CarnegieScience

The Newsletter of the Carnegie Institution
SPRING 2013

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

On the Inside

LETTER FROM THE PRESIDENT

The Carnegie Institution for Science is now over 110 years old. At the founding of the institution in 1902, U.S. government funding for fundamental scientific research was largely non-existent, and the major research university in its current incarnation had yet to be born. It is not much of an exaggeration to suggest that fundamental research in the early 1900s in some fields was completely dominated by Carnegie. Today, of course, the landscape for scientific research is very different, with many large academic and governmental research performers. Nonetheless, Carnegie has continued to play an important role in scientific research, though one that has evolved from its early days. This has been accomplished in large measure by remaining true to Andrew Carnegie's original vision of supporting exceptional individuals and by retaining a degree of independence that is both distinctive and of great consequence.

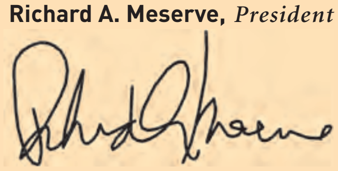
In early 2012 we embarked on a study to assess how the Carnegie Institution is perceived to inform our planning for a major expansion of our outreach and fundraising activities. The study involved interviews with industry, academic, and government thought-leaders in the sciences to explore the function of fundamental scientific research in our society; perceptions of Carnegie's image and reputation; the attributes that generate enthusiasm about scientific research; and impressions of private research institutions more generally. We also sought to identify opportunities to communicate our research activities and their impact more effectively.

Some of the key findings from the study include the following:

- The Carnegie name is viewed favorably, but there is confusion about the relationship of the Carnegie Institution to the 22 other Carnegie non-profit organizations.
- Our research is very well regarded and our scientists remain at the forefront of their respective fields, but we are not well known by the public.
- We received high marks for our publications and news, but there is a significant opportunity to raise our public profile.
- Individuals interested in scientific research connect emotionally with narrow areas of research that relate to their background, experience, and interests. They are more interested in a particular research area and in the scientist conducting that research than in the institution as a whole or in the department in which the research takes place.
- While Carnegie's history is of some interest, the respondents were far more excited by present and future research programs.
- Interdisciplinary research is viewed very favorably and is considered critical to solving many of humankind's most pressing problems. Carnegie's small size and flexible approach to scientific research are conducive to this type of research.
- Private research institutions occupy a special place in the landscape. Key attributes include institutional independence, the ability to take a long-term view and pursue high-risk research, and the flexibility and creativity that these attributes engender.

We are in the process of developing a strategy that will build on these findings as we seek to enhance our impact. In the meantime, it is satisfying to receive feedback that corroborates the value of independent research and of the Carnegie Institution's distinctive contributions. As we begin to implement our response to the study, we welcome your feedback about the institution and our work.

Richard A. Meserve, *President*



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Trustee News

Global Ecology Hosts Trustees

Global Ecology hosted the trustees' November meeting at Taaffe House, the Packard family home in Los Altos Hills, CA, where board members could enjoy the spectacular vistas in between meetings. The Finance and Development committees met on Thursday, November 15, followed by the first session of the board. The Audit, Nominating, and Governance committees met the following day, before the second session of the board.

On Thursday afternoon and evening, trustees visited the Global Ecology labs. Director Chris Field introduced the group to the department by describing the energy efficiencies of its "green building." Then the gathering broke into four groups that toured ten different stations. The trustees learned about the scientists' work with the United Nations' Intergovernmental Panel on Climate Change Working Group II, oxygen-depleted "dead zones" in the Gulf of Mexico, carbon stocks in Peru and Panama, the imaging and mapping capabilities of the Carnegie Airborne Observatory, the collection of tropical plant species from the Spectranomics Project, use of atmospheric trace gases to study the biosphere, and much more.

Later that evening, the trustees and staff gathered for dinner in the Vidalakis Dining Room of Stanford University's Knight Management Center. The after-dinner program, "Climate and Energy," featured a talk by Donald Kennedy, president emeritus of Stanford. Kennedy spoke about the choices and policy challenges that the U.S. faces regarding different types of energy sources. To conclude the evening, Chris Field described some of the exciting work that is coming out of each of the department's labs. □

Carnegie trustee Will Hearst (inset) listens to Asner lab's Chris Anderson's explanation of the Airborne Taxonomic Mapping System (AToMS) used on the Carnegie Airborne Observatory. Launched in June 2011, AToMS combines laser and spectral imaging onboard a twin-engine aircraft to measure an ecosystem's chemistry, structure, biomass, and biodiversity. In its first year, AToMS mapped tens of millions of acres in California, Panama, Colombia, Costa Rica, the Peruvian Andes, and the Amazon basin.

Trustee John Crawford (inset) listens while Berry lab graduate student Jen Johnson talks about analyzing trace gases to unravel the details of the nitrogen cycle.

Yixian Zheng

Solving Stem Cell Mysteries

Embryonic stem cells differentiate into different types of cells, each with different functions. This process is regulated and maintained by a complex series of chemical interactions that are not well understood. Learning more about this process could prove useful for stem cell-based therapies. A team led by Carnegie's Yixian Zheng zeroed in on the process by which stem cells maintain their proper undifferentiated state.

Embryonic stem cells go through a process called self-renewal: they undergo multiple cycles of division while not differentiating into any other type of cell. This process is dependent on three protein networks that guide both self-renewal and eventual differentiation. But the integration of these three networks has remained a mystery.

Using a combination of genetic, protein-oriented, and physiological approaches involving mouse embryonic stem cells, the team—which also included current and former Carnegie scientists Junling Jia, Xiaobin Zheng, Junqi Zhang, Anying Zhang, and Hao Jiang—uncovered a mechanism that integrates all three networks involved in embryonic stem cell self-renewal and provides a critical missing link to understanding this process.

The key is a protein called UTF1, which serves three important roles. UTF1 balances between activating and deactivating the genes necessary to direct the cell toward

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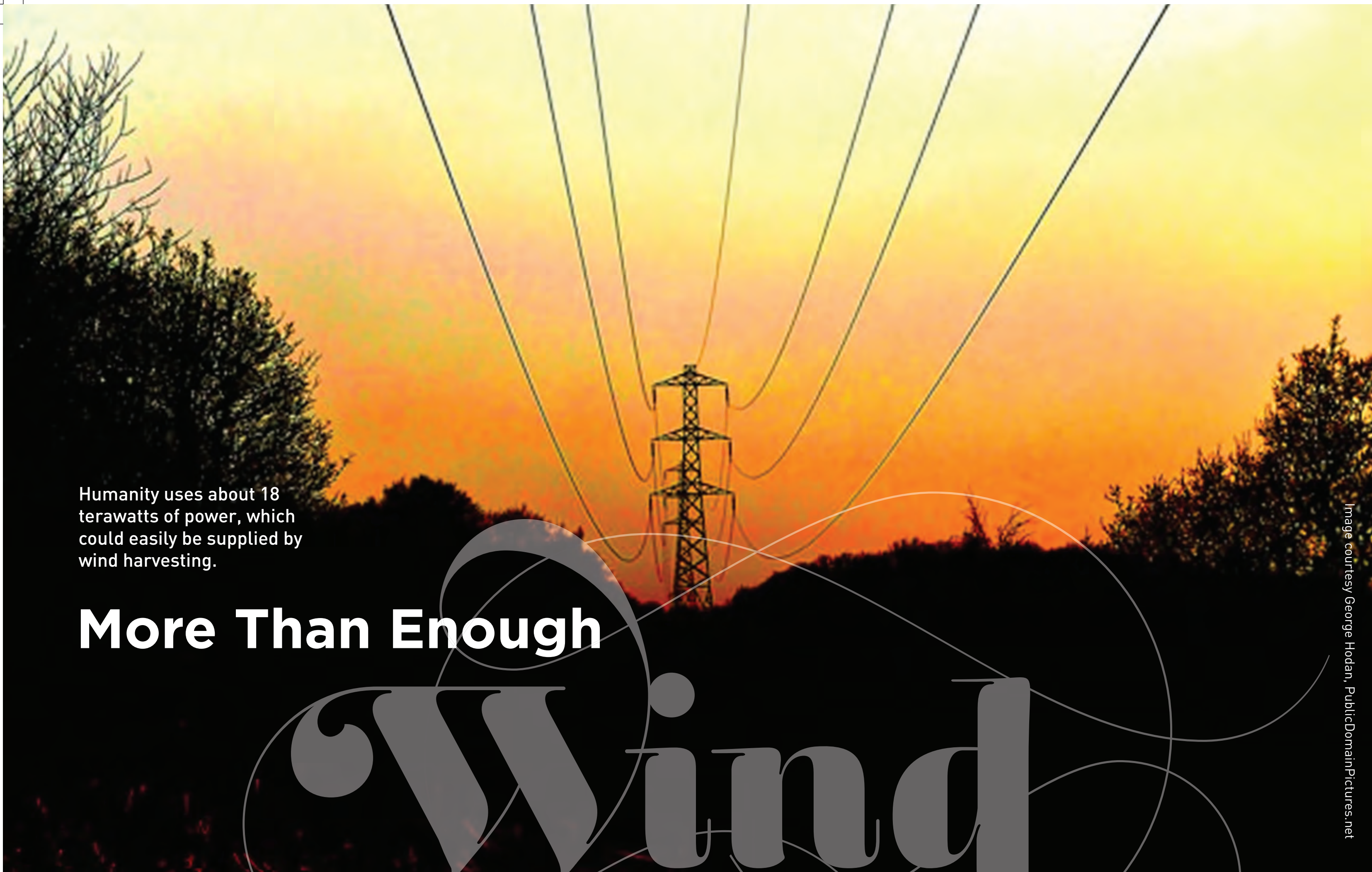


Image courtesy George Hodan, PublicDomainPictures.net

Humanity uses about 18 terawatts of power, which could easily be supplied by wind harvesting.

More Than Enough Wind Power

Image courtesy AnalySwift.com

Turbines supported by towers on land or in the ocean can harvest power from surface winds. High-altitude winds can be accessed through turbines that work like kites.

Ken Caldeira

There is enough energy available in winds to meet all of the world's demand. Atmospheric turbines that convert steadier and faster high-altitude winds into energy could generate even more power than ground- and ocean-based units. New research from Carnegie's Ken Caldeira examined the limits on the amount of power that could be harvested from winds, as well as the effects high-altitude wind power could have on the climate as a whole.

The team used models to quantify the amount of power that could be generated from both surface and atmospheric winds. Surface winds were defined as those that can be accessed by turbines supported by towers on land or rising out of the sea. High-altitude winds were defined as those that can be accessed by technology that merges turbines and kites. The study looked only at the geophysical limitations of these techniques, not at technical or economic factors.

Turbines create drag, or resistance, which removes momentum from the winds and tends to slow them. As the number of wind turbines increase, the amount of energy that is extracted increases. But at some point, the winds would be slowed so much that adding more turbines will not generate more electricity. This study focused on finding the point at which energy extraction is highest.

Using models, the team was able to determine that more than 400 terawatts of power could be extracted from surface winds and more than 1,800 terawatts could be generated from winds extracted throughout the atmosphere. Today, civilization uses about 18 terawatts of power. Near-surface winds could provide more than 20 times today's global power demand, and wind turbines on kites could potentially capture 100 times current global power demand.

At maximum levels of power extraction, wind harvesting would substantially affect the climate. But the study found that the climate effects of extracting wind energy at the level of current global demand would be small, as long as the turbines are spread out and not clustered in just a few regions. At the level of global energy demand, wind turbines might affect surface temperatures by about 0.1°C and affect precipitation by about 1%. Overall, the environmental impacts would not be substantial.

Their work was published in September by *Nature Climate Change.* □

Most Distant Galaxy Discovered

Daniel Kelson

A team of astronomers, including Carnegie's Daniel Kelson, set a new distance record for finding the farthest galaxy yet seen in the universe. The work was published by *The Astrophysical Journal* last November. By combining the power of NASA's Hubble and Spitzer Space Telescopes and one of nature's own "zoom lenses" in space, they found a galaxy whose light traveled 13.3 billion years to reach Earth.

The diminutive blob—only a tiny fraction of the size of our Milky Way galaxy—offers a peek back in time to when the universe was only three percent of its 13.7-billion-years-old age. The light from this newly discovered galaxy, named MACS0647-JD, is from 420 million years after the Big Bang.

Redshift, a measure of cosmological distance, is a consequence of the expansion of space over cosmic time. The astronomers estimate that MACS0647-JD has a redshift of 11, the highest redshift ever observed. The wavelengths of near-ultraviolet light from the galaxy have been stretched into the near-infrared part of the spectrum as the light traveled through an expanding universe.

The first galaxies probably formed somewhere between 100 million and 500 million years after the Big Bang. Galaxies that formed at such an early time are more pristine than those formed later; they are relatively free of the heavy elements generated by later generation of supernovae.

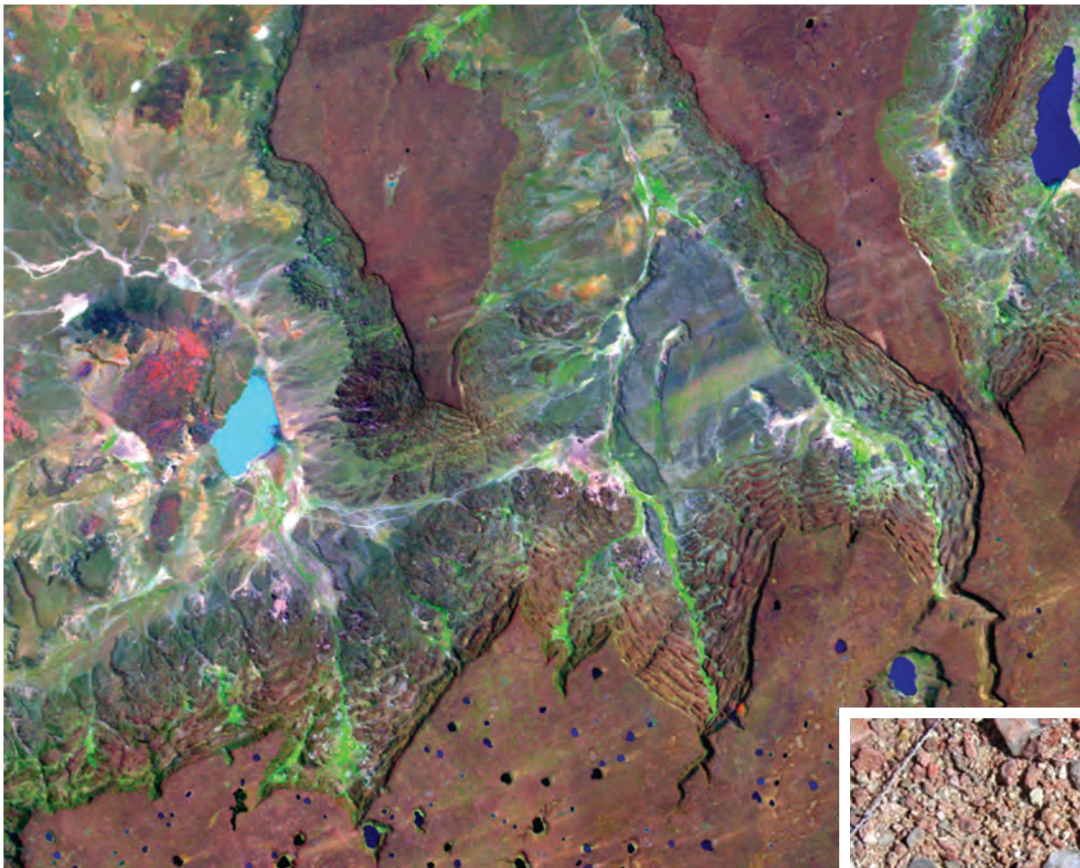
MACS0647-JD's size indicates it might have been in the first embryonic steps of forming an entire galaxy. An analysis shows that the galaxy is less than 600 light-years wide. Based on observations of somewhat closer galaxies, astronomers estimate that a typical galaxy of that epoch should be about 2,000 light-years wide. For comparison, our Milky Way is 150,000 light-years across. The estimated total mass of the stars in this baby galaxy is roughly equal to just 100 million to a billion suns, or about 0.1% to 1% of the mass of the Milky Way's stars.

This small galaxy may be too far away for any current telescope to confirm its distance using the usual methods. Nevertheless, the team is confident the fledgling galaxy is the new distance champion based on its unique colors and on their extensive analysis. By measuring how bright the object is at various wavelengths, the team determined a reasonably accurate estimate of the object's distance. □

Image courtesy NASA/ESA/STScI/CLASH

This image is a composite of observations taken with Hubble's Wide Field Camera 3 and the Advanced Camera for Surveys on October 5 and November 29, 2011. Astronomers used the massive galaxy cluster MACS J0647+7015 as a giant cosmic telescope. The bright yellow galaxies near the center of the image are cluster members. The cluster's gravity serves as a lens, boosting the light from the faraway galaxy MACS0647-JD and making its image appear approximately eight times brighter than it otherwise would. The gravitational lensing technique allowed astronomers to detect the galaxy more efficiently and with greater confidence. Without the cluster's magnification powers, astronomers would not have seen this remote galaxy.

The CLASH Multi-Cycle Treasury Program is based on observations made with the NASA/ESA Hubble Space Telescope. The Association of Universities for Research in Astronomy operates the Space Telescope Science Institute under a NASA contract. This work is also based in part on observations made with the Spitzer Space Telescope, which is operated by the California Institute of Technology's Jet Propulsion Laboratory under a contract with NASA. The Danish National Research Foundation funds the Dark Cosmology Centre. Internationale Spitzenforschung II-1 of the Baden-Württemberg Stiftung, Deutsche Forschungsgemeinschaft's (DFG's) Origin and Structure of the Universe Cluster of Excellence, and Michigan State University's High Performance Computing Center and Institute for Cyber-Enabled Research supported the research in this paper.



Images courtesy NASA/JPL/NIMA

This Landsat image shows basalt cliffs near Sierra Colorada, Argentina. Landsat bands in blue, green, and red were used.

Frances Jenner

Image courtesy the U.S. Forest Service

Erupted magma cools to form basalt, the planet's most-common rock and the basis for oceanic crust.

Un-Muddling a Magma Mystery

Oceanic crust covers two-thirds of the Earth's solid surface, but scientists still don't entirely understand the process by which it is made. Analysis of more than 600 samples of oceanic crust by a team including Carnegie's Frances Jenner revealed a systemic pattern that alters long-held beliefs about Earth's deep geological processes.

Magmas generated by the melting of the Earth's mantle rise up below the oceanic crust and erupt onto the Earth's surface at mid-ocean ridge systems, the longest mountain ranges in the world. When the magma cools, it forms basalt—the planet's most-common rock and the basis for oceanic crust. It has long been assumed that the composition of magmas erupting out of mid-ocean ridges is altered when minerals that form during cooling sink out of the remaining liquid, a process called fractional crystallization.

In theory, trace elements that are not included in the crystallizing minerals should be little affected by this process, and their ratios should be the same in the erupting magma as they were in the original magma before cooling. If this is true, trace-element ratios in magmas erupting at mid-ocean ridges should represent those of the original parental magma that formed deep in the Earth's mantle. However, this process doesn't account for the high abundance of trace elements found in samples of basalt from mid-ocean ridges around the world, so the reality of the situation is more complicated than previous theories indicated.

Using the extensive array of samples and advanced modeling, Jenner and her research partner demonstrated that the concentration of trace elements is due to the process by which the magma is cycled through the oceanic crust prior to erupting on the seafloor at the mid-ocean ridges.

Magma collects under the Earth's surface in a pool of liquid rock called a magma chamber. Each chamber is frequently flushed with new magma, which mixes with the old magma that was already there, and then this blended magma erupts onto the ocean floor. Following the influx of new magma and eruption, the remaining magma undergoes fractional crystallization, and minerals are separated out from the magma as it cools. However, these minerals contain only minor amounts of the trace elements. To account for the high abundance of trace elements, the researchers find that they build up in the magma over time, as the magma chamber is continually replenished by new magma coming into the system. The work was published in November in *Nature*. □

This work was funded by the Australian National University.

This is a root from a pepper plant. The researchers discovered that an inner layer of tissue in branching roots is sensitive to salt and can activate a stress hormone, which stops root growth.

Image courtesy Scott Bauer, USDA Agricultural Research Service

Coping with Too Much Salt

Until now it has not been clear how salt, a scourge to agriculture, halts the growth of the plant-root system. A team of researchers, led by Carnegie's José Dinneny and Lina Duan, found that not all types of roots are equally inhibited. They discovered that an inner layer of tissue in the branching roots that anchor the plant is sensitive to salt and can activate a stress hormone, which stops root growth. The study, published in January in *The Plant Cell*, is a boon for understanding the stress response and for developing salt-resistant crops.

An important missing piece of the puzzle to understanding how plants cope with stressful environments is to know when and where stressors such as salt act to affect growth. Irrigation of agricultural land is a major contributor to soil salinity—salt accumulates in irrigated soils due to the evaporation of water, which leaves the salt behind. And as sea levels rise with climate change, soil salt levels will rise, so understanding how plants, particularly crops, react to salt might allow us to develop plant varieties that can grow in the saltier soils that will likely occur in coastal zones.

The scientists grew seedlings and measured the dynamic process of root growth throughout the salt response. Roots are intimately associated with their environment and develop highly intricate branched networks that enable them to explore the soil. The branching roots grow horizontally off the main root and are important for water and nutrient uptake. The ability to track root growth in real time led the scientists to observe that branching roots entered a dormant phase of growth as salt was introduced. To determine how dormancy might be regulated, they surveyed the roles of different plant hormones in this process and found that abscisic acid was the key signaling molecule.

It turns out that abscisic acid, a stress hormone produced in the plant when it is exposed to drought or salty environments, is important in controlling the plant equivalent of a fight-or-flight mechanism, determining how far a plant grows into a dangerous territory. The investigators devised a strategy to inhibit the response to this hormone in different tissue layers of the root. Live imaging allowed them to watch what happened to root growth in these mutant plants. They found that a significant portion of the salt response was dependent upon how a single cell layer sensed the hormone.

The "inner-skin" of the root, the endodermis, was most critical for this process. This tissue layer acts like a semipermeable barrier, limiting which substances can enter the root system from the soil environment. This means that, in addition to acting as a filter for substances in the soil, the endodermis—with abscisic acid—also acts as a guard, preventing a plant from growing in dangerous environments. □

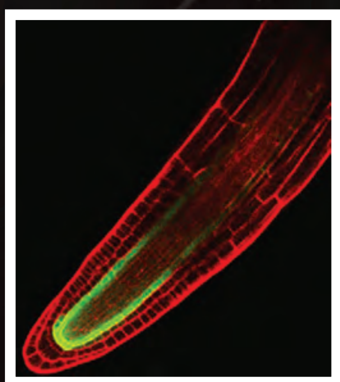


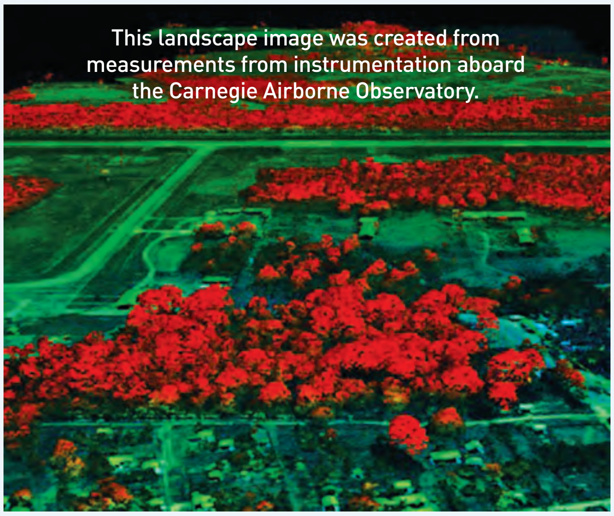
Image courtesy José Dinneny

This is a confocal microscope image of a branching lateral root. Red marks the cell boundaries, and the green fluorescent protein signal (green) marks the endodermis.

This study was conducted in collaboration with Malcolm Bennett at The University of Nottingham, U.K. Singapore National Research Foundation provided funding of the portion of this work performed at Temasek Lifesciences Laboratory. Carnegie Institution for Science supported the research performed at the Carnegie Institution.

Greg Asner

A forest seen through the eyes of the Carnegie Airborne Observatory.



This landscape image was created from measurements from instrumentation aboard the Carnegie Airborne Observatory.

Images courtesy Greg Asner

ATOMS Rolls Out With a Splash

"In its inaugural year of operation, AToMS mapped tens of millions of acres of ecosystems..."

Carnegie researchers, led by Global Ecology's Greg Asner, rolled out results from the new Airborne Taxonomic Mapping System (AToMS) at December's American Geophysical Union (AGU) meetings in San Francisco. The groundbreaking technology and the scientists' observations are uncovering a previously invisible ecological world.

AToMS, which launched in June 2011, uniquely combines laser and spectral imaging instrumentation onboard a twin-engine aircraft for simultaneous measurements of an ecosystem's chemistry, structure, biomass, and biodiversity. AToMS includes a unique imaging spectrometer implemented by Carnegie scientists, in close collaboration with engineers at NASA's Jet Propulsion Laboratory. In its inaugural year of operation, AToMS mapped tens of millions of acres of ecosystems in California, Panama, Colombia, Costa Rica, the Peruvian Andes, and the Amazon basin. The results presented at AGU have applications ranging from mitigating climate change to forest conservation and ecosystem management.

The team assessed the impacts of the 2010 Amazon basin megadrought on the forest's structure, carbon stocks, and biodiversity. Because the frequency of Amazonian droughts is predicted to increase in the future, understanding how the 2010 drought changed the forest is critically important to predicting the future of the region. Using the Carnegie Airborne Observatory's (CAO) AToMS system, Asner and his team revealed huge areas of drought-stressed vegetation in the Amazon basin, finding previously unknown impacts ranging in scale from individual branches to whole canopies among millions of rainforest trees.

Another CAO study led by Mark Higgins considered how Panamanian forests are patterned by the unique geology of the region. The results help to explain why Panamanian ecosystems remain some of the most biologically diverse in Central America. Stanford graduate student Dana Chadwick's report explained how she used AToMS to examine the terrain hidden beneath the Amazonian rainforest canopy. Three-dimensional mapping revealed how the Amazonian environment promotes the coexistence of so many rainforest species.

Claire Baldeck and Jean-Baptiste Féret, Carnegie scientists working with the airborne technology to map plant diversity in African savannas and in Amazonian rainforests, led two other reports. Baldeck reported on the holy grail of ecology—finding how landscapes evolve to support different assemblages of plants. Féret, meanwhile, showed that subtle variation in Amazonian forest soils and terrain impart huge differences in overall biological diversity—a measurement made possible for the first time by the CAO.

Other topics presented at the AGU ranged from how Mediterranean ecosystems in California are assembled to how streams play an important role helping forests store global-warming gases, such as carbon dioxide. □

The Gordon and Betty Moore Foundation, the W. M. Keck Foundation, the Margaret A. Cargill Foundation, Mary Anne Nyburg Baker and G. Leonard Baker, Jr., William R. Hearst III, the John D. and Catherine T. MacArthur Foundation, the Andrew Mellon Foundation, the Avatar Alliance Foundation, and the Grantham Foundation for the Protection of the Environment

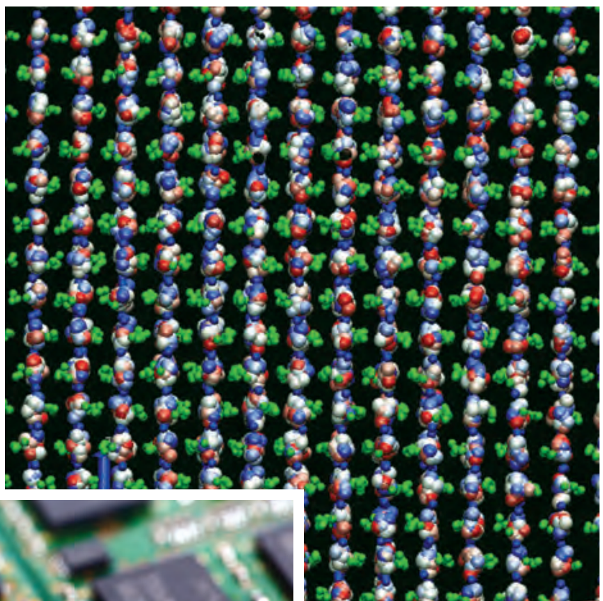
Better Refrigeration Through Crystals

A team led by Carnegie's Ronald Cohen has discovered a new efficient way to use crystals to pump or extract heat. The crystals even work on the nanoscale, so they could be used on computer chips to prevent overheating or even meltdown, which is currently a major limit to higher computer speeds. The research is published by *Physical Review Letters.*

Cohen's team performed simulations on ferroelectric crystals—materials that have electrical polarization in the absence of an electric field, which can be reversed by applying an external electrical field. The scientists found that the introduction of an electric field caused a giant temperature change in the material, dubbed the electrocaloric effect.

Ferroelectrics can become paraelectric, meaning that they have no polarization under zero electric field, above a so-called transition temperature. The electrocaloric effect has been known since the 1930s, but it has not been exploited because people were using materials with high transition temperatures. Cohen and his co-author Maimon Rose, who was an intern at the time of the research, found that low transition temperature materials are preferable.

Rose and Cohen used atomic-scale molecular dynamics simulations, where they followed the behavior of atoms in the ferroelectric lithium niobate as functions of temperature and an electrical field. □



The image shows a molecular dynamics simulation of lithium niobate under a time varying electric field, which changes the sign of polarization. Niobium (red), oxygen (green), and lithium show a range of colors for different time steps. Niobium and oxygen are shown only for one time step for clarity. The image shows a small part of the actual simulation.

Image courtesy Ronald Cohen

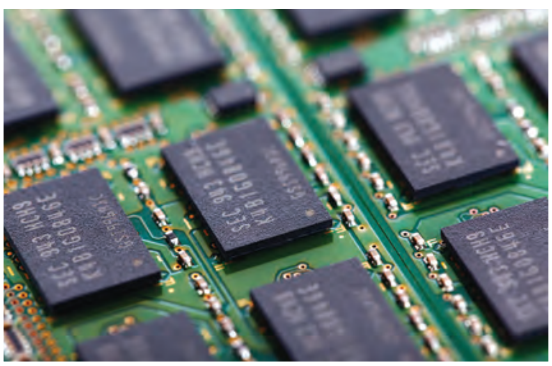


Image courtesy Petr Kratochvil, PublicDomainPhotos.net

Cohen's crystals could be used on computer chips to prevent overheating or even meltdown, currently a major limit to higher computer speeds.

The Center for Energy Frontier Research in Extreme Environments (EFree) at Carnegie Institution's Geophysical Laboratory supported this work.

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Solving Stem Cell Mysteries

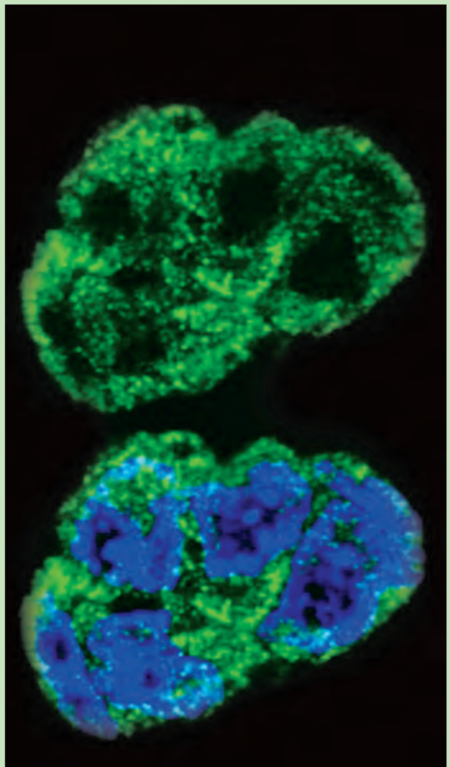


Image courtesy Yixian Zheng

A subunit of the complex in charge of decapping mRNA, thus preventing it from being translated into protein, is shown in the cytoplasm in green and in the nucleus in blue in this embryonic stem cell. Decapping mRNA is an important part of UTF1's regulation of the genes that direct a stem cell toward differentiation.

differentiation. At the same time, UTF1 acts on the messenger RNA (mRNA) that is the transcription product of these genes when they are activated; it tags the mRNA for degradation, rather than allowing the mRNA to continue to serve its cellular function. Lastly, UTF1 blocks a genetic feedback loop that normally inhibits cellular proliferation, allowing proliferation to occur in the rapid nature characteristic of embryonic stem cells.

The results were published in October by *Cell.* □

This research was supported by NIH, National Heart, Lung, and Blood Institute Division of Intramural Research, Howard Hughes Medical Institute, and Cystic Fibrosis Foundation Therapeutics, Inc.

MARTIAN METEORITE BONANZA

Over the years, meteorites from Mars, found on Earth, have given scientists key insights into the evolution of the Red Planet. Recently, two teams analyzing different meteorites have made some discoveries that are expanding our understanding of the formation and evolution of Earth's close cousin.

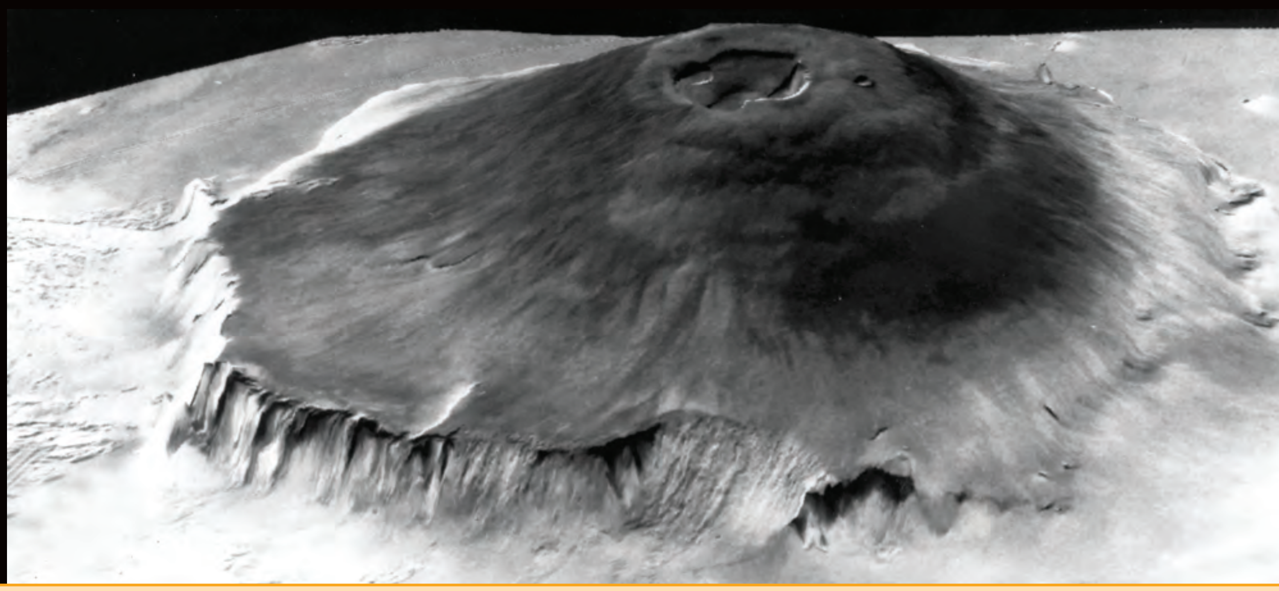
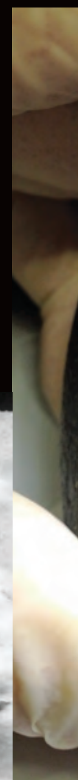


Image courtesy NASA



First Linked to Martian Crust

Extensive analyses of a meteoric sample by a team of scientists, including Carnegie's Andrew Steele, Marilyn Fogel, Roxane Bowden, and Mihaela Glamoclija, have identified a new class of Martian meteorite, one that likely originated from Mars's crust. It is also the only meteoritic sample dated to 2.1 billion years ago, the early era of the most recent geologic epoch on Mars—an epoch called the Amazonian. The meteorite was found to contain an order of magnitude more water than any other Martian meteorite, as well as macromolecular organic carbon. The research was published in January by *Science Express.*

The unique meteorite, dubbed Northwest Africa (NWA) 7034, has some similarities to—but is very different from—other Martian meteorites, known as SNC (named for the shergottite, nakhlite, and chassigny types). There are currently 110 known SNC meteorites, and so far they are the only Martian meteoritic samples that scientists have been able to study. However, their point of origin on the Red Planet is not known. In fact, recent data from lander and orbiter missions suggest that they are a mismatch for the Martian crust.

The texture of the NWA meteorite is not like any of the SNC meteorites. NWA 7034 is made of cemented fragments of basalt, rock that forms from rapidly cooled lava, dominated with feldspar and pyroxene, most likely from volcanic activity. This composition is common for lunar samples, but not from other Martian meteorites. This unusual chemistry suggests the meteorite came from the Martian crust, and it is the first link thus far of any meteorite to the Martian crust. The Carnegie team's carbon analysis also showed the presence of macromolecular organic carbon in feldspar grains associated with iron oxides, hinting that perhaps there is a different non-biological process at work than that which explains the presence of macromolecular carbon in other Martian meteorites.

Further analysis of the oxygen isotopes showed that NWA 7034 is not like other meteorites or planetary samples. Its chemistry is consistent with a surface origin and an interaction with the Martian atmosphere. The abundance of water, some 6,000 parts per million, suggests that the meteorite interacted with the Martian surface some 2.1 billion years ago.

Perhaps most exciting is that the high water content could mean there was an interaction of the rocks with surface water, either from volcanic magma or from fluids from impacting comets during that time. NWA 7034 is geochemically the richest Martian meteorite, and further analyses are bound to unleash more surprises. □

NASA's Cosmochemistry Program, a NASA ASTEP and NAI grant to Steele, the New Mexico Space Grant Consortium, and NSF award ATM0960594 supported this research.

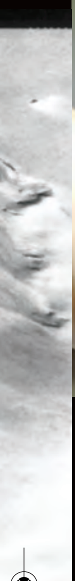
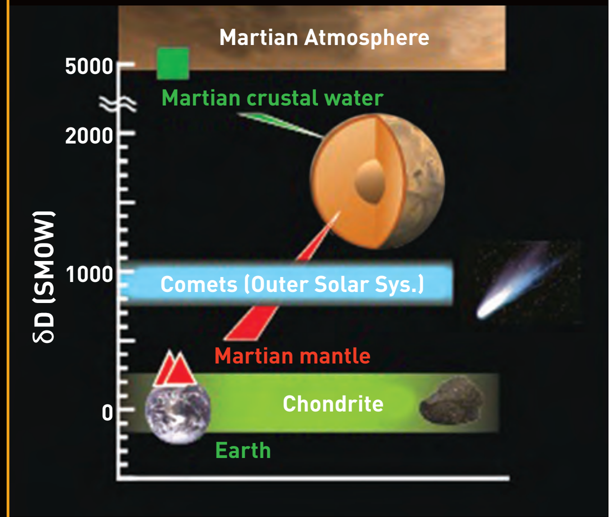


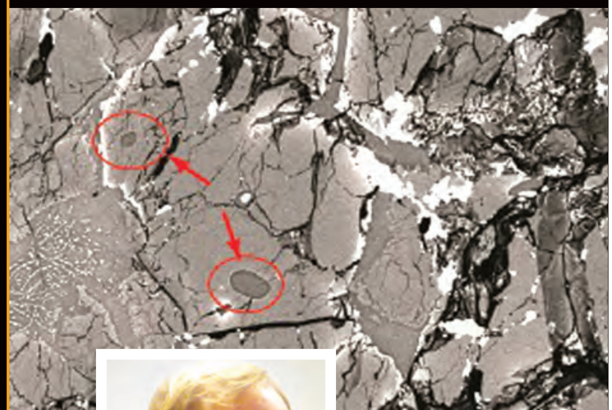
Image courtesy Carl Agee, University of New Mexico

(Far left) This is an image of Olympus Mons, the largest volcano on Mars, some 370 miles (600 km) across and 17 miles (27 km) high. The high water content of the meteorite the researchers studied could mean there was an interaction of the rocks with surface water, either from volcanic magma or from comet fluids.

(Left) The unusual Martian meteorite, Northwest Africa (NWA) 7034, is the first meteorite that scientists have found linked to the Martian crust.

Image courtesy Tomohiro Usui and T. Imai





Conel Alexander

Scientists have observed the signatures of Martian surface water (green square) and primordial water (red triangle) in the Martian meteorites LAR06319 and Yamato 980459, respectively. The distinct compositions of these reservoirs, measured in tiny (less than 20 micrometer-sized) melt inclusions—material imbedded in the rock—are shown in parts per thousand differences in the hydrogen to heavy hydrogen (deuterium) ratio (δD). Several of the studied inclusions hosted by the mineral olivine in Yamato 980459 are shown in a scanning electron microscope image above.

What About the Water?

Much controversy surrounds the origin, abundance, and history of water on Mars. The sculpted channels of the Martian southern hemisphere speak loudly of flowing water, but this terrain is ancient. Consequently, planetary scientists often describe early Mars as "warm and wet" and current Mars as "cold and dry." Debate in the scientific community focuses on how the interior and crust of Mars formed, and how these formative processes differ from those that took place on Earth.

A team of scientists, including Carnegie's Conel Alexander and Jianhua Wang, studied water concentrations and hydrogen isotopic compositions trapped inside crystals within two Martian meteorites. One meteorite appears to have changed little on its way up from the Martian mantle to the surface of Mars. It has a hydrogen isotopic composition similar to that of Earth. The other meteorite appears to have sampled Martian crust that had been in contact with the Martian atmosphere. Thus, the meteorites represent two very different sources of water. One sampled water from the deep interior and represents the water that existed when Mars formed as a planet, whereas the other sampled water from the shallow crust and atmosphere.

The team's findings imply that terrestrial planets, including Earth and Mars, have similar water sources—meteorites. However, unlike on Earth, Martian rocks that contain atmospheric volatiles such as water do not get recycled into the planet's deep interior. Although Mars and Earth formed from similar building blocks, there were differences in the later evolution of the two planets.

The concentration of water in the meteorites is also very different. One has a rather low water concentration, meaning that the interior of Mars is rather dry. Conversely, the enriched basalt of the other meteorite has 10 times more water, suggesting that the surface of Mars could have been very wet at one time. Scientists are starting to learn which meteorites can tell us about the Martian interior and which samples can tell us about the Martian surface. The work was published in December by *Earth and Planetary Science Letters.* □

This work was supported by a NASA Mars Fundamental Research Program grant, a NASA Cosmochemistry Program grant, and a NASA Astrobiology Institute grant.

What Happens with Tree Die-Offs?

Over the past two decades, extensive forest death triggered by hot and dry climatic conditions has been documented on every continent except Antarctica. Forest mortality due to drought and heat stress is expected to increase due to climate change. Although research has focused on isolated incidents of forest mortality, little is known about the potential effects of widespread forest die-offs. An analysis of the current literature on this topic by Carnegie's William and Leander Anderegg was published in September by *Nature Climate Change*.

The brothers found that heat and drought, including drought-related insect infestation, can disproportionately affect some species of trees or can hit certain ages or sizes of trees particularly hard. This can result in long-term shifts in an area's dominant species, with the potential to trigger a transition into a different ecosystem, such as grassland. It can also impact the understory—the layer of vegetation under the treetops—as well as organisms living in the soil. More research on forest community impact is needed, particularly on the trajectories of regrowth after forest die-off.

From an ecosystem perspective, forest die-off will also likely affect hydrological processes and nutrient cycles. Depending on the type of forest, soil moisture could be increased by the lack of treetop interception of rainfall or decreased by evaporation due to more sun and wind exposure. Debris from fallen trees could also increase the risk of forest fire.

Forests also have an effect on the climate as a whole. Forests play an important role in determining the amount of heat and light that is reflected from the Earth into space and in absorbing carbon dioxide from the atmosphere. On one hand, forest mortality increases the reflection of the sun's energy back into space, producing a cooling effect. But, on the other hand, the decomposition of fallen trees releases carbon into the atmosphere, producing a warming effect. Overall, whether forest die-offs result in local cooling or warming is expected to depend on the type of forest, the latitude, the amount of snow cover, and other complex ecosystem factors.

Mass tree mortality would likely cause substantial losses to the timber industry, even if saplings and seedlings were unaffected. Little research has been conducted on the impact die-off could have on other types of forest products that humans use, such as fruits or nuts, but there would presumably be changes in those industries as well. Recent research has examined other benefits provided by forests that would likely be negatively affected by die-off, such as declines in property value following widespread tree mortality. □

William Anderegg

Image courtesy Piotr Wojtkowski, PublicDomainPictures.net

The decomposition of fallen trees releases carbon into the atmosphere, producing a warming effect. This is a concern in the event of mass forest mortality.

Image courtesy Petr Kratochvil, PublicDomainPhotos.net

Large-scale forest mortality could likely cause significant losses to the timber industry as well as changes to other businesses built around the human use of forest products, such as fruits and nuts.

Magnesium Oxide and Early Earth Magnetism

The mantles of Earth and other rocky planets are rich in magnesium and oxygen. The mineral magnesium oxide—due to its simplicity—is a good model for studying the nature of planetary interiors. New work from a team led by Carnegie's Stewart McWilliams studied how magnesium oxide behaves under the extreme conditions found deep within planets. They found evidence that alters our understanding of planetary evolution.

Magnesium oxide is particularly resistant to changes when under intense pressure and high temperature. Theoretical predictions claim that, under planetary conditions, the mineral has just three unique states, each with different structures and properties. It is solid under ambient conditions (such as on the Earth's surface), liquid at high temperature, and another solid structure at high pressure. The latter structure has never been observed before.

McWilliams and his team observed magnesium oxide between pressures of about 3 million times normal atmospheric pressure (0.3 terapascals) to 14 million times atmospheric pressure (1.4 terapascals) and at temperatures reaching as high as 90,000°F (50,000 K); these are conditions that range from those at the center of our Earth to those of large exoplanet super-Earths. The team's observations indicated substantial changes in molecular bonding as the magnesium oxide responded to these various conditions, including a transformation to a new high-pressure solid. In fact, when magnesium oxide melted, there were signs that it changed from an electrically insulating material like quartz (i.e., electrons do not flow easily through the material) to a conductive metal similar to iron (i.e., electrons flow easily).

Drawing from these and other recent observations, the team concluded that—while magnesium oxide is solid and nonconductive under conditions found on present-day Earth—the early Earth's magma ocean might have been able to generate a magnetic field. Likewise, the metallic, liquid state of magnesium oxide can exist today in the deep mantles of super-Earth planets, as can the newly observed solid state. The work was published in November by *Science Express.*

The research is also notable for taking advantage of new laser techniques, which allow investigations of the behavior of the materials at pressures and temperatures never before explored experimentally. □

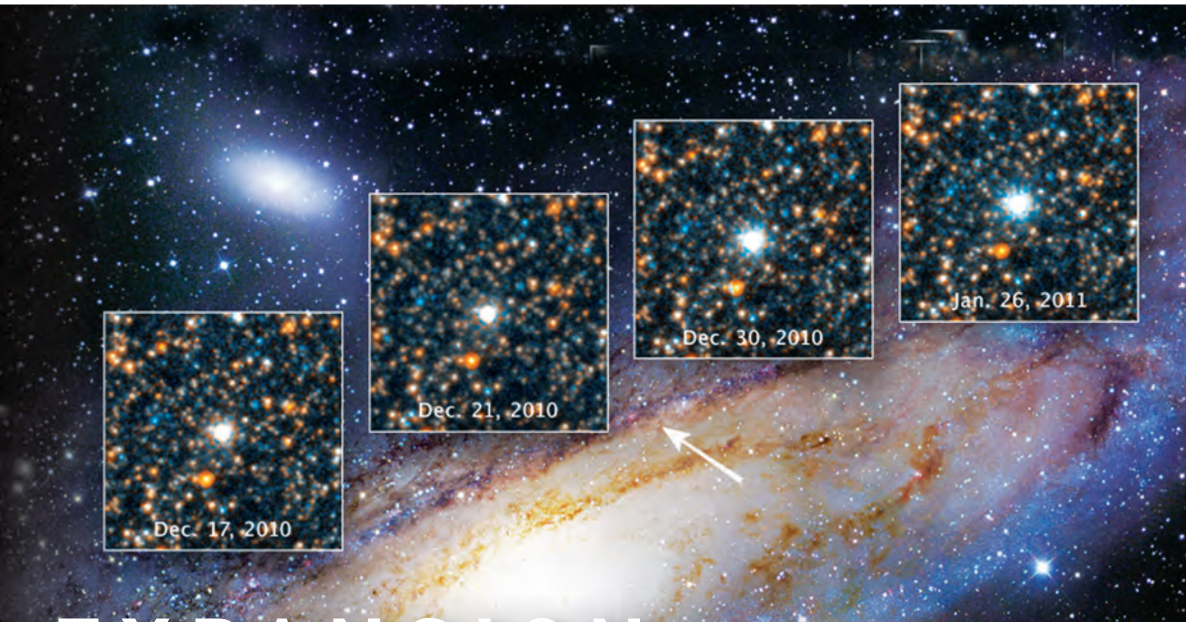
Image courtesy Eugene Kowaluk, Laboratory for Laser Energetics

This photo shows a experiment in progress. It is the center of the target chamber, where a sample of material is struck with several high-power laser pulses at once. The material is initially at low pressure and temperature, similar to conditions on the Earth's surface. In one billionth of a second, it is artificially heated and compressed to a state found deep within a planet. This extreme state is quickly studied using probes and imaging devices pointed at the target, before it explodes into a cloud of dust and vapor, as seen in this photo.

Stewart McWilliams

"Magnesium oxide is particularly resistant to changes when under intense pressure and high temperature."

The experiments were carried out at the Omega Laser Facility of the University of Rochester, which is supported by the Department of Energy (DOE)/NASA. The research involved a team of scientists from the University of California, Berkeley and Lawrence Livermore National Laboratory. DOE, the U.S. Army Research Laboratory's Army Research Office, a Krell Institute graduate fellowship, the DOE/NNSA National Laser User Facilities Program, the Miller Institute for Basic Research in Science, and the University of California supported this work.



This NASA/ESA image of the galaxy M31 shows a pulsating Cepheid variable star. These objects are used to measure the rate of the universe's expansion.

Image courtesy NASA/ESA

Image courtesy Elena Zhukova

SPACE-EXPANSION Measurement Improved

Wendy Freedman

A team of astronomers led by Carnegie Observatories director Wendy Freedman used NASA's Spitzer Space Telescope to make one of the most accurate and precise measurements yet of the Hubble constant, a fundamental quantity that measures the current rate at which our universe is expanding.

The Hubble constant is named after 20th-century Carnegie astronomer Edwin P. Hubble, who astonished the world by discovering that our universe is not only expanding now but also that it has been growing continuously since its inception. Determining the Hubble constant, a direct measurement of the rate of this continuing expansion, is critical for gauging the age and size of our universe.

The team's finding agrees with an independent supernovae study conducted last year and improves upon a seminal 2001 Hubble Space Telescope study by a factor of three. The newly refined value is 74.3 ± 2.1 kilometers per second per megaparsec (a megaparsec is roughly three million light-years).

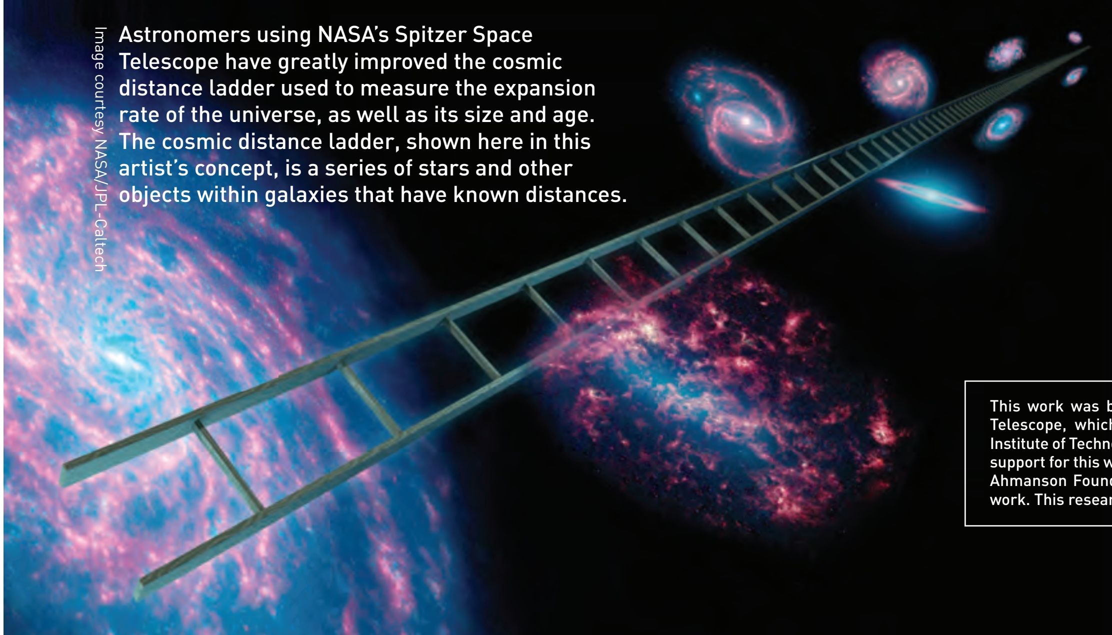
The Spitzer Space Telescope was able to improve upon past measurements of the Hubble constant due to its infrared vision, which sees through dust to provide better views of variable stars called Cepheids. These pulsating stars are vital "rungs" in what astronomers call the cosmic distant ladder—a set of objects with known distances that, when combined with the speeds at which the objects are moving away from us, reveal the expansion rate of the universe.

Cepheids are crucial to these calculations because their distances from Earth can be readily measured. These stars pulse at a rate that is directly related to their intrinsic brightness. To visualize why this is important, imagine somebody walking away from you while carrying a candle. The candle appears dimmer the farther it travels, and its apparent brightness reveals its distance. The same principle applies to Cepheids, standard "candles" in our cosmos. By measuring how bright the Cepheids appear in the sky and comparing this to their known brightness as if they were close-up, astronomers can calculate their distances from Earth.

The Spitzer Space Telescope observed ten Cepheids in our own Milky Way galaxy and 80 in a nearby galaxy called the Large Magellanic Cloud. Without the cosmic dust blocking their view, the research team was able to obtain more precise measurements of the apparent brightness of the stars, and thus their distances, than previous studies had done. With these data, the researchers could tighten up the rungs on the cosmic distant ladder, opening the way for a new and improved estimate of our universe's expansion rate.

The research team included former and current Carnegie scientists Barry Madore, Vicky Scowcroft, Andrew Monson, Chris Burns, Mark Seibert, Eric Persson, and Jane Rigby.

These results were published by *The Astrophysical Journal.* □



Astronomers using NASA's Spitzer Space Telescope have greatly improved the cosmic distance ladder used to measure the expansion rate of the universe, as well as its size and age. The cosmic distance ladder, shown here in this artist's concept, is a series of stars and other objects within galaxies that have known distances.

Image courtesy NASA/JPL-Caltech

This work was based in part on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology (JPL/Caltech) under a contract with NASA. NASA provided support for this work through an award issued by JPL/Caltech. A grant from The Ahmanson Foundation made possible the computing resources used for this work. This research made use of the NASA/IPAC Extragalactic Database (NED).

InBrief

Image courtesy Elena Zhukova

❶ President Obama selected Sandra Faber to receive the National Medal of Science.

❷ (Top) President Richard Meserve (second from left) was inducted a Foreign Member of the Russian Academy of Sciences at the National Academies on Dec. 5 by Nikolay Laverov (left), the vice president of the Russian Academy. Meserve poses also with Boris Myasoyedov (third) and Yuri Shiyan (right) of the Russian Academy.

(Bottom) Meserve visited the Sheikh Zayed Grand Mosque while in Abu Dhabi.

❸ Steve Farber (left) poses with graduate student Rosa Miyares after her successful defense of her Ph.D. thesis.

TRUSTEES AND ADMINISTRATION

❶ Current trustee and former Carnegie postdoctoral astronomer **Sandra Faber** received the National Medal of Science, the nation's highest scientific honor. Faber has made important contributions to understanding the structure and history of the universe. She is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society. She has received many other awards and honors and has coauthored nearly 250 scientific papers.

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❷ Carnegie president **Richard A. Meserve** attended meetings of the Council of the National Academy of Engineering in Washington, DC, on Sept. 28-29 and in Irvine, CA, on Feb. 6-7. He attended meetings of the American Academy of Arts and Sciences' Council and Trust in Cambridge, MA, on Oct. 5-7 and the GMT board retreat in Washington, DC, on Oct. 13-14. He gave an invited talk on the future of nuclear power at the Global Nuclear Energy Summit in Atlanta, GA, on Oct. 20. Meserve cochaired a meeting on the National Academies' Committee on Science, Technology, and Law in Woods Hole, MA, on Oct. 22-23; he chaired a meeting of the IAEA's International Nuclear Safety Group in Vienna, Austria, on Oct. 31-Nov. 1. He visited the United Arab Emirates Nov. 3-6 and on Nov. 28 spoke about the future of US energy at a forum sponsored by Resources for the Future in Washington, DC. Meserve presided at Harvard Board of Overseers' meetings in Cambridge, MA, on Dec. 1-2 and Feb. 2-3. He spoke at the opening plenary session of the American Society of Mechanical Engineers' nuclear safety workshop on Dec. 4 in Washington, DC. On Dec. 6 he chaired a meeting of DOE's Nuclear Energy Advisory Committee in Washington, DC, and on Dec. 10 participated in a board meeting of Carnegie Canada in Montreal with board member **William Turner**. Meserve served on a panel of international advisors to the newly established Japanese Nuclear Regulatory Authority on Dec. 14 in Tokyo and on Dec. 16 gave the keynote speech at the Fukushima Ministerial Conference on Nuclear Safety in Koriyama, Japan. On Jan.10 he participated in a roundtable discussion at the World Bank on the future of global energy mix in Washington, DC, and on Jan. 17 he spoke in a seminar at the US Nuclear Regulatory Commission in Rockville, MD concerning the Davis-Besse Nuclear Power Station incident. He spoke at an MIT Energy Initiative seminar on Feb. 12 in Cambridge, MA.

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CASE received a $10,000 grant from the Association of American Medical Colleges for two SciLife® science, technology, engineering, and mathematics (STEM) career exploration events for Washington, DC, students in Oct. and Feb. The events—one for middle school and one for high school—were held at Carnegie's headquarters.

EMBRYOLOGY

Allan Spradling attended the David and Lucile Packard Foundation meeting, the Lasker Award ceremony for **Donald Brown**, and the advisory meeting of the Genetics and Developmental Biology Department at the Institut Curie. He was an invited speaker at the Cold Spring Harbor Laboratory's Germ Cell meeting, also attended by postdoc **Lei Lei**. Spradling presented his work at Yale U. and attended an HHMI scientific conference with postdoc **Jianjun Sun**. He was also an invited speaker at the Cold Spring Harbor Asia Conference on Stem Cells and Developmental Mechanisms in Shanghai.

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Joe Gall presented a seminar at U. Virginia. He also attended the Lasker Award ceremony for Donald Brown and served on a review committee at Brown U. He was an after-dinner presenter at the 13th Annual Meeting of the RiboClub of Canada, Orford, Canada, and an invited Distinguished Lecturer at Duke U.

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Marnie Halpern attended a Society for Neuroscience meeting and organized the "Genetic Models Social: Probing Genomes, Behavior and Disease." She was an invited speaker at a Janelia Farms workshop on zebrafish. Members of her lab attended the Mid-Atlantic Regional Zebrafish (MARZ) meeting in Philadelphia.

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Trustee **Michael Wilson** (right) traveled to Afghanistan to show *Skyfall* to US troops. This was his last stop on a world tour. ☐

Image courtesy Don Brown

John Gurdon, this year's cowinner of the Nobel Prize in Physiology or Medicine, spent six months at Embryology when on sabbatical in 1965. **Donald Brown** (left) attended the Nobel events in Stockholm and is shown with John and Jean Gurdon. ☐

❸ **Steve Farber** presented a seminar at Vanderbilt U. about an unexpected link between fat and cholesterol absorption. He was an invited speaker at the International Conference on Environmental Bioinorganic and Toxicology Research in Sao Paolo, Brazil, and was a judge for the National Siemens Competition in Math, Science, and Technology.

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In Oct. **Alex Bortvin** attended the Cold Spring Harbor Laboratory's Germ Cell meeting with lab members **Safia Malki**, **Pavol Genzor**, **Julio Castaneda**, and **Diana Camerota**.

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Farewell Marilyn and Garret

About 150 colleagues bade farewell to **Marilyn Fogel** and **Garret Huntress** on Nov. 30. There was a mariachi band and a series of science talks. Carnegie president Richard Meserve, president emerita Maxine Singer, advancement's Susanne Garvey and Rick Sherman, CASE's Toby Horn, and chief information officer Gotthard Sághi-Szabó also attended. ☐

Marilyn Fogel (left), secretary of the Carnegie board Deborah Rose (center), and department director Rus Hemley (right) bid Fogel and Huntress good-bye.

Garret Huntress, Andrew Steele, and Danielle Appleby (from left to right) smile for the camera.

Maintenance associate **Lloyd Allen** died on Jan. 20. He worked at Carnegie's administration building from 1959 until his Apr. 2005 retirement. Coworkers remember Allen as dedicated, cheerful, and always willing to take on any task. A funeral service was held on Jan. 28, in District Heights, MD.

❹ Katie McDole (left) and Yixian Zheng (right) toast McDole's successful Ph.D. thesis defense.

❻ Retiring Susan Kern (left) chats with Pat Englar (right), who retired from the department in 2006. Englar returned to Baltimore for Kern's retirement reception.

❺ Lakshmi Gorrepati

❼ Bob Hazen

❽ Sandra Siljeström

❾ Vincenzo Stagno

Nick Ingolia was an invited speaker at Wesleyan U., the NIH/NHLBI Biochemistry and Biophysics Center, Seattle BioMed, the Fred Hutchinson Cancer Research Center, and Thomas Jefferson U.

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Christoph Lepper presented a poster at the NIH Early Independence Award retreat.

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❹ **Yixian Zheng** was a session chair at Cold Spring Harbor Laboratory's meeting "Nuclear Receptors and Disease." She attended the ELS editorial board meeting and, with her lab team, attended the annual American Society for Cell Biology meeting in San Francisco.

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Gall graduate student **Gaëlle Talhouarne** presented a poster at the 14th International *Xenopus* Conference in the Giens Peninsula, France.

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❺ **Arrivals: Frederick Tan** returned to the department on the research faculty. He completed his graduate studies in Andy Fire's labs at Carnegie and at Stanford U. Tan joined the Koshland lab at Carnegie, before going to UC-Berkeley for his postdoctoral training. **Lakshmi Gorrepati** joined the Lepper lab as a postdoc from U. Maryland. **David Lawrence** joined the lab as business manager. **Teddi Schott** joined as human resources and procurement administrator. Student volunteer **Daifong Wong** joined the Fan lab, and aquatics facility technician **Gregory Moore** joined the fish facility.

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❻ **Departures:** Spradling postdoc **Lucy Morris** moved to the Australian National U., Canberra. Halpern lab's **Vanessa Matos-Cruz** is now a postdoc at Yale U. Business manager **Susan Kern** retired. Animal technician **Vance Martin** and postdoc **Mario Izaguirre-Sierra** also left the lab.

GEOPHYSICAL LABORATORY

Russell Hemley presented talks at the 50th European High Pressure Research Group Meeting on Sept. 17 in Thessaloniki, Greece; the HPCAT Workshop on Advances in Matter under Extreme Conditions on Oct. 11 at Advanced Photon Source; and "The NIF's Capabilities for Exploring the Physics and Chemistry of Giant Planets" workshop on Dec. 7 at Lawrence Livermore National Laboratory. He helped lead the Deep Carbon Observatory Executive Committee meeting in Berlin and Potsdam, Germany, Sept. 20-21.

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❼ **Robert Hazen** was named a 2013 Linus Pauling Memorial Lecturer by the Institute for Science, Engineering and Public Policy, Portland, OR; a 2013 Nobel Symposium Lecturer, Stockholm, Sweden; the 2013 Qualline Lecturer of U. Texas. He presented the 2012 Charles and Marie Fish Lecture and the Vetlesen Distinguished Lecture at U. of Rhode Island on the origin of life and the George Moore Lecture on mineral evolution, both at Oregon State U. He presented a Pardee keynote lecture on deep carbon mineralogy at the Geological Society of America's annual meeting in Charlotte, NC, and he presented the keynote address on mineral evolution to the Virginia Community College Science Conference in Virginia Beach. Hazen lectured on the coevolution of the geosphere and biosphere at the Coast Geological Society in Ventura, CA; at U. Stockholm in Sweden; and at the American Institute of Physics in MD; and he cohosted the NSF Early Career Stakeholders Workshop on EarthCube at Carnegie's Broad Branch Road campus, where he lectured on computational needs in Earth science. Hazen coorganized a session at the annual meeting of the AGU on the coevolution of the geosphere and biosphere and presented a talk on mineral evolution.

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Ho-kwang (Dave) Mao presented an invited talk at the international G-COE Symposium 2012 on Sept. 25-28, Sendai, Japan. He also delivered a plenary talk on "Energy Frontier Research in Extreme Environments" at the 2012 Materials Research Society meeting, Nov. 25-30 in Boston.

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Bjørn Mysen gave invited lectures and seminars on Sept. 19 and Sept. 20 at the Chinese Academy of Sciences, Beijing; Sept. 21 at Peking U., Beijing; Sept. 26 at the G-COE Symposium 2012, Sendai, Japan; Oct. 10 at Seoul National U., Seoul; Oct. 19 at Tohoku U., Sendai, Japan; Oct. 22 at Ehime U., Matsuyama, Japan; Oct. 26 at Tohoku U., Sendai, Japan; Nov. 7 at the 53rd High Pressure Conference of Japan, Osaka, Japan; and Nov. 10 at Tokyo U.

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Postdoctoral fellow **Duck Young Kim** received the Benzelius Prize from the Royal Society of Sciences in Uppsala, Sweden, on Sept. 4.

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❽ Postdoctoral fellow **Sandra Siljeström** received an Astrobiology Program Travel Award to fund her trip to NASA's Ames Research Center in Mar. and Yellowstone in the summer of 2013.

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❾ Postdoctoral research associate **Vincenzo Stagno** was awarded the "Best Ph.D. Thesis" by the Italian Society of Mineralogy and Petrology at the First European Mineralogical Conference in Frankfurt, Germany, Sept. 2-6, where he also gave a talk. He was author/coauthor of two abstracts for poster presentations and was a session convener at AGU's annual meeting.

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HPSynC/HPCAT

Postdoc **Ji Cheng** joined HPSynC in Sept. from Texas Tech. Short-term visitors at HPSynC were **Meilan Qi**, **Ke Yang**, **Lei Liu**, **Jun Zhu** and **Yufeng Peng**, all from China. **Wenge Yang** cochaired the session "Advanced Synchrotron Techniques on High-Pressure Research" at AGU's Dec. meetings. **Katherine Crispin** became the new microbeam specialist in Sept.

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❿ A team of GL/DCO scientists—**Mihaela Glamoclija**, **Marilyn Fogel**, **Andrew Steele**, **Karyn Rogers** and **Roxane Bowden**—participated in a drilling project at the Campi Flegrei hydrothermal area near Naples, Italy. The collaboration, with the International Continental Scientific Drilling Program and the Vesuvius Observatory of Italy's National Institute of Geophysics and Volcanology in Naples, provides a rare opportunity to study deep subsurface life and deep carbon cycling related to volcanic processes. In Oct. and Nov. Glamoclija, Rogers, and Bowden participated in the pilot hole drilling and brought home core samples from about 1,450 and 1,640 ft. (443 and 502 m) down. The main hole is expected to reach depths up to 2.4 miles (3.8 km) deep and 930°F (500°C).

GLOBAL ECOLOGY

Chris Field and **Ken Caldeira** led sessions in the Knight Science Journalism Boot Camp at MIT on Dec. 17-19.

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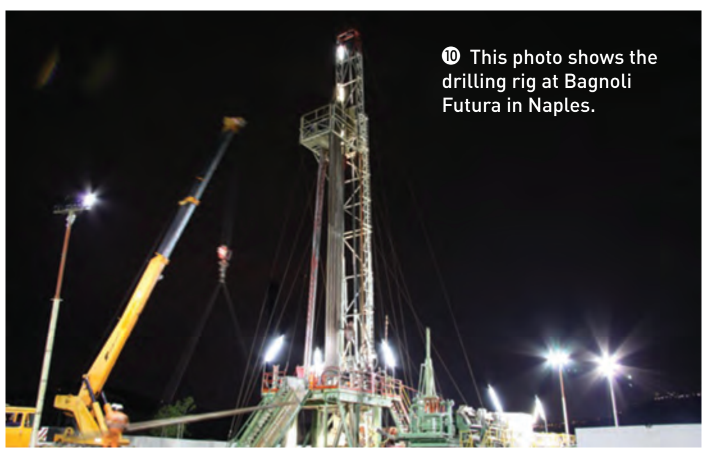

❿ This photo shows the drilling rig at Bagnoli Futura in Naples.

Image courtesy C. Serio

Deep Carbon Observatory

The Deep Carbon Observatory (DCO) sponsored a Pardee Keynote Symposium and Town Hall Meeting at the Geological Society of America's annual meeting on Nov. 7 in Charlotte, NC. Participants included **Robert Hazen**, **Russell Hemley**, **Craig Schiffries**, **Steven Shirey**, and senior visiting investigator **Dimitri Sverjensky**. More than a dozen Carnegie scientists participated in several DCO workshops and sessions at the AGU in Dec. The Alfred P. Sloan Foundation awarded two grants to support comprehensive data science and engagement activities. Sloan has also awarded a grant to launch a new genre of research on diamonds. Led by DTM's **Steven Shirey**, the proposal involves 20 project leaders and partners from 11 countries. DCO held an executive committee meeting Sept. 20-21 in Berlin and Potsdam, Germany. It cosponsored the Oman Drilling Workshop on Sept. 13-17 in Palisades, NY, and the Serpentine Days Workshop on Sept. 2-6 on Porquerolles Island, France. □


⓫ Katie Mach


⓫ Mike Mastrandrea


⓫ Yuka Estrada


⓬ Joe Mascaro


⓬ Kyla Dahlin


⓭ Luis Fernandez


⓮ Barry Madore

⓫ The Intergovernmental Panel on Climate Change crew (**Chris Field**, **Katie Mach**, **Mike Mastrandrea**, **Yuka Estrada**, **Eric Kissel**, and **Rob Genova**) organized a Working Group II lead author meeting for 350 colleagues in Buenos Aires on Oct. 22-26. Field was named "Doctor Honoris Causa" of U. Buenos Aires and a Foreign Correspondent of the Argentine Academy of Environmental Sciences on Oct. 25.

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⓬ **Greg Asner**'s Carnegie Airborne Observatory (CAO) team completed a two-month mission to map the northern Peruvian Amazon. On Sept. 13 Asner, **John Clark**, and **Raul Tupayachi** briefed the Peruvian government on deforestation. On Sept. 25 Asner presented forest carbon monitoring approaches to the Governors' Climate and Forests Task Force in Chiapas, Mexico. On Sept. 28 he gave the keynote address at the NOAA 45th anniversary conference in Boulder, CO. On Oct. 24 he was the featured speaker at "*WIRED* Magazine 2012" in London. On Oct. 27 he gave the keynote address at the International Canopy Conference in Oaxaca, Mexico. Asner presented the state of Amazon forests following the 2010 drought on Dec. 7 at the AGU meeting in San Francisco. On Oct. 11 Asner and **Joe Mascaro** represented Carnegie at the "USAID SilvaCarbon" meetings in Washington, DC. From Nov. 12 to 15, Asner and **Robin Martin** attended the annual Oxford Center for Tropical Forests conference at Oxford U. Asner lab members gave ten presentations at the fall meeting of the AGU. Among them was **Mark Higgins**' presentation titled "Geological Control of Canopy Structure and Function in Panamanian Forests as Identified by CAO-AToMS," **Kyla Dahlin's** presentation titled "Environmental Controls on Plant Chemical Traits: Using the CAO-VSWIR to Characterize Patterns in a Mediterranean-Type Ecosystem," and Asner's presentation about geological control of canopy structure and function in Panamanian forests using CAO-AToMS.

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On Oct. 24 **Ken Caldeira** participated in a panel discussion "Campaign 2012: Energy Matters," on the presidential candidates and energy policy coorganized by the League of Women Voters. On Oct. 27 he participated in the taping of "Doomsday Live, Part 2" for *Big Picture Science* in Mountain View, CA, before an audience of about 400. The radio program is available at http://radio.seti.org. On Dec. 6 Caldeira gave an invited overview on ocean acidification at the fall AGU meeting. The talk is available on YouTube.

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Anna Michalak gave a keynote address at the Conference on Geostatistics for Environmental Applications in Valencia, Spain, and presented invited talks at the Statistical and Applied Mathematical Sciences Institute opening of the program on methodology for massive datasets in NC and at the fall AGU meeting. Lab members made six presentations and organized two AGU sessions.

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Abhishek Chatterjee, in the Michalak lab, defended his dissertation titled "Data Assimilation for Atmospheric CO_2: Towards Improved Estimates of CO_2 Concentrations and Fluxes" on Oct. 9. He was awarded a UCAR postdoctoral fellowship in global and climate change and began his appointment with Jeff Anderson at the National Center for Atmospheric Research in Jan.

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Michalak lab's **Dorit Hammerling** defended her dissertation titled "Global Atmospheric CO_2 Distributions from Satellite Observations" on Aug. 15. She was awarded a Statistical and Applied Mathematical Sciences Institute postdoctoral fellowship and began her appointment with Richard Smith and Montse Fuente in Sept.

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⓭ On Oct. 23-24 **Luis Fernandez** presented preliminary findings from the Carnegie Amazon Mercury Ecosystem Project (CAMEP) to the Blue Moon Fund's Amazon-Andes section in Washington, DC. He was an invited participant in a special session on land use and remote sensing at the 8th International Conference on Ecological Informatics in Brasília, Brazil, Dec. 3-7. He was featured in a Dec. 9 *Sacramento Bee* article discussing environmental degradation in the Peruvian forest and his work for CAMEP.

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William Anderegg gave the presentation "Drought and Tree Carbohydrates: Insights from Observations, Drought Experiments, and Induced Carbon Starvation" at Dec.'s AGU meeting.

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Arrivals: Dario Caro, a student from Italy, is visiting the Caldeira lab as a predoctoral student. **Jana Maclaren** became a new postdoc in the Caldeira lab in Oct. **Elif Tasar** joined the Asner lab in Nov. as the project coordinator for the CLASlite program. In Oct. **Michael Dini** started in the Field lab as a laboratory technician.

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Departures: Lorelei Carranza returned to Puebla, Mexico, in Dec. **John Clark** left the Asner Lab in Sept. to work in private industry. Asner lab's **Kyla Dahlin** moved to Boulder, CO, in Oct. to start a postdoc at the National Center for Atmospheric Research. In Sept. **Steve Davis** became an assistant professor at UC-Irvine. **Shane Easter** left in Oct. for a start-up company in Palo Alto, CA. **Rob Genova** left at the end of the year for a software engineering job. **Paola Perez** left her intern position in Dec. to return to her studies in Switzerland. **Kenny Schneider** left in Dec. to work for Professor Robert Dunbar at Stanford U.

OBSERVATORIES

Luis Ho has been appointed Distinguished Visiting Professor of the Chinese Academy of Sciences. He coorganized and gave an invited talk at the "Frontiers in Radio Astronomy and FAST Early Sciences" conference to inaugurate the construction of the Five-hundred-meter Aperture Spherical Telescope (FAST) in Guizhou, China. He gave lectures at the National Astronomical Observatories and Peking U. in Beijing. Ho attended the TIARA workshop "Star Formation and Its Environment in the Center of Galaxies" at Tsinghua U. in Hsinchu, Taiwan, and gave a colloquium at the Academia Sinica Institute of Astronomy and Astrophysics in Taipei, Taiwan. He attended the "Torus 2012" workshop at U. Texas-San Antonio.

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⓮ In Aug. senior research associate **Barry Madore** gave the invited talk "Cognitive Astrophysics" at the

Vera Rubin and Kent Ford

The American Physical Society's Historic Sites selection committee designated the Department of Terrestrial Magnetism as an historic site, in recognition of **Vera Rubin** and **Kent Ford**'s pioneering research on dark matter. The duo made measurements of galactic rotations, which showed that galaxies do not behave as they should, under the laws of gravity. They concluded that something else was at work—the mysterious material dubbed dark matter. A spring ceremony will include a plaque presentation.

15 Andrew Bensonn

16 Mansi Kasliwal

17 Winslow Briggs

19 Ming-Yi Bai

18 Devaki Bhaya is in Crewe, Cheshire, UK for the Ideas Lab. Image courtesy Devaki Bhaya

20 Linda Elkins-Tanton

21 Conel Alexander

International Astronomical Union's General Assembly in Beijing. In Nov. Madore served as a committee member on the "habilitation" defense (the highest academic qualification a scholar can achieve in the French research community, which includes an accreditation to supervise students) by former Carnegie research fellow, Samuel Boissier, who is now a senior research astronomer at the Laboratoire d'Astrophysique de Marseille, France.

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On Aug. 17 staff astronomer **Joshua Simon** gave a lecture for the Ventura County Astronomical Society. In Sept. he presented a talk at the meeting "Supernovae Illuminating the Universe: From Individuals to Populations" in Garching, Germany.

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15 Staff associate and Hale Scholar **Andrew Benson** gave a talk at the workshop "Dwarf Galaxies" on Nov. 29 at UCLA. He also spoke at the conference "GALEX Fest" in Sept. at Caltech and organized the 13th annual "Theoretical Astrophysics in Southern California" meeting held at the department.

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Postdoctoral research associate **Rik Williams** gave an invited colloquium at Universidad Católica on Oct 23 in Santiago, Chile.

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Carnegie fellow **Ian Roederer** gave talks at the "Nuclei in the Cosmos" meeting and r-process workshop in Aug. in Cairns, Australia. In Oct. he spoke at the American Physical Society's Division of Nuclear Physics meeting in Newport Beach, CA. He also gave talks at U. Wisconsin-Madison, U. Utah, and UC-Santa Cruz from Sept. to Nov. All of the talks were about r-process nucleosynthesis products in metal-poor stars.

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16 Hubble-Carnegie-Princeton fellow **Mansi Kasliwal** gave a colloquium at McGill U. on Sept. 10-13 and at U. Chicago on Oct. 31-Nov. 1. She attended a massive star workshop in St. Paul, MN, on Oct. 1-3 and the Palomar Science Meeting in Pasadena, CA, on Nov. 15.

PLANT BIOLOGY

Wolf Frommer spoke at the 2012 Plant Protein Phosphorylation Workshop on Oct. 26 in Keystone, CO, and talked about membrane protein/signaling. He was the invited Clayton Pearson Lecturer on Nov. 27 at the U. British Columbia-Vancouver. On Dec. 14 he gave a seminar about the conversion of an ammonium transporter into a biosensor at UC-Riverside's Center for Plant Cell Biology 10th Anniversary Symposium.

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17 On Sept. 14 **Winslow Briggs** spoke about guard cells at the Carnegie faculty seminar series. On Oct. 3 he presented a talk to the Morgan Hill Rotary Club, Morgan Hill, CA, titled "Recovery of Vegetation after a California Wildfire." He also spoke about plant wildfire adaptation at the 10th International Conference on Frontiers in Plant Biology: Development and Environment, on Nov. 5 in Huangshan, China. On Nov. 10 he spoke about wildfires at the State Key Laboratory of Agrobiotechnology Retreat in Hainan, China. On Nov. 12 he spoke about guard cells at the Chinese U. Hong Kong, and on Dec. 23 he gave another guard-cell talk at U. Missouri-Columbia.

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On Apr. 27 **Zhiyong Wang** gave a talk at the symposium of "Proteomics and the Art of Mass Spectrometry" in San Francisco. On May 24 he gave a talk at the 29th Annual Interdisciplinary Plant Group Symposium at U. Missouri-Columbia. On June 27 he gave the plenary lecture at the First International Brassinosteroid Conference held in Barcelona, Spain. He also gave talks on the brassinosteroid signaling network at the Society of Experimental Biology's annual meeting on July 3 in Salzburg, Austria, and at the Plant Biology Congress 2012 on Aug. 3 in Freiburg, Germany. On Nov. 26 Wang spoke at the Plant Protein Phosphorylation Workshop held at Keystone, CO. He also gave talks on brassinosteroids at the Plant Biology Conference on Oct. 10-13 in Yangling, China; the 10th International Conference on the Frontiers of Plant Biology in Huangshan, China; and at the 4th International Symposium on Frontiers in Agriculture Proteome Research in Wuhan, China. He also gave seminars at the Institute des Sciences du Végétal on July 24 at CNRS Gif-sur-Yvette, France; on July 26 at U. Strasbourg, France; and on July 27 at U. Tubingen, Germany.

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Eva Huala organized the conference "Phenotype Research Coordination Network, Second Working Group Meeting" at Asilomar Conference Grounds on Oct. 26-29 in Pacific Grove, CA.

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18 **Devaki Bhaya** gave the invited seminar at UC-Merced on Oct. 12, titled "Thermophilic Microbial Communities: Hotbeds of Diversity and Conflict?" She also gave a seminar on Nov. 9 at U. North Carolina-Charlotte on light and life in microbial communities. From Dec. 3-7 she was one of 30 participants invited to Ideas Lab, a NSF-BBSRC joint workshop in Crewe, Cheshire, UK, on reducing inputs of nitrogen fertilizers to non-leguminous crops while maintaining or increasing yield.

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19 **Ming-Yi Bai** of the Wang lab gave a talk at the First International Brassinosteroid Conference on June 27 in Barcelona.

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Eunkyoo Oh of the Wang lab attended "Auxin 2012" on Dec. 9-12 in Kona, HI.

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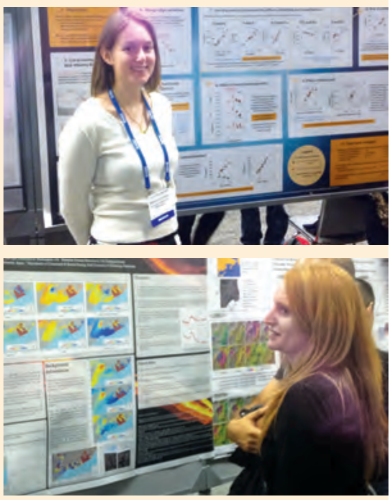
Arrivals: Visiting investigator **Michael Jensen** from Copenhagen U. arrived on Sept. 3 for the Frommer lab. Visiting research associate **Rita Kuo** joined the Grossman lab in Nov. **Chuangqi Wei** joined the Wang lab on Sept. 1 as a visiting researcher from Heibei Normal U., China. Postdoctoral research associate **Thomas Hartwig** also joined the Wang lab on Sept. 24 from Purdue U. The Rhee lab welcomed postdoctoral research associate **Chuan Wang** on Oct. 1 from China Agricultural U. Postdoctoral research associate **Jose Sebastian** joined the Dinneny lab on Dec. 16 from Cornell

22 Alan Boss

23 Alycia Weinberger

24 Diana Roman

Images courtesy Kasey Cunningham



25 DTM's Marion le Voyer (top) and Christelle Wautheir (bottom) presented posters at the AGU.

26 Last fall the directors and research staff of the Observatories, DTM, and GL discussed different studies that crossed department boundaries and that could be ripe for collaboration. The group is shown here.

U. The Jonikas lab welcomed senior lab manager **Muh-Ching (MC) Yee** on Oct. 1 from Stanford U. On Nov. 8 the lab was joined by postdoctoral research associate **Xiaobo Li** from Michigan State U. and lab technician **Nina Ivanova** on Dec. 10 from Aurora Algae, Inc., of Hayward, CA.

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Departures: Postdoc **Xenie Johnson** departed the Grossman lab on Oct. 31 for CEA, a government-funded research organization in France. Postdoc **Lilyana Chandra** left the Rhee lab on Dec. 21. Postdoctoral research associate **Megan Bergkessel** left the Bhaya lab on Sept. 30, and **Jay Kim**, an intern in the Huala group, left on Oct. 16 for a local biotech start-up.

TERRESTRIAL MAGNETISM

20 In Dec. director **Lindy Elkins-Tanton** attended the workshop "Siberian Traps and the end-Permian Extinction: Coincidence or Causality?" in San Francisco. She is president-elect for the Planetary Sciences Section of the AGU; she convened a session titled "Evolution of the Continental Lithosphere." She also presented an invited talk in Dec. to an ISSI Forum on the future of exoplanet research, and she convened the AGU session "Volcanism and Global Climate Change." In Jan. she was a member of the visiting committee for the Institut de Physique du Globe de Paris. She also gave an invited talk at the Applied Physics Laboratory in Laurel, MD. In Oct. and in Jan. she hosted visiting Merle A. Tuve Senior Fellow **David Bercovici**, Yale U. Also in Jan. MIT EAPS graduate student **Ben Black** returned to continue his research on the Siberian Traps flood basalts with Elkins-Tanton and **Erik Hauri**.

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21 In Dec. **Conel Alexander** traveled to France and presented invited talks in Nancy and Paris.

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22 In Nov. **Alan Boss** spoke at the Observatories in Pasadena, CA, about how the results from NASA'S Kepler Mission have placed new constraints on exoplanet formation theories. In Jan. Boss gave a colloquium about the Kepler results at the Florida Institute of Technology in Melbourne, FL, where he also gave an evening public lecture on the search for habitable planets.

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Rick Carlson attended the Geological Society of America's (GSA's) annual meeting in Charlotte in Nov. and the AGU meeting in Dec., followed by an invited presentation at the Cooperative Institute for Dynamic Earth Research Workshop at UC-Berkeley. In Jan. he presented a public lecture at Miami U. of Ohio on "The Age of the Earth."

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In Nov. **Steve Shirey** attended the annual GSA meeting in Charlotte, NC, and delivered the talk "Diamonds and the Geology of Mantle Carbon." He also gave an invited talk and attended the fall AGU meeting in San Francisco.

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Erik Hauri attended the fall AGU meeting in San Francisco and gave an invited lecture on the volatile element geochemistry of submarine volcanoes. He chaired a workshop of the Reservoirs and Fluxes Directorate of the Deep Carbon Observatory on Dec. 5 in San Francisco, where **Steve Shirey** also attended.

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In Nov. **Larry Nittler** attended a workshop on dust in supernovae in Ascona, Switzerland, and a MESSENGER Science Team Meeting in Santa Monica, CA. In Jan. he attended a workshop on presolar materials at U. Chicago.

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23 In Oct. and Jan. **Alycia Weinberger** participated in NASA's "Exoplanet Exploration Program Analysis Group" meetings as a member of the group's executive committee. Also in Jan. she gave a talk at the 221st American Astronomical Society's (AAS's) meeting in Long Beach, CA.

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In Oct. **John Chambers** presented a talk at the 2012 annual meeting of the AAS's Division for Planetary Sciences in Reno, NV.

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24 In Oct. **Diana Roman** attended a UNAVCO workshop on strainmeter science at Scripps, and in Dec. she, with students/collaborators, presented research at the fall AGU meeting. Also in Dec. Ph.D. student **Mel Rodgers** visited from U. South Florida for her dissertation research.

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In Jan. postdoctoral fellow **Susan Benecchi** presented her Kuiper Belt object light-curve work at the AAS meeting. She observed at the Las Campanas Observatory in Oct. and Dec.

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In Sept. postdoctoral fellow **Joleen Carlberg** hosted Karen Hamm (U. Virginia) and Gail Zasowski (Ohio State U.). She went to Las Campanas in Oct. and Jan. Also in Jan. she attended the 221st AAS meeting in Long Beach, CA, where she presented a poster. She also attended an APOGEE Collaboration Meeting in Pasadena, CA, in Jan.

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In Jan. research fellow **Christopher Stark** gave a talk titled "A Search for Exozodis with Kepler" at the AAS conference in Long Beach, CA.

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25 Nineteen members of DTM attended the AGU meeting: **Terry Blackburn**, **Paul Byrne**, **Rick Carlson**, **Kelsey Druken**, **Lindy Elkins-Tanton**, **Matt Fouch**, **Erik Hauri**, **David James**, **Frances Jenner**, **Christian Klimczak**, **Marion le Voyer**, **Alan Linde**, **Jared Marske**, **Ryan Porter**, **Steve Shirey**, **Deborah Smith**, **Liyan Tian**, **Christelle Wauthier**, and **Shoshana Weider**. Web writer **Kasey Cunningham** covered the talks and poster sessions for DTM's web site.

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Established in 2011, the inaugural AGU **Paul G. Silver** Outstanding Scientific Service Award was presented on Dec. 4 at the 2012 AGU fall meeting in San Francisco. Nathalie Valette-Silver and her family attended as the award was presented to Andrew Nyblade, Associate Professor of Geosciences at Pennsylvania State U.

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Arrivals: Postdoctoral fellow **Hanika Rizo** arrived on Oct. 15 from Le Laboratoire Magmas et Volcans, Université Blaise Pascal, Clermont-Ferrand, France, to collaborate with **Lindy Elkins-Tanton**, **Rick Carlson**, and Rich Walker (U. Maryland). In Oct. **Peter Baines** (U. Melbourne) presented a Merle A. Tuve Senior Fellow lecture and collaborated with Selwyn Sacks. Senior visiting investigator and former postdoctoral fellow **Paul Rydelek** returned to collaborate with Selwyn Sacks. In Jan. temporary administrative assistant and seminar coordinator **Hayley Johnson** joined DTM.

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Departures: DTM postdoctoral fellow **Zan Peeters** left in Oct., and **Christian Miller** left in Dec. Temporary seminar coordinator **Adrienne Barnes** also departed.

GL/DTM

26 In Oct. **Davide Novella**, Ph.D. student from Bayerisches Geoinstitut, Bayreuth, Germany, arrived to collaborate with DTM's Erik Hauri and GL's Yingwei Fei. Librarian **Shaun Hardy** gave a presentation on open access at the Geoscience Information Society's annual meeting in Charlotte, NC, in Nov. On Oct. 3-5 the directors of the Observatories, DTM, and GL, along with select members of their faculty, held a joint science meeting at the Broad Branch Road campus. On Oct. 26 the Broad Branch Road campus held its annual fall picnic. □

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CHARITY NAVIGATOR
Four Star Charity

Astronomer and photographer Yuri Beletsky captured two Southern Hemisphere comets streaking across the sky just after sunset at Carnegie's Las Campanas Observatory in Chile on February 28. The comet on the upper left is the green-glowing comet Lemmon, which visits our neck of the Solar System every 50 years. Comet PANSTARRS, at right, may have come from the far-off Oort cloud.