon Commission on America's Nuclear Future on July 20 in Washington, DC. Meserve participated in council meetings of the National Academy of Engineering on July 31-Aug. 2 in Woods Hole, MA, and on Sept. 28-29 in Washington, DC. He spoke to a subcommittee of the Idaho Leadership in Nuclear Energy Commission on Aug. 24. He testified with Gen. Brent Scowcroft on the Blue Ribbon Commission report before the Senate Committee on Energy and Natural Resources on Sept. 12 in Washington, DC. Meserve chaired a forum on the Fukushima accident at the 56th IAEA General Conference on Sept. 17 in Vienna, Austria. He presided at a Harvard Board of Overseers meeting Sept. 22-23.

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❷ Director of external affairs **Susanne Garvey** was appointed president of the Pomona College Alumni Association Board for 2012-2013. This strengthens the Carnegie tie to the school. Observatories' astronomers lead advanced astrophysics seminars every spring at Pomona and mentor Pomona undergraduates every summer.

EMBRYOLOGY

Director **Allan Spradling** served on the Janelia Farm scientific review panel, the NIH Early Stage Investigator Award panel, and the Genetics Society of America MOHB-Cancer Genetics meeting with lab members Rebecca Frederick, Matt Sieber, and Rebecca Obniski. Spradling presented a lecture at the NIH modENCODE symposium and the keynote address at the National Inst. for Basic Biology Symposium in Okazaki, Japan.

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❸ **Yixian Zheng** presented her work at UC-San Diego and at the Gordon Research Conferences: Intermediate Filaments. She was an ASCB group member who met with congressional staff to explain the role of basic research in treatments for disease and the positive economic impact of NIH and NSF funded research.

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❹ **Steven Farber** and Jamie Shuda of U. Pennsylvania shared the SDB Viktor Hamburger Outstanding Educator Prize for BioEYES. He also was appointed a professor in The Johns Hopkins U. School of Education. Farber co-organized a workshop at the 10th International Conference on Zebrafish Development and Genetics in Madison, WI, and presented a lecture about education in the zebrafish meeting.

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Marnie Halpern attended the 10th International Conference on Zebrafish Development and Genetics in Madison, WI.

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Nick Ingolia attended "RNA Sciences in Cell and Developmental Biology II" at the RIKEN Center for Developmental Biology in Japan and the Gordon Research Conference on post-transcriptional gene regulation.

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Christoph Lepper was an invited speaker at the FASEB meeting "Skeletal Muscle Satellite and Stem Cells" in Lucca, Italy, in Aug.

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Staff associate **David MacPherson** is now an assistant member at the Fred Hutchinson Cancer Research Center.

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Spradling lab postdoc **Matt Sieber** was awarded a three-year Jane Coffin Childs Memorial Fund for Medical Research Fellowship. Postdoc **Rebecca Frederick** completed her training and is now a policy advisor at NINDS/NIH.

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Farber lab postdoc **Jessica Otis** was awarded a three-year NRSA fellowship. Fan lab graduate student **Michelle Rozo** was awarded a three-year NRSA predoctoral fellowship.

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❺ Ingolia graduate student **Eric Mills** was awarded a two-year American Heart Association predoctoral fellowship.

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❻ Three graduate students defended their Ph.D. theses: **Vanessa Matos-Cruz**, Halpern lab; **Peter Lopez**, Fan lab; and **Julio Castaneda**, Bortvin lab.

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Arrivals: Stephen Ching is a research technician in the Gall lab. Animal technician **Vance Martin** joined the animal facilities. Student volunteer **Jahi Omari** joined the Halpern lab. **Jun Wei Pek** is a collaborative fellow in the Gall/Spradling labs. **Yihan Wan** is visiting the Zheng lab. Undergraduate researcher **Stephanie Kuo** and lab technician **Reid Wood** joined the Lepper lab. New graduate students are: **Diana Camerota**, Bortvin lab; **Rebecca Obniski**, Spradling lab; **Vanessa Quinlivan-Repassi**, Farber lab; **Sara Roberson**, Halpern lab; **Gaelle Talhouarne**, Gall lab; **Blake Weber**, Zheng lab; **Yue Zheng**, Fan lab. Summer students were **Joseph Igwe**, **Aaron Katrikh**, **Joshua Raudebaugh**, and **Oscar Reyes**.

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Donald Brown Wins Lasker-Koshland Award!

Director Emeritus Donald Brown of the Dept. of Embryology received the prestigious 2012 Lasker-Koshland Special Achievement Award in Medical Science "for exceptional leadership and citizenship in biomedical science–exemplified by fundamental discoveries concerning the nature of genes–and by selfless commitment to young scientists; and by disseminating revolutionary technologies to the scientific community." □

Departures: Halpern postdoc **Sang Jung Ahn** left the lab for the Korea Research Inst. **Keisha Breland** left the animal facility. Research technician **Eugene Gardner** left the Gall lab for graduate school at U. Maryland. Halpern postdoc **Daniel Gorelick** took a position at U. Alabama-Birmingham. Spradling lab research technician **Joan Pulupa** left for graduate school at Rockefeller U. **Lakishia Smith** left the administration. Research technician **Liyang Tang** left the Lepper lab for school. Lab technicians **Karina Conkrite**, **Min Cui**, and **Michael Rongione** left the MacPherson lab.

GEOPHYSICAL LABORATORY

Director **Russell Hemley** presented the talk "Hydrogen at High Pressure" at the Gordon Research Conferences: Research at High Pressure held June 24-29 in Biddeford, ME.

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❼ **Alexander Goncharov** was appointed a visiting professor at the Inst. of Solid State Physics (ISSP), Chinese Academy of Sciences, at a newly established Center for Energy Matter in Extreme Environments. He hosted postdoctoral associate **Sergey Lobanov** and postdoctoral student **Artem Chanyshev** from Novosibirsk, Russia. Their high-pressure/temperature work was supported by the Deep Carbon Observatory and the Alfred P. Sloan Foundation.

—

Bob Hazen presented lectures on mineral evolution at Boston College, MIT, and the 22nd VM Goldschmidt Conference in Montreal. He lectured on the Deep Carbon Observatory at the Jet Propulsion Laboratory (JPL). Hazen was named 2012 Condon Lecturer (Oregon State U.), 2013 Linus Pauling Memorial Lecturer (Inst. for Science, Engineering and Public Policy), 2013 Oualline Lecturer (U. Texas-Austin), and 2013 Naff Lecturer (U. Kentucky).

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Ho-kwang (Dave) Mao presented an invited talk at the "Frontiers of Diamondoid Science" workshop June 18-19 at Stanford U. He also delivered a plenary talk at the 6th Asian Conference on High Pressure Research Aug. 8-12 in Beijing.

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Douglas Rumble was appointed a visiting adjunct professor at Dartmouth College.

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Amol Karandikar presented the invited poster at the Gordon Research Conferences: Research at High Pressure held June 24-29 at U. New England, Biddeford, ME.

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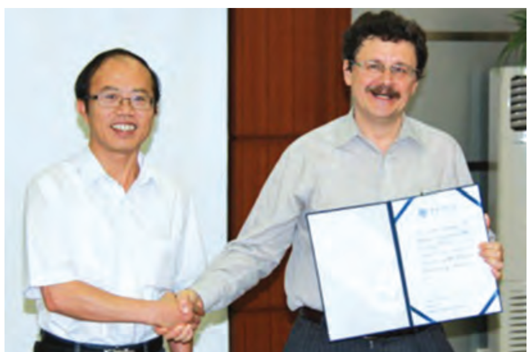
Research Scientist **Karyn Rogers** attended the 2nd International Workshop on Microbial Life Under Extreme Energy Limitation in Aarhus, Denmark, and the C-DEBI workshop on "Ocean Crust Processes and Consequences for Life" in Bremen, Germany. She also visited the high-pressure microbiology laboratory of Jens Kallmeyer in Potsdam,



❼ Yingjian Wang (left), director of Hefei Institutes of Physical Science, and Alexander Goncharov pose at the award ceremony at the Inst. of Solid State Physics on July 18.

❼ Artem Chanyshev

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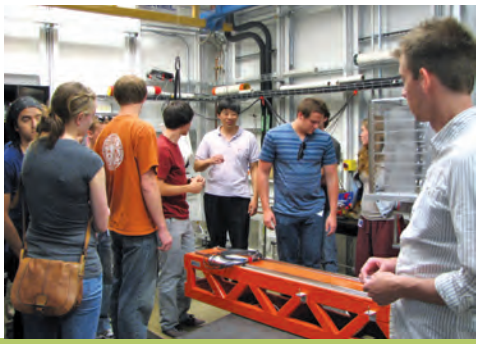


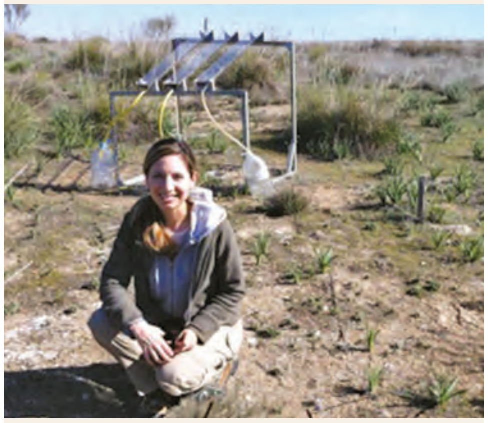
Images courtesy HPCAT

❽

(Left) Beamline scientist Yue Meng gives a tour of the bending magnet beamline hutch for the "Science Careers in Search of Women Conference" group.

(Center) The group of girls participating in the "Science Careers in Search of Women Conference" pose at HPCAT.

(Right) On June 30 undergraduate students participating in the Research Experience for Undergraduates visited HPCAT as part of their tour of Argonne National Laboratory.



❾ Rebecca Hernandez

❿ Jen Johnson

⓫ Dorit Hammerling

Germany. In Aug. she conducted field-work on Cerro Negro Volcano, Nicaragua, to investigate the habitability of the acid sulfate weathering fumarole system—a Mars analog environment.

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Vincenzo Stagno gave a talk as an invited speaker at the 22nd VM Goldschmidt Conference in Montreal in June. In Sept. he was awarded the prize for the best Ph.D. thesis by the Italian Soc. of Mineralogy and Petrology.

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HPSynC/HPCAT

The High Pressure Synergetic Consortium (HPSynC) facility welcomed the following visiting investigators to Argonne National Laboratory's Advanced Photon Source (APS): **Jung-Fu Lin**, assistant professor, Jackson School of Geosciences at U. Texas-Austin, and **Sean Shieh**, associate professor at U. Western Ontario, Canada.

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The High Pressure Collaborative Access Team (HPCAT) welcomed **Genevieve Boman** and **Hongping Yan** (postdoctoral fellow, Deep Carbon Observatory).

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❽ HPCAT's **Genevieve Boman**, **Yue Meng**, and **Maddury Somayazulu** participated in Argonne National Laboratory's "Science Careers in Search of Women Conference" offered to upper level high school girls. Beamline associate Genevieve Boman gave a presentation on her science and high-pressure research at HPCAT, while Meng and Somayazulu talked to the girls about research at the lab.

—

Guoyin Shen gave two invited talks, one at the Inst. of High Energy Physics on Apr. 26 and the other at Beijing U. on Apr. 27.

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Summer intern **Katie Lazarz** established a new user lounge at HPCAT with a display of the facility. She also collected and organized HPCAT statistics. Intern **Daniel Shen** studied the behavior of amorphous silicon at high pressures with mentor beamline scientist Stas Sinogeikin.

—

On June 28 the American Physical Society Topical Group on Shock Compression of Condensed Matter toured HPCAT to exchange ideas and information. On July 27 students from U. Nevada-Las Vegas stopped at HPCAT on their tour of APS as part of the Research Experience for Undergraduates. HPCAT also hosted NX School on Aug. 13-15.

GLOBAL ECOLOGY

On Aug. 1 dept. director **Chris Field** testified at a hearing of the US Senate Committee on Environment and Public Works on the latest climate science.

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In Apr. **Ken Caldeira** participated in the annual meeting of the European Ocean Acidification Research Program in Nice, France. He is a member of its International Science Advisory Panel. He also did a commentary on fossil fuel prices and carbon emissions for the BBC World Service on May 1. On May 11 Caldeira gave a keynote talk about energy systems and emissions for "Energy Policy in the European and Global Context" at the G8 & G20 Youth Summit in Berlin.

—

❾ Field lab's **Rebecca R. Hernandez** was an NSF-sponsored trainee at MicroTrop's workshop, "Microbial Interactions and Sustainable Soil Management" June 24-July 21 in Dakar, Senegal. She received advanced training in tropical soil ecology, agroecosystems, and food security, and she collaborated with 20 other scientists from North America and Africa.

—

❿ Berry lab Ph.D. student **Jen Johnson** led a field expedition to AZ, NM, and TX between June and Aug. to study the ecology of *Flaveria*—a model plant system for studying the evolution of C4 photosynthesis. Johnson, with Carnegie's **Joe Berry** and Claire Kouba (Stanford), rafted down the Colorado River to get to remote populations of *Flaveria*. The trip was a collaboration with the USGS Grand Canyon Monitoring and Research Center, Grand Canyon National Park, and the "Partners in Science" program of Grand Canyon Youth. Intern **Eric Slessarev** was a key player in the expedition. At the beginning of Sept. Johnson presented some preliminary results from this work at "Southwest Climate: Past, Present, and Future" at the Valles Caldera National Preserve in Jemez Springs, NM.

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Michalak lab's **Abhishek Chatterjee** was selected to attend an international summer school on advanced data assimilation for geosciences at École de Physiques des Houches in France from May 28-June 15. He is one of the 55 participants selected from all over the world.

—

⓫ Michalak lab's **Dorit Hammerling** was selected for a two-year postdoctoral fellowship at the Statistical and Applied Mathematical Sciences Inst. (SAMSI), for a program that focuses on fundamental mathematical questions and computer science posed by massive datasets. SAMSI is a partnership of Duke U., North Carolina State U., U. North Carolina-Chapel Hill, and the National Inst. of Statistical Sciences in Research Triangle Park, NC. SAMSI is part of NSF.

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Mathew Colgan received his doctorate from Stanford U. and joined the Asner lab as a postdoc on July 1.

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Arrivals: Teresa Bilir joined the Field group at Jasper Ridge Apr. 16. **Natalie Vande Pol** was a Field lab intern for July. The Asner lab welcomed intern **Paola Perez** on July 1 and computer programmer **Sinan Sousan** July 24. Postdoc **Yuanyuan Fang** joined the Michalak lab on Aug. 1; research assistant **Jeff Ho** joined June 25. **Kate Ashe** joined Luis Fernandez's team in Peru Apr. 16.

—

Departures: Former Asner lab programmer **Aravindh Balaji** returned to India on Apr. 27. Asner lab's **Kyla Dahlin** received her doctorate from Stanford U. in June. She left in Oct. for a postdoc position at the National Center for Atmospheric Research in CO. **Ben Kravitz** left the Caldeira lab at the end of Aug. for Lawrence Berkeley National Laboratory. Visiting researcher **Alessandro Baccini** returned to the Woods Hole Research Center in Aug. **Guillaume Tochon**, a visiting Asner intern, returned to France on June 22.

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The dept. recently upgraded some computer equipment and storage units and

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Image courtesy Barry Madore

Director Wendy Freedman was elected a fellow of the American Physical Society this spring. Freedman was selected to receive a NASA Honor Award—an Exceptional Scientific Achievement Medal "for determining the Hubble constant with unprecedented precision using the Spitzer Space Telescope." In Aug. she attended the 28th General Assembly of the International Union (IAU) in Beijing and gave a plenary talk, plus two additional talks—one on the Giant Magellan Telescope (GMT). □

Observatories director Wendy Freedman answers questions following her plenary address at the IAU in Bejing, China.

⓬ John Mulchaey

⓭ Andrew Benson

donated the obsolete equipment to the Children's Discovery Museum of San Jose to improve the museum's CDMedia.Studio, which provides computer-assisted programs for middle school youth.

OBSERVATORIES

Staff astronomer **Eric Persson** was invited to speak at the Jodrell Bank Center for Astrophysics at U. Manchester-UK July 2-4. He gave a talk on deep, multi-frequency radio observations of high-redshift starbursts at a South Pole Telescope Submillimeter Galaxy workshop held at Caltech Aug. 6-8.

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Staff astronomer **Luis Ho** was appointed associate editor of *The Astrophysical Journal Letters.*

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Staff astronomer **Ian Thompson** gave a couple of talks in Cairns, Australia, in Aug. at the "Nuclei in the Cosmos" meeting and the "Workshop on r-process Nucleosynthesis."

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Staff astronomer **Michael Rauch** was a Raymond and Beverly Sackler Distinguished Visitor at the U. of Cambridge, collaborating with colleagues at the Inst. of Astronomy and the Kavli Inst. for Cosmology in July and Aug.

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⓬ Staff astronomer **John Mulchaey** organized the meeting "Energetic Astronomy: Richard Mushotzky at 65" held June 4-6 in Annapolis, MD, in honor of Richard Mushotzky's 65th birthday.

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Staff astronomer **Joshua Simon** gave a public lecture to the Ventura County Astronomical Society on Aug. 18 titled "A Journey Back in Time to the First Stars."

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Staff associate **Jeff Crane** attended the SPIE Astronomical Telescopes and Instrumentation Conference in Amsterdam in July and presented a poster about the Michigan/Magellan Fiber System (M2FS). He also contributed to presentations about the Apache Point Observatory Galactic Evolution Experiment (APOGEE) and the GMT-CfA, Carnegie, Católica, Chicago Large Earth Finder (G-CLEF).

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⓭ In June staff associate and Hale Scholar **Andrew Benson** gave a talk at the "CMB Polarization Cosmology in the Coming Decade" workshop in Pasadena, CA.

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Postdoctoral research associate **Joshua Adams** gave a poster at Kavli Inst. for Theoretical Physic's (KITP) "First Light and Faintest Dwarfs" conference held in Santa Barbara Feb. 13-17.

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Postdoctoral research associate **Rik Williams** spoke at the conference "Stellar Populations Across Cosmic Times" at the Inst. Astrophysique de Paris, France, July 25-29. He also spoke at the conference "Galaxies: Insight Out" in Leiden, The Netherlands, July 2-5.

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Postdoctoral research associate **Nimish Hathi** presented his work on Lyman-break galaxies at z=1-3 at the "Ultraviolet Astronomy: HST and Beyond" conference in Kauai, Hawaii, June 18-21.

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Hubble-Carnegie-Princeton Fellow **Mansi Kasliwal** attended the "Great Andromeda Galaxy Workshop" in Princeton, NJ, in June. In July she participated in the Palomar Transient Factory team meeting, KITP, UC-Santa Barbara, and in Aug. the Rattle and Shine Conference, KITP, UC-Santa Barbara. In Sept. she traveled to McGill U., Montreal, Canada, and Las Campanas, Chile.

PLANT BIOLOGY

On May 7 **Wolf Frommer** gave a talk about Förster resonance energy transfer (FRET) sensors at U. Potsdam, Germany. May 8 he gave a seminar at Max Planck Inst. of Molecular Plant Physiology, Potsdam, about FRET. He gave a talk at the 29th Annual Interdisciplinary Plant Group Symposium "Plant Physiology in the Omics Era" in St. Louis, MO, also about FRET, and he gave an invited talk at the 77th Cold Spring Harbor Symposium May 30-June 4. On July 1-6 he spoke at the Gordon Research Conferences: Membrane Transport Proteins held in Les Diablerets, Switzerland, about SWEET transporters. He was a chair of the Plant-Microbe Symposium at the July 20-24 annual meeting of American Society of Plant Biologists held in Austin, TX, and gave a talk titled "Plant Versus Pathogen: A Tug of War for Food."

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On May 8-11 **Arthur Grossman** served on a review panel to evaluate the future of the UTEX Culture Collection of Algae in Austin, TX. He was a member of a Dept. of Energy Joint Genome Institute "Strategic Planning for the Genomic Sciences" workshop held May 30-June 1 in Washington, DC. He was an invited plenary speaker at the 15th International Conference on the Cell and Molecular Biology of *Chlamydomonas* in Potsdam, Germany, June 3-10. On June 18-27 Grossman spoke on the *Porphyra* genome at the Phycological Society of America and Research Coordination Network held in Charleston, SC. He also attended an editorial meeting of the *Journal of Phycology* held June 18-27 in Charleston, SC. Grossman was on a review panel for bioenergy for the Advanced Research Projects Agency-Energy held in Washington, DC, on Aug. 7-9. He was also on a review panel to evaluate the NSF Experimental Program to Stimulate Competitive Research at U. Nebraska Aug. 14-16.

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David Ehrhardt spoke at the Gordon Research Conferences: Plant Cell Walls at Colby College, Waterville, ME, on Aug. 4-9. On Aug. 12-17 he gave a keynote address at the Gordon Research Conferences: Plant and Microbial Cytoskeleton in Andover, NH.

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Kathryn Barton was an honors examiner for four Swarthmore College students—Julia Cooper, Rosalie Lawrence, Elan Silverblatt-Buser, and Melissa Frick, who have to defend their theses. All four were students of Nick Kaplinsky—a former Carnegie postdoc. Rosalie Lawrence's research was supervised by **David Ehrhardt**. Barton gave an invited talk at the 77th Cold Spring Harbor Symposium on "Quantitative Biology: The Biology of Plants." She also gave an invited talk at the Society for Developmental Biology 72nd Annual Meeting, Montreal, July 19-23.

—

José Dinneny gave a talk at the Gordon Research Conferences: Salt and Water Stress in Plants held June 24-29 at the Chinese U. of Hong Kong. He also spoke about the salt stress response at the American Society of Plant Biologists conference on July 19-24 in Austin, TX.

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Martin Jonikas gave a talk about transforming our understanding of photosynthesis at the 15th International Conference on the Cell and Molecular Biology of *Chlamydomonas* in Potsdam, Germany, on June 6.

—

Wolf Frommer and **David Ehrhardt** co-organized the 4th Pan American Plant Membrane Biology Workshop held at Asilomar, CA, on May 16-20 where Ehrhardt delivered a talk about the

Wolf Frommer received the Lawrence Bogorad Award at the American Society of Plant Biologists meeting held July 20 in Austin, TX, for "his major contributions in the development of fundamental tools and technologies essential for breakthrough discoveries that advance our understanding of glucose, sucrose, ammonium, amino acid, and nucleotide transport in plants." □

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⓭ Jianjun Guo

⓭ Jonas Danielson

⓭ Luke Mackinder

⓭ Sean Blum

⓮ Director Lindy Elkins-Tanton conducts fieldwork in Siberia.
Images courtesy Lindy Elkins-Tanton

cortical cytoskeleton. Postdoctoral speakers included **Cindy Ast**, **Li-Qing Chen**, **Roberto DeMichele**, **Guido Grossmann**, **Cheng-Hsun Ho**, and **Alexander Jones**.

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TAIR curator **Donghui Li** talked about TAIR at Biocuration 2012 and at a biocuration workshop in Washington, DC, on Apr. 2-5.

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Tong-Seung Tseng, a senior research associate in the Briggs lab, presented a talk about blue light at the American Society of Plant Biologists meeting held in Austin, TX, July 20. Also presenting a joint poster at this meeting were **Winslow Briggs**, **David Ehrhardt**, visiting researcher **William Eisinger**, and senior researcher **Rajnish Khanna**.

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⓭ **Arrivals:** Postdoctoral research associate **Chan-Ho Park** joined the Rhee lab on Apr. 1 from Chung-Ang U., Korea, as did postdoc **Jianjun Guo** on July 16 from UC-Davis. May 1 arrivals to the Frommer lab were Swedish Research Council Fellow **Jonas Danielson** from Lund U., Sweden, and lab technician **Tianying Su** from UC-San Diego. Carnegie **F**ellow **Luke Mackinder** joined the Jonikas lab on June 18 from Kiel U., Germany. On July 16 lab technician **Sean Blum** also joined that lab. Postdoctoral research associate **Shahram Emami**, from UC-Davis, and Carnegie Fellow **Ruben Rellen-Alvarez**, from Autonomous U. of Madrid, Spain, joined the Dinneny lab on June 1 and July 1, respectively.

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Departures: Two members of the TAIR group left on Mar. 31**:** **Philippe Lamesch**, curator, left to be cultural outreach coordinator for Luxembourg**,** and intern **Damian Priamurskiy** left to return to school. On June 30 **Enrico Magnani** departed the Barton lab for INRA-Centre de Versailles-Grignon, France. Two left on July 13, Jonikas lab technician **Spencer Gang** and Frommer lab technician **Maria Sardi**, both for graduate school. On Aug. 31 **Roberto de Michele** returned to Italy for a position at a university in Milan.

TERRESTRIAL MAGNETISM

⓮ In May director **Lindy Elkins-Tanton** gave an invited colloquium at Goddard Space Flight Center and was on a Ph.D. defense committee at MIT. A member of the Committee on Astrobiology and Planetary Science (CAPS) at the National Academy of Sciences, Elkins-Tanton participated in a CAPS meeting in May and gave an invited talk at the "Workshop on Planetary Origins and Frontiers of Exploration" at the Weizmann Inst. of Science in Israel. That month she also attended the Carnegie/Explorers Club event in Manhattan. In June Elkins-Tanton gave an invited talk at the AGU Chapman Conference on Volcanism and the Atmosphere in Selfoss, Iceland, and another at "Comparative Climatology of Terrestrial Planets" in Boulder, CO. In July she conducted fieldwork in Siberia. In Aug. she taught an Earth and space science class for middle and high school teachers at U. Massachusetts-Amherst. In Sept. Elkins-Tanton gave an invited talk at the Smithsonian workshop "Life in the Cosmos" and an invited plenary lecture at the BABEL conference in Boston, MA. In Oct. she organized a workshop on collaborative planetary science to include the Observatories and the Geophysical Laboratory. She also presented a paper at the American Astronomical Society Division for Planetary Sciences meeting in Reno, NV, that month. In May Elkins-Tanton had an asteroid named after her, Asteroid (8252) Elkins-Tanton.

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⓯ In June DTM held a good-bye party for former director Sean Solomon, who is now director of the Lamont-Doherty Earth Observatory at Columbia U. A Princeton Elm tree was planted in his honor.

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In Aug. staff scientist **Conel Alexander** attended the 75th Annual Meeting of the Meteoritical Society, in Cairns, Australia, as did ion microprobe research specialist **Jianhua Wang** and postdoctoral fellows **Shoshana Weider** and **Alexander (Zan) Peeters**.

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In June staff scientist **Alan Boss** served on the Ph.D. thesis defense committee for Johannes Sahlmann, of U. Geneva, and gave an invited seminar. In July Boss and staff scientist **Alycia Weinberger** performed the first all-remote run for their astrometric planet search program, operating the CAPSCam camera on the du Pont telescope in Chile from their Washington, DC, facility. In Aug. Boss attended the IAU's 28th General Assembly in Beijing, where, as commission president, he chaired the meeting of IAU Commission 53 on Extrasolar Planets. Boss spoke about habitable worlds around M dwarf stars at IAU Symposium 293, held in Beijing during Aug. He chaired sessions at both IAU Symposium 293 and IAU Special Session 10 on Dynamics of the Star-Planet Relations and served on the Scientific Organizing Committees for both meetings. In Sept. Boss chaired the sessions on exoplanets at the "NASA New Telescope Meeting" at Princeton U. In Oct. he spoke about the orbital migration of giant protoplanets at the annual meeting of the AAS in Reno, NV.

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Staff scientist **Paul Butler** presented the May lecture "Planets Around Nearby Stars" at the Explorers Club in Manhattan.

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In July **Rick Carlson** taught at the Kavli Inst. for Theoretical Physics at UC-Santa Barbara. In Oct. he attended the Ph.D. defense of Matthew Sanborn at Arizona State U.

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Staff scientist **John Chambers** was awarded the 2012 Paolo Farinella Prize based on his research results in the field of formation and early evolution of the Solar System. In Sept. Chambers attended the European Planetary Science Congress in Madrid, Spain. In Oct. he attended the 44th annual meeting of the AAS in Reno, NV.

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In May staff scientist **Larry Nittler** gave an invited talk at the annual workshop on Secondary Ion Mass Spectrometry in Philadelphia. In Aug. he attended the 12th International Symposium on Nuclei in the Cosmos and the 75th Annual Meeting of the Meteoritical Society, both in Cairns, Australia.

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The annual Plant Biology intern program from May to Sept. was larger this year. Held in conjunction with Stanford U., the program culminated in a poster presentation. Barton lab technician **Adam Longhurst** was the organizer. Interns included: **Jose Enrique Bravo**, **Marisa Brown**, **Rik Brugman**, **Anne-Hortense Carrot**, **Lilyana Chandra**, **Tara Chandran**, **Philipp Denning**, **Varun Dwaraka**, **Amir Ghowsi**, **Caryn Johansen**, **Andrew Lin**, **Stephanie May**, **Qais Moradi**, **Grace Park**, **Kimberly Pham**, **Valeria Sandoval**, **Alice Shieh**, **Jacqueline Tang**, **Tam Tran**, **Max Tyler**, **Graciela Watrous**, and **Mandy Wong**. □

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⓯ Sean Solomon planting the tree in his honor.

⓰ Book lovers from DTM and GL crowded into the campus library in June for a book fair marking the summer solstice.

In May staff scientist **Scott Sheppard** presented at the "Asteroids, Comets, Meteors 2012" conference in Niigata, Japan. In Oct. he gave a talk at Pontifical Catholic U. in Chile. He presented at the AAS meeting in Reno and was a part of the Scientific Organizing Committee.

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In Aug. **Diana Roman** presented "Intermediate-Term Seismic Precursors to the 2007 Father's Day Intrusion and Eruption at Kilauea Volcano, Hawaii" at the AGU Chapman Conference on Hawaiian Volcanoes. She conducted fieldwork in Hawaii in Aug. and Sept.

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In May **Steve Shirey** organized and led a three-day field trip to look at geoneutrino-producing Archean and Proterozoic crustal rocks of the Sudbury, Ontario, for researchers from U. Maryland and the Sudbury Neutrino Observatory.

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In Aug. **Erik Hauri** and DTM-DCO Fellow **Jared Marske** collected cinder cones in Hawaii. They then presented research results at the AGU Chapman Conference on Hawaiian Volcanoes Aug. 20-24. The conference honored the founding of the Hawaiian Volcano Observatory, which was originally supported in part by Carnegie researcher Frank Perret from 1911 to 1915.

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In July Mass Spec lab manager **Tim Mock**, GL staff scientist **Anat Shahar**, and **Steve Shirey** hosted the Smithsonian Science Education Academy for Teachers, who learned how geological age is measured in the mass spectrometry lab. In Aug. Shirey joined a group from U. Wisconsin to study the volcanic rocks of Mount Mazama and Crater Lake.

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Alycia Weinberger presented astronomy colloquia in Feb. at Michigan State U. and U. Michigan, in Mar. at Villanova U., and in May at U. Maryland and at Pontifical Catholic U. in Chile. In Apr. she gave the first annual Myhill Memorial Seminar at Marymount U. in honor of former DTM research associate Liz Myhill. She also made handheld spectrographs at the Carnegie booth at the USA Science & Engineering Festival on Apr. 27 and 28 with postdocs **Chris Stark**, **Susan Benecchi**, and **Stella Kafka**. In June Weinberger was selected to serve on the Large Binocular Telescope Interferometer key project science team, which met in Sept. in Tucson, AZ. In July she gave an invited talk at a workshop at Catholic U. She also gave a talk at the National Capital Area Disks meeting.

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In May staff scientist **Rick Carlson** hosted **Dmitri Ionov**, a professor at U. Jean Monnet, St. Etienne, France, and **Leonard Acuta**, a Ph.D. student at Lehigh U. Former postdoc **Jonathan O'Neil**, now at Clermont-Ferrand, returned to analyze the 3.2- to 4.4-billion-year-old rocks from the Nuvvuagittuq, Canada. In June staff scientists **Conel Alexander**, Carlson, **Erik Hauri**, **Steve Shirey**, lab manager **Mary Horan**, DCO Fellow **Marion Le Voyer**, and former Carnegie Fellow **Jonathan O'Neil** attended the 22nd VM Goldschmidt Conference in Montreal.

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In May staff scientist **Matt Fouch** conducted fieldwork at Telica Volcano, Nicaragua, with staff scientist **Diana Roman** and ASU colleagues to install a prototype volcanic gas monitoring system. In May Fouch presented a lecture at the campus lecture series. In June he presented a poster at the Incorporated Research Institutions for Seismology (IRIS) national workshop and two talks about IRIS. Postdoc **Ryan Porter** also presented at this meeting. In Aug. Fouch participated in the Mars Science Laboratory (MSL) rover landing festivities in Pasadena, CA, with his wife and former GL postdoctoral fellow Michelle Minitti, a member of the MSL team.

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In May postdoc **Susan Benecchi** collected data at Las Campanas Observatory (LCO). In Aug. she gave a seminar for the Planetary Science Inst. about her Kuiper Belt light curve project. In Oct. Benecchi observed at LCO and presented a seminar at Pontifical Catholic U. in Chile.

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In May MESSENGER Fellow **Paul Byrne** attended the 26th MESSENGER Science Team meeting in Vancouver, Canada, along with MESSENGER Fellows **Shoshana Weider**, **Christian Klimczak**, former director **Sean Solomon**, and **Larry Nittler**. In June Byrne was an invited presenter at JPL. In July he participated in the 2012 Planetary Science Summer School at JPL, and in Aug. Byrne attended the 27th MESSENGER Science Team meeting in Salem, MA. In Sept. he presented MESSENGER tectonic work at the European Planetary Science Congress in Madrid, Spain. In Oct. Byrne attended the joint MESSENGER-BepiColombo workshop in NY.

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In June Vera Rubin Fellow **Joleen Carlberg** presented her work at the "Cool Stars 17" conference in Barcelona, Spain, and attended a workshop at Temple U. In July she attended a workshop at NYU. In Aug. she gave a talk at Penn. State's Center for Exoplanets and Habitable Worlds.

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In May postdoc **Christian Klimczak** gave a seminar at the Lunar and Planetary Inst. in Houston, TX. In Aug. he attended the 27th MESSENGER Science Team meeting in Salem, MA. In Sept. he presented at the European Planetary Science Congress in Madrid, Spain.

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In June DCO Fellow **Marion Le Voyer** gave a seminar at the Smithsonian Institution's National Museum of Natural History.

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In July Carnegie Fellow **Frances Jenner** was an invited speaker at the Gordon Research Conference in New Hampshire.

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NAI Fellow **Nickolas Moskovitz** gave an invited talk at the Aug. 13-17 "Asia Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly" in Singapore. In Oct. he presented a talk at the 44th annual AAS meeting in Reno. Moskovitz had an asteroid named after him, Asteroid (8254) Moskovitz.

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Arrivals: In May postdoctoral fellow **Christelle Wauthier** arrived from U. Liège, Belgium, to work with Diana Roman. In May graduate student **John D. West** from ASU visited DTM to collaborate for his Ph.D. dissertation with **Matt Fouch**. In July graduate student **Chelsea Allison** spent a week in the Mojave Desert with **Matt Fouch** and **Ryan Porter** to complete a paper on the Cima Volcanic Field. Porter was named the first Paul G. Silver Fellow in Seismology in July. MIT predoctoral student **Stephanie Brown** spent June and July running models of the early Earth with **Lindy Elkins-Tanton** and U. Maryland's Richard Walker. In July former DTM postdoctoral fellow **Chin-Wu Chen** collaborated with **Matt Fouch** and **David James** on the High Lava Plains project. In July Merle A. Tuve Senior Fellow **Michael Werner** arrived for a month and presented a Tuve lecture. In Aug. Stanford Ph.D. student **Megan D'Errico** arrived to work with **Mary Horan**. Also in Aug. postdoctoral fellow **Pamela Arriagada** arrived to work with **Paul Butler** on exoplanets. Visiting investigator **Satoshi Inaba**, from Waseda U., Japan, arrived in Aug. to collaborate with **Alan Boss, John Chambers** and others on planet formation. Former postdoctoral fellow **Alex Song** arrived in Sept. for a month to collaborate with the geophysics group. Also in Sept. postdoctoral fellow **Terrence Blackburn** arrived to work on cosmochemistry and astronomy. **Tyler Hosford** came in June and July as a temporary administrative assistant and departed in Aug. for Texas A&M U. Former GL administrative assistant **Susan Schmidt** is now a library volunteer.

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Departures: Postdoctoral fellow **Nick Moskovitz** departed for an NSF fellowship at MIT in Aug. Also in Aug. postdoctoral associate **Stella Kafka** departed for the American Inst. of Physics.

GL/DTM

⓰ In June the library held a library book fair, giving away over 600 books thanks to the generosity of Frank Press, Sean Solomon, and Nathalie Valette-Silver, in memory of Paul Silver. In Aug. the campus held a farewell party for **Pedro Joaquin Roa**, who joined Carnegie in 1986 as a maintenance technician. ☐

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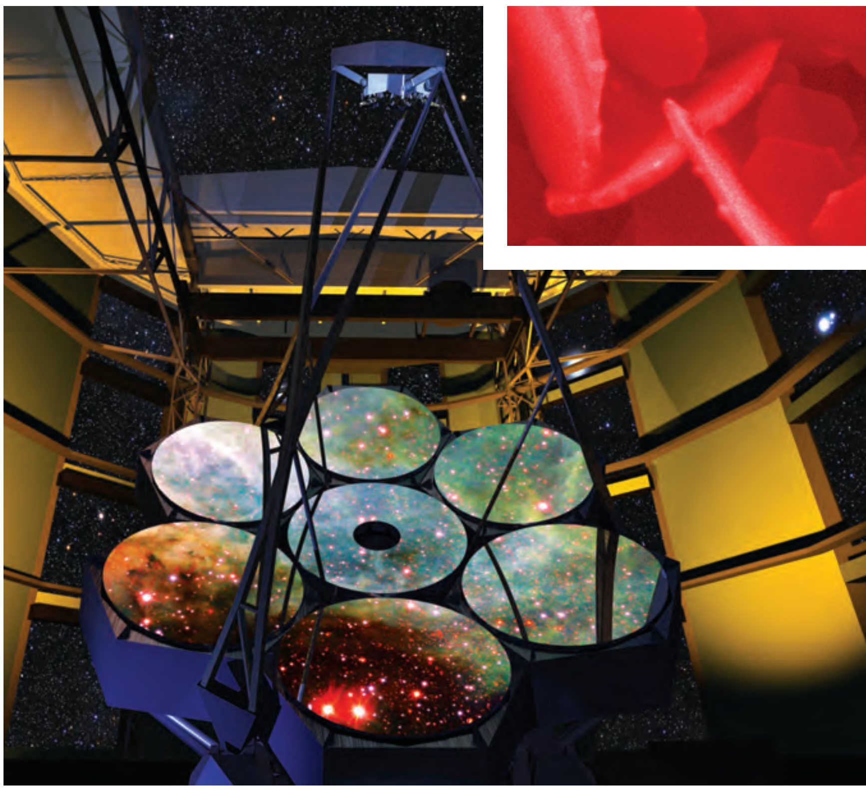

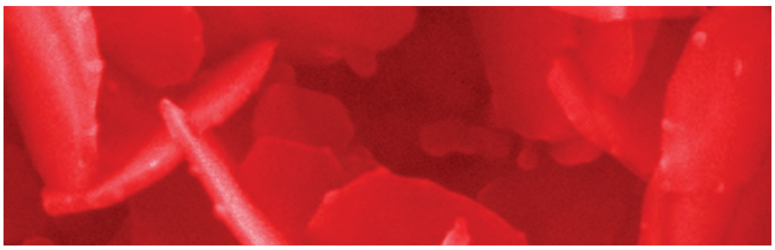

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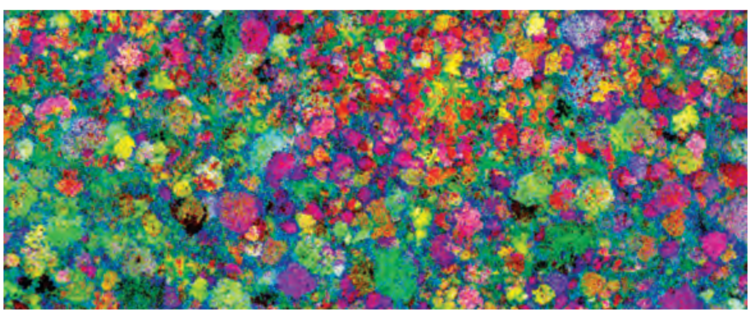

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