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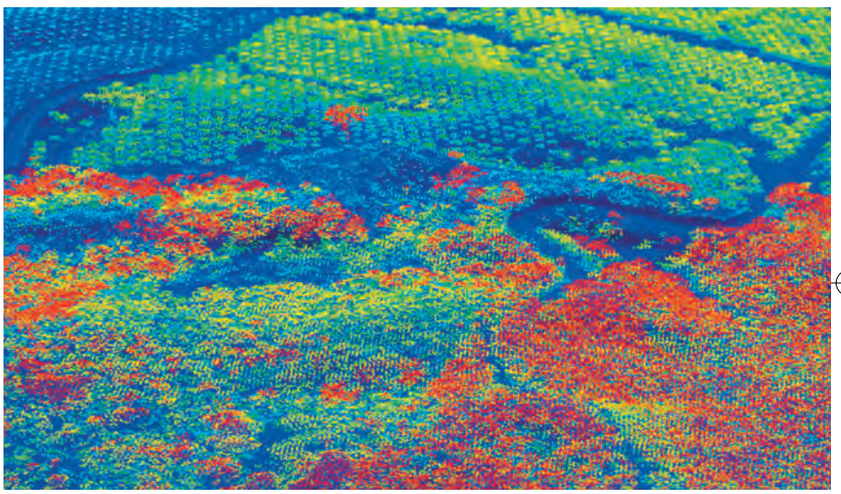
CarnegieScience

The Newsletter of the Carnegie Institution
FALL 2014

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

On the Inside



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CARNEGIE SCIENCE: A Beacon *of* I

CARNEGIE SCIENCE

Carnegie Institution for Science
1530 P Street, NW
Washington, D.C.
20005-1910

202.387.6400
www.CarnegieScience.edu

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LETTER FROM THE PRESIDENT

My first month at Carnegie Science has been full of great encounters with the scientists and staff at each of the six departments and at the P Street headquarters. Every one of them is carrying on a rich tradition of American discovery. I am fortunate to be following in the footsteps of Dick Meserve; no one appreciates more than I how masterfully he guided Carnegie Science through times of dramatic changes in the scientific enterprise and through a devastating recession.He deserves our deep thanks and certainly has mine for all the help he's given me.

The description of Carnegie Science as a beacon of light and hope, from staff scientist Andrew Steele, exactly captures my own feelings as I join this amazing institution. The world has much to gain from people who are driven by values of free inquiry, risk-taking, and deep, long-term thinking. Our Carnegie people have a fascination with the history and evolution of the universe, the Earth, and life. Universities are often safe harbors for unfettered exploration, but Andrew Carnegie realized that even more was possible by allowing superb scientists to pursue their hopes and dreams with few distractions. He was right. The breadth of amazing discoveries from Carnegie Science is astonishing: the recognition of DNA as the carrier of genetic information, the expansion of the universe, the jumping genes that control plant pigmentation and explain rapid transmission of antibiotic resistance, the dramatically altered properties and behaviors of elements squeezed by the depths of the Earth, the completely new mechanisms of gene control, the exoplanets that fill the universe, and many others.

We can and should celebrate that history, but I am even more excited about what lies ahead. The same social and organizational system of science that led to those successes is thriving. Some recently created research institutions strive to emulate exactly the Carnegian way of doing science: senior scientists who do experiments and analysis themselves rather than delegating, small groups that vigorously debate ideas and approaches, the intellectual synergy of interdisciplinary teams, the invention of high technology, limited administrative and committee duties, and less reliance on federal grant systems that sometimes impart short-term goals. Carnegie scientists have been living this style of work since 1902. And free exploration works. The best way to cope with a brick wall is not to charge at it. The curious child, who takes a flashlight into the dark shed nearby, will find the ladder.

Hans-Lukas Teuber, a legendary researcher and teacher of psychology at MIT, taught that the most important questions in science are those a child would ask. Where in

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f Light and Hope

my head are my memories? How do airplanes stay up? Where do stars come from and what makes them fall down? What makes waves on the beach? What colors rainbows? Do dogs have emotions? Since the world turns, why can't I feel it? Can I live forever? Why do I look like my parents, kind of? How come we don't know when earthquakes are coming? Why do I have to sleep? Can I see dinosaurs somehow? How could ice cream possibly be bad for me?

Adult scientists frequently have traits of curiosity and enthusiasm reminiscent of a child exploring the wonders of her world. As with children, or the young Darwin exploring the world on the *Beagle*, absence of dogma provides freedom to explore. Carnegie Science is a place where kids of all ages explore, not only during the wonderful teaching programs of Carnegie Academy for Science Education and Math for America, but during the adult work of the research enterprise itself.

"TOUCH A SCIENTIST AND YOU TOUCH A CHILD."

—Ray Bradbury

Exploration science always leads to something valuable. I heartily disagree with the common division of scientific goals into "basic" and "applied." To make progress, there must be a way to see and investigate something that was not accessible before. Whether they are novel tools for engineering and controlling genes, new microscopes, giant telescopes, diamond anvils, or satellites that watch forests from space, Carnegie has always led the way. Our cell phones became a reality because physicists explored properties of materials—an enterprise that continues to have immense potential and is a major feature of Carnegie Science. In fact, the surest way to have dramatic impact on medicine, agriculture, and our technological devices is to pursue intriguing mysteries that have a "handle" to gain entry.

My own experience provides a good example of how pure exploration research leads to useful outcomes. In 1980 I began isolating genes that control the body segmentation pattern of fruit flies, i.e., that striped pattern of segments so visible on the abdomen of a yellow-jacket wasp. The genes had been identified by Christiane Nüsslein-Volhard and Eric Wieschaus in work that later won them a Nobel prize. We purified a gene that codes for a receptor protein called Patched that becomes located on the surfaces of cells in embryos. When a signaling molecule excreted by certain embryo cells comes along and binds to Patched, the receiving cell is changed and will divide or change its shape. However, when the gene is damaged, the signal can't get through and birth defects occur. This signaling system is one of more than a dozen that work together to control the formation and growth of tissues and organs.

Having the fly gene in hand, we looked for and found a related mouse gene and then the corresponding human gene. With help from friends, we mapped the human gene to a chromosome location and discovered that inherited birth defects and cancer syndrome was caused by mutations in that chromosome region. We proved that the syndrome is due to mutations that damage the human *Patched* gene. We then found that mutations in *Patched* are responsible for basal cell carcinoma (BCC), the most common human cancer, and medulloblastoma, the most common malignant childhood brain tumor. These discoveries, along with work done in many other laboratories, led to the invention of an FDA-approved drug that is now used for BCC patients who have metastatic cancer. Thus, studying how insect bodies form led to a therapy for the most common human cancers. Who would ever have predicted such a thing? Imagine proposing to a grants agency "I want to cure cancer so I'll go look at fruit fly bodies."

At Carnegie Science hundreds of people continue to explore, to follow their own beacons of hope and light. In doing so, they are laying the foundations of innovations in technology, medicine, and agriculture and discovering our own human history in deep time. We are proud that our Carnegie "kids"...are ok.

Matthew Scott, *President*

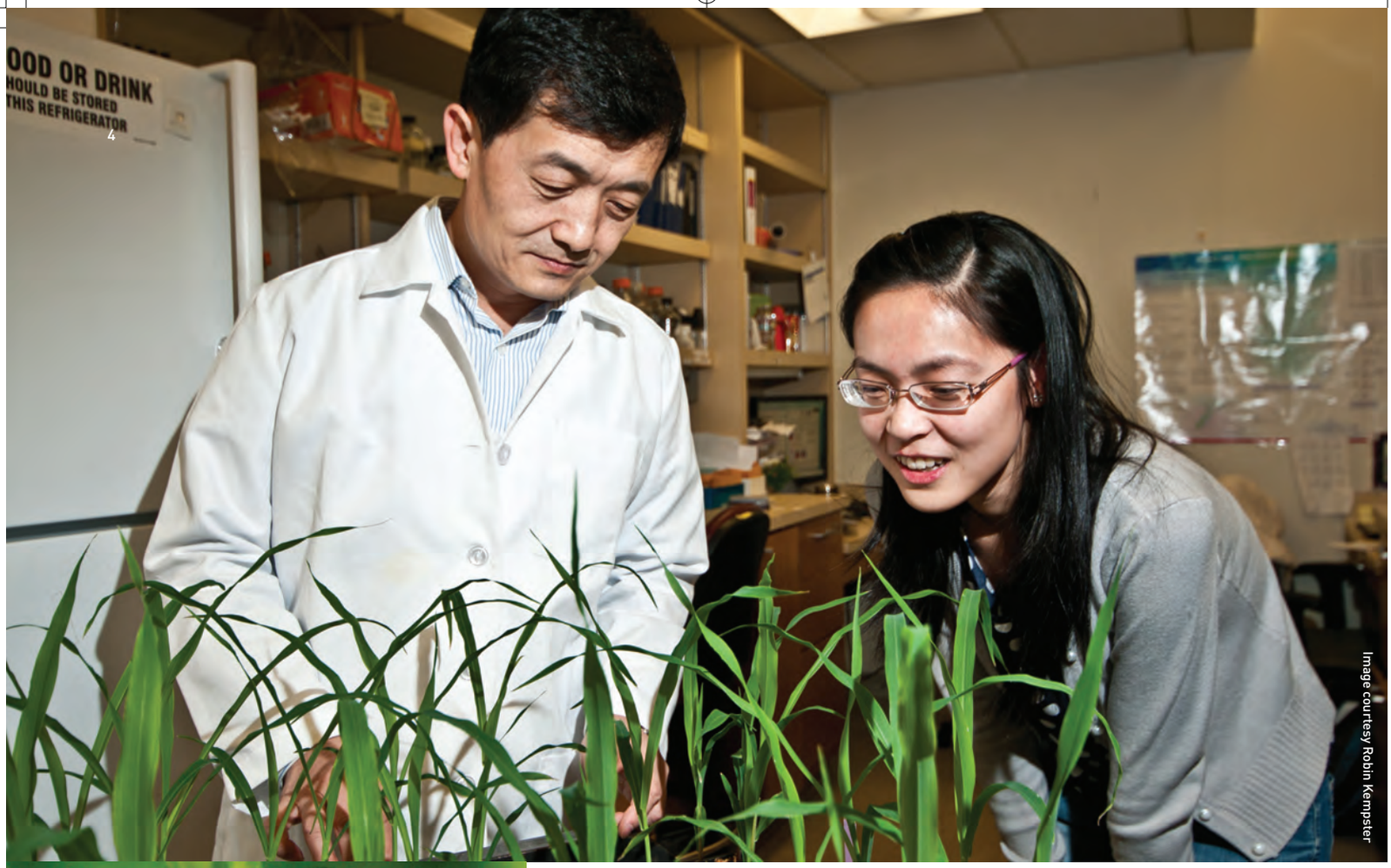
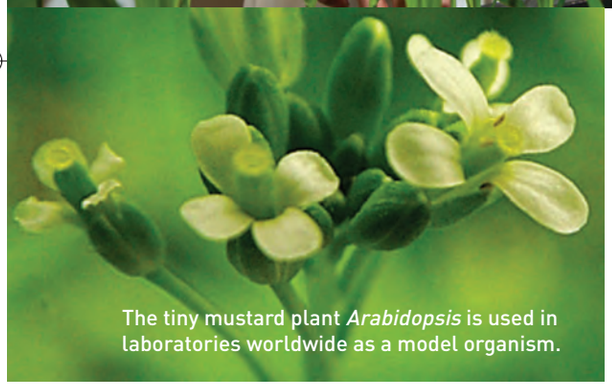


Image courtesy Robin Kempster

Carnegie's Zhiyong Wang (left) was a coauthor on the study.

Image courtesy NASA



The tiny mustard plant *Arabidopsis* is used in laboratories worldwide as a model organism.

Image courtesy Yuri Beletsky

Putting the Brakes **on Cellular Signaling**

A team of researchers studying a flowering plant has zeroed in on the way cells manage external signals about prevailing conditions, a capability that is essential for cells to survive in a fluctuating environment. The team's discovery, published in *Science* June 6, has potential applications ranging from agricultural to cancer research.

Carnegie's Zhiyong Wang, with colleagues at U.C.-Berkeley, the Plant Gene Expression Center, and U.C.-San Francisco, identified a novel mechanism by which the strength of such an external signal is reduced, or attenuated. Their work focuses on the tiny mustard plant used as a model, *Arabidopsis*.

Signaling attenuation is analogous to the brakes on a car. While acceleration is desirable, without restraint it can be disastrous. Cellular signaling triggered by external cues such as sunlight enables organisms to adapt to the prevailing conditions. When the organism perceives something that requires a response, a bucket brigade of chemical signals is activated. This signaling is generally very robust at first. But at some point it is necessary to dial it back or turn it off entirely—a restraint that falls to different, less-understood signaling pathways.

In this research, *Arabidopsis* seedlings were taken from subterranean darkness into sunlight, which triggered a response leading to "rapid and extensive" redirection of gene expression—the turning on of genes—ultimately resulting in familiar green seedlings.

A brake on this acceleration of new gene expression is necessary to restabilize the cells at a new equilibrium. The research team discovered a nuclear-localized, bimolecular signaling configuration by which the braking mechanism is directly linked to the accelerator to provide simultaneous acceleration and restraint.

Light signaling in *Arabidopsis* involves the binding of an activated photoreceptor molecule called phytochrome to a transcription factor (a switch that controls which genes are turned off or on) called PIF. This binding destroys PIF, switching off its target genes. However, the researchers found that in imposing PIF's destruction, phytochrome is simultaneously executed, thus reducing the incoming light-signaling intensity.

"Understanding such molecular mechanisms underlying the light response kinetics is important for engineering crops that can better adapt to environmental fluctuations," said Wang. This bimolecular mutually assured destruction (MAD) mechanism of signaling attenuation appears to represent a new configuration. □

The National Institutes of Health, the Department of Energy, and the U.S. Department of Agriculture supported this work.

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Very Distant **Galaxy Cluster** Confirmed

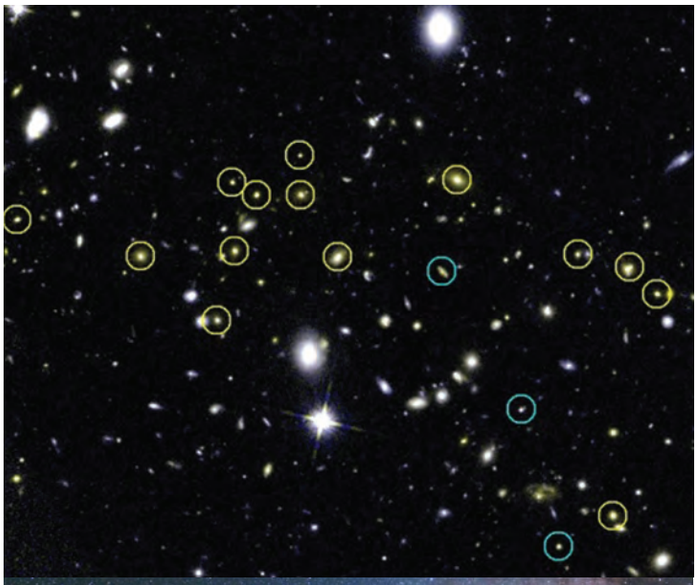

Image courtesy NASA

Image courtesy Yuri Beletsky

At top is a Hubble Space Telescope image of the center of the newly confirmed JKCS 041 galaxy cluster, located at a distance of 9.9 billion light years. The galaxies located in the cluster are circled. Blue circles show the few galaxies that continue to form new stars, while yellow circles show those that have already entered quiescence.

Andrew Newman has been a Carnegie–Princeton Fellow since 2013. He is pictured with one of the twin Magellan telescopes at Carnegie's Las Campanas Observatory.

Many of the oldest and most massive galaxies reside in enormous, concentrated clusters. Galaxy clusters in the early universe are thought to be key to understanding the life cycles of old galaxies, but to date astronomers have located only a handful of these rare structures. The structures and star populations of massive galaxies appear to change as they age, but much about how these galaxies formed and evolved remains mysterious. New research from a team led by Carnegie-Princeton Fellow Andrew Newman has confirmed the presence of an unusually distant galaxy cluster, JKCS 041. *The Astrophysical Journal* published the research.

The team began studying JKCS 041 in 2006, and it has taken years of observation with many of the world's most powerful telescopes to finally confirm its distance. The team used the Hubble Space Telescope to capture sharp images of the distant cluster and to split the starlight from its galaxies into their constituent colors, a technique known as spectroscopy. They found 19 galaxies at precisely the same great distance of 9.9 billion light years, the telltale sign of an early galaxy cluster.

"Our observations make this galaxy cluster one of the best-studied structures from the early universe," Newman said.

A previous study using the Chandra X-ray Observatory discovered X-ray emissions in the location of JKCS 041.

"These X-rays likely originate from hot gas in JKCS 041, which has been heated to a temperature of about 80 million degrees by the gravity of the massive cluster," said team member Stefano Andreon of the Brera Astronomical Observatory.

The largest and oldest galaxies are found in clusters, but there is a mystery about when and why these giant galaxies stopped forming new stars and became dormant. Peering back to a time when the galaxies in JKCS 041 were only 1 billion years old—or 10% of their present age—the team found that most had already entered their quiet phase.

"Because JKCS 041 is the most-distant known cluster of its size, it gives us a unique opportunity to study these old galaxies in detail and better understand their origins," Newman said.

Once massive galaxies enter their quiet phase, they continue expanding in overall size. This is thought to occur as galaxies collide with one another and evolve into a new, larger galaxy. Early clusters are suspected to be prime locations for these collisions, but to the team's surprise they found that the galaxies in JKCS 041 were growing at nearly the same rate as non-cluster galaxies. □

The international team included Carnegie's Andrew Newman and Stefano Andreon, Ginevra Trinchieri of the Brera Astronomical Observatory, Richard Ellis of Caltech, Tommaso Treu of the University of California at Santa Barbara, and Anand Raichoor of the Paris Observatory. This work was based on observations made with the NASA/ESA Hubble Space Telescope obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. These observations are associated with program number GO-12927, which was supported under NASA contract NAS 5-26555. The agreement ASI-INAF I/009/10/0 and the Brera Astronomical Observatory also supported the work.

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Sacrificing EGGS for the Greater Good

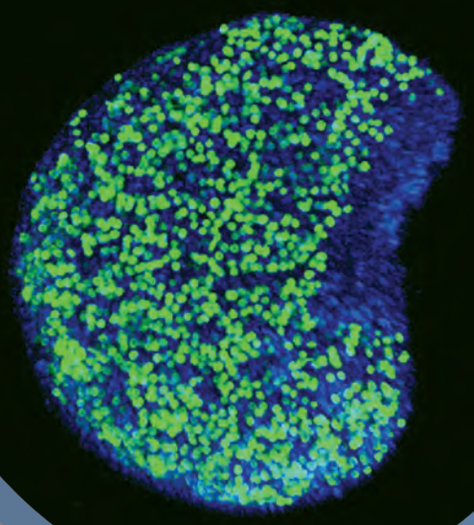

Image courtesy of Safia Malki

◁ This image shows a mouse fetal ovary whose eggs (green) were protected from dying by the drug AZT. The color blue identifies genomic DNA in all cells of the ovary.

▽ Carnegie's Alex Bortvin (left) and postdoctoral fellow Safia Malki are unraveling the earliest stages of egg selection, which may have broad implications for women's health and fertility.

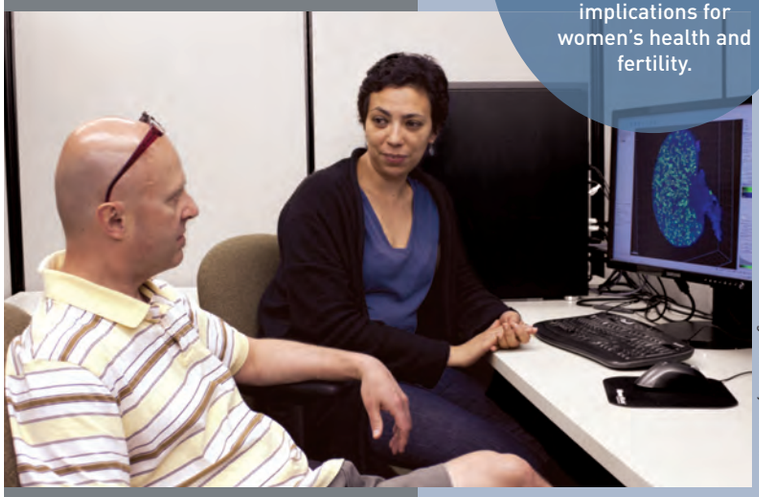

Image courtesy Alex Bortvin

A woman's supply of eggs is a precious commodity; only a few hundred mature eggs are produced, and each must be as free as possible from genetic damage. Part of egg production involves winnowing the egg supply during fetal development, childhood, and into adulthood. Carnegie's Alex Bortvin and postdoctoral fellow Safia Malki gained new insights into the earliest stages of egg selection, which may have broad implications for women's health and fertility. *Developmental Cell* reported the work.

The most stringent egg selection takes place at the earliest stages. Even before a baby girl is born, she has already lost 80% of her initial pool of immature eggs. This phenomenon has been observed in primates, rodents, and invertebrates, which indicates that it has been around for a long time evolutionarily. Despite its ancient origins, little is understood about how these selections are made.

Bortvin's team discovered that the fetal egg die-off is connected to segments of the egg's DNA known as transposable elements or "jumping genes." As developing eggs gain the ability to guide embryo development, transposons gain the ability to start moving. These ancient virus-like genes begin to leapfrog around the egg's DNA producing new mutations, just as transposon movement causes color mutations in kernels of corn. The transposable element named LINE1 is the most likely transposon activated in mammalian eggs.

Jumping genes can be particularly destructive in sperm and eggs, since much of their genetic material is essential for developing a healthy baby. Think of the genome of an egg or sperm as a stack of papers being photocopied. To be read and understood, they have to come out of the copier in the same order they went in. Jumping genes are like pages that insert themselves at random into the stack, making reading difficult or even impossible.

Prior studies by Bortvin and others showed that male germ cells—immature sperm—quash the movement of transposons, minimizing mutations and ensuring high levels of sperm production. In contrast, Bortvin and Malki discovered that female mice allow transposon movement to take place but then get rid of immature eggs harboring the highest number of mutations before the mouse is even born. The team proposes that this purging process allows for the selective survival of immature eggs whose genetic material has acquired relatively few new mutations.

Bortvin's group also discovered that the process of immature egg purging must be finely balanced. Overly stringent surveillance could result in excessive egg purging, too few surviving eggs, and premature loss of fertility. Surveillance that is not stringent enough, on the other hand, would allow eggs with a lot of jumping gene-related errors to survive, leading to a high level of birth defects.

"Our findings suggest that the ovary of a newborn girl already contains both 'good' eggs and those destined to give rise to Down syndrome or miscarriages," Bortvin said. "Further study may show that these 'good' cells are ovulated first and the abnormal ones usually come later."

Importantly, they discovered that the drug AZT, which inhibits multiplication of AIDS-causing HIV virus in humans, also alters jumping gene activity in immature eggs. It is effective against LINE1 transposons. This discovery raises the possibility that the number and quality of immature eggs might be enhanced by drug treatment.

Is this immature egg purge a blessing in disguise? Despite their destructive power, jumping genes are also the source of genetic novelty that can make species stronger and better suited for survival. □

The endowment of Carnegie Institution for Science by a CPRIT R1101 award and National Institutes of Health grant GM40367 supported this work. An EMBO Long-Term Fellowship, a McClintock Fellowship, and a Hollaender Fellowship supported researchers.

Image courtesy Avishay Gal-Yam of the Weizmann Institute of Science

Mansi Kasliwal, a Hubble–Carnegie–Princeton Fellow, was part of the discovery team.

New Technique Sleuths
Supernova Parent

Astronomers have long wondered whether Wolf-Rayet stars propagate certain types of exploding stars (supernovae) because they are particularly large and very hot. New work from the Palomar Transient Factory (PTF) team, including Carnegie's Mansi Kasliwal, is homing in on the answer: They have identified a Wolf-Rayet star as the likely progenitor of a recently exploded supernova. *Nature* published their work.

Wolf-Rayet stars have strong stellar winds and are deficient in hydrogen when compared with other stars, making them easily recognizable. Researchers think that Wolf-Rayet stars explode as type IIb, Ib, or Ic supernovae. Yet direct evidence has been missing.

The team, led by Avishay Gal-Yam of the Weizmann Institute of Science in Israel, applied a novel observational method called flash spectroscopy to identify the likely progenitor of a type IIb supernova called SN 2013cu just over 15 hours after it exploded.

"This supernova was discovered by the Palomar 48-inch telescope in California. The on-duty PTF team member in Israel promptly sounded an alert about this supernova discovery, enabling another PTF team member to get a spectrum with the Keck telescope before the sun rose in Hawaii," Kasliwal explained. "The global rapid-response protocol ensures the sun never rises for the PTF team!"

When a supernova explodes, it flash ionizes its immediate surroundings, giving the astronomers a direct glimpse of the progenitor star's chemistry. The opportunity lasts only for a day before the supernova blast wave sweeps the ionization away. So it's crucial to rapidly respond.

The observations found evidence of composition and shape that aligns with that of a nitrogen-rich Wolf-Rayet star. What's more, the progenitor star likely experienced an increased loss of mass shortly before the explosion, which is consistent with model predictions for Wolf-Rayet explosions.

Previously, when looking for a pre-explosion star using the Hubble Space Telescope, astronomers could only look over a range of about 20 megaparsecs. But by using these new tools they can increase that distance five times, allowing them to identify many more supernovae progenitors.

Shri Kulkarni of the California Institute of Technology leads the PTF collaboration. PTF has discovered more than 2000 supernovae during its four and a half years of observations, including many rare and exotic types of cosmic outbursts. □

The I-CORE Program\The Quantum Universe of the Planning and Budgeting Committee and the Israel Science Foundation (ISF) and grants from the ISF, U.S.-Israel Binational Science Foundation, German-Israeli Foundation for Scientific Research and Development, Minerva, the FP7/European Research Council, and a Kimmel Investigator award supported this research. The Hubble and Carnegie–Princeton Fellowships; the Arye Dissentshik Career Development Chair and a grant from the Israeli Ministry of Science Technology, and Space; the National Science Foundation (NSF); an NSF Postdoctoral Fellowship; and the TABASGO Foundation, the Christopher R. Redlich Fund, and NSF grant AST-1211916 also provided support. The National Energy Research Scientific Computing Center, supported by the Office of Science of the U.S. Department of Energy, provided staff, computational resources, and data storage for this project.

The intermediate Palomar Transient Factory (iPTF)—led by the California Institute of Technology (Caltech)—started searching the skies for certain types of stars and related phenomena in February. The iPTF was built on the legacy of the Palomar Transient Factory (PTF), designed in 2008 to systematically chart the transient sky by using a robotic observing system mounted on the 48-inch Samuel Oschin Telescope on Palomar Mountain near San Diego, California. iPTF is a scientific collaboration among Caltech, Los Alamos National Laboratory, the University of Wisconsin-Milwaukee, the Oskar Klein Center, the Weizmann Institute of Science, the TANGO Program of the University System of Taiwan, and the Kavli Institute for the Physics and Mathematics of the Universe.

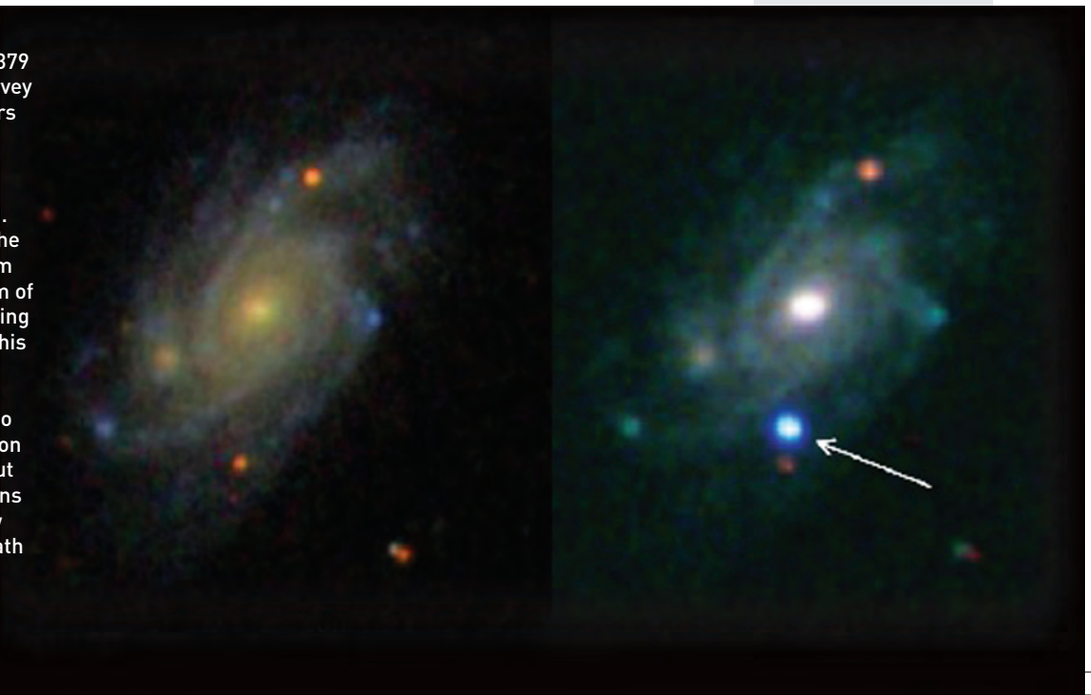

Image courtesy Avishay Gal-Yam of the Weizmann Institute of Science

While observing a galaxy known as UGC 9379 (left; image from the Sloan Digital Sky Survey (SDSS) located about 350 million light years away from us, the team discovered a new source of bright blue light (right, marked with an arrow; image from the 60-inch robotic telescope at Palomar Observatory). This white-hot young supernova marked the explosive death of a massive star. The team conducted a detailed study of the spectrum of colors composing the supernova's light using a technique called "flash spectroscopy." This study revealed the signatures of a wind blown by the aging star just prior to its terminal explosion and allowed the team to determine what elements were abundant on the surface of the dying star as it was about to explode as a supernova. The observations provided important information about how massive stars evolve just prior to their death and the origin of crucial elements such as carbon, nitrogen, and oxygen.

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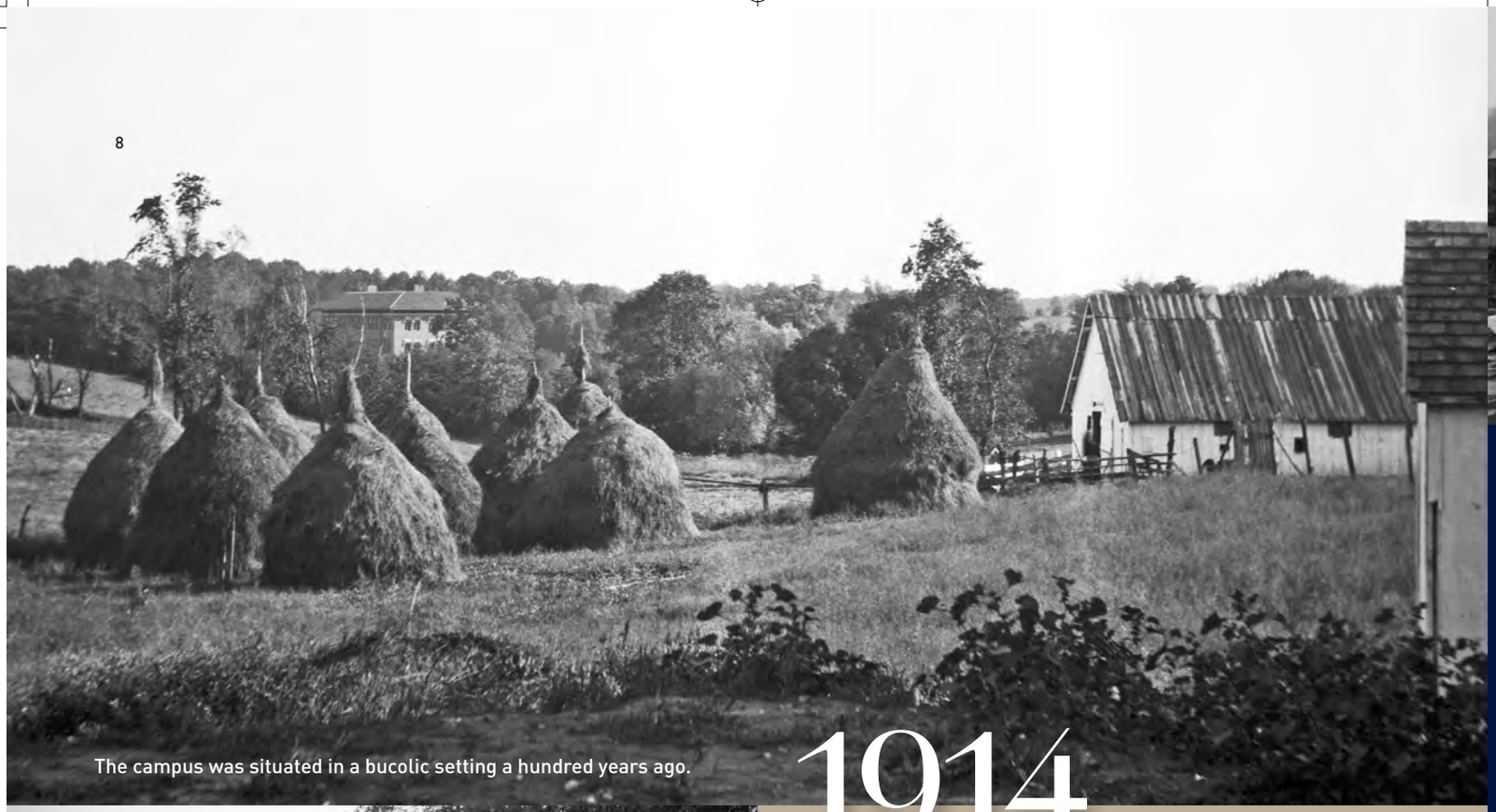

The campus was situated in a bucolic setting a hundred years ago.

1914

Broad Branch Road Campus Debut

By **SHAUN HARDY**

Clearing land was vastly different then; horses bore the brunt of the work in 1913.

"Perhaps no building being erected at the present time has excited so much interest ... as has the new edifice in progress [at Broad Branch Road]. Certainly no structure has required so much precise care in workmanship and a thorough knowledge of building to meet the delicate needs of a building of this character. It is the last word in scientific building."

Washington Times, November 22, 1913

The unusual structure takes shape.

Images courtesy Carnegie archives

The gleaming modern laboratory is open for business in 1914.

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Carnegie staff enjoyed a picnic on the rooftop deck in the 1920s.

April 1, 1914, was cool and rainy, but spirits must have been high among the staff of the Department of Terrestrial Magnetism (DTM). The department started its eleventh year with a move to its new campus "out in the country" in Washington, D.C.'s, northwest fringe.

The department's expanding research program and the need for fireproof storage for its geophysical data convinced the Carnegie trustees in 1913 to allocate $127,200 ($3 million in today's dollars) to build it a permanent home. A seven-acre tract "admirably located amidst rural surroundings" near Rock Creek Park was acquired, far from "disturbing influences" such as electric streetcar lines, for precise scientific measurements.

Waddy B. Wood, a prominent Washington, D.C., architect, was selected to design the new laboratory and office building. Just seven years earlier he had designed the Geophysical Laboratory's headquarters, a mile to the south. The particular requirements for DTM's new home posed special challenges. The building needed to be exceptionally strong and fireproof, and its floors and walls had to be "vibrationless." The use of structural steel had to be kept to a minimum to reduce magnetic interference.

Davis Construction Company broke ground in May 1913. Working primarily in reinforced concrete and brick, the builders employed novel and sometimes difficult construction techniques, in particular, isolating the massive floor slabs from the walls by beds of sand. Local papers followed the unusual project. "Science Structure Hard on Builders," reported the *Washington Times* in September 1913. "There is certainly no other structure in this city which requires the care in building that compares with it, and it is the general belief that there is nothing exactly similar in the country."

On February 14, 1914, the elegant, brick Italian Renaissance style "Main Building" was finished. It cost $68,000 to build—in an era when the average American earned $600 a year and a typical house cost $3,000. Constant-temperature rooms for experiments were fabricated underground; above were three floors of offices, laboratories, "computing rooms" (computers were human then), an instrument shop, library, and archives. A rooftop deck for observational work crowned the building. A symbolic compass rose, cast in brass and set in the vestibule floor, branded the building for its intended mission in geomagnetic research. One hundred years later, the building is still going strong. □

MEAT Turns Up the Heat

Carnegie's Ken Caldeira

Eating meat contributes to climate change, thanks to the greenhouse gases emitted by livestock. New research finds that livestock emissions are on the rise and that beef cattle are responsible for far more greenhouse gas emissions than other types of animals. The research team, including Dario Caro, formerly of Carnegie and now at the University of Siena in Italy, and Carnegie's Ken Caldeira had their results published in *Climatic Change*.

Carbon dioxide is the most prevalent gas when it comes to climate change. But the greenhouse gases methane and nitrous oxide are significant causes of global-warming activity; they are released, in part, by livestock. Methane comes from microorganisms that are involved in livestock digestion, and nitrous oxide comes from decomposing manure. These two gases are responsible for a quarter of these non-carbon dioxide gas emissions and 9% of total greenhouse gas emissions overall.

The research team estimated the greenhouse gas emissions related to livestock in 237 countries over nearly half a century and found that livestock emissions increased by 51% over this period.

They found a stark difference between livestock-related emissions in the developing world, which accounts for most of this increase, and these emissions in developed countries. Livestock-related emissions in the developing world are expected to increase going forward, as demand for meat, dairy products, and eggs is predicted by some scientists to double by 2050. By contrast, developed countries reached maximum livestock emissions in the 1970s and have been in decline since then.

"The developing world is getting better at reducing greenhouse emissions caused by each animal, but this improvement is not keeping up with the increasing demand for meat," said Caro. "As a result, greenhouse gas emissions from livestock keep going up and up in much of the developing world."

Of livestock-related greenhouse gas emissions; 54% came from beef cattle, while 17% came from dairy cattle. Part of this is due to the abundance of cows, but it is also because cattle emit greater quantities of methane and nitrous oxide than other animals. Sheep comprised 9%, buffalo 7%, pigs 5%, and goats 4%.

"That tasty hamburger is the real culprit," Caldeira said. "It might be better for the environment if we all became vegetarians, but a lot of improvement could come from eating pork or chicken instead of beef." □

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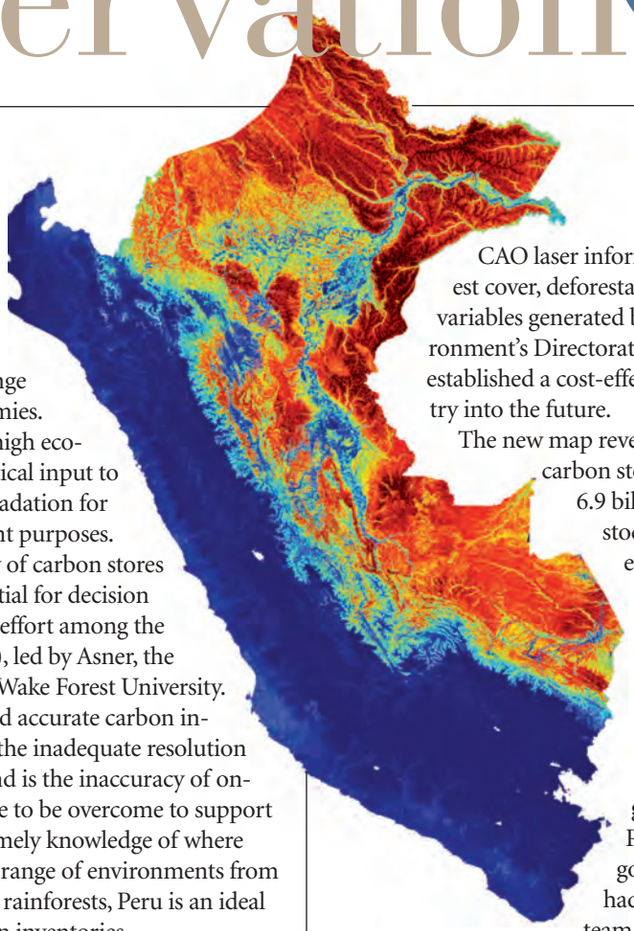
PERU'S CARBON QUANTIFIED:

Economic & Conservation Boon

Images courtesy Greg Asner



A team of researchers led by Greg Asner unveiled the first high-resolution carbon map for the entire country of Peru. The new and improved methodology used to make the map marks a sea change for future market-based carbon economies. The map also reveals Peru's extremely high ecological diversity, and it provides the critical input to studies of deforestation and forest degradation for conservation, land use, and enforcement purposes. The technique includes the uncertainty of carbon stores throughout the country, which is essential for decision makers. The mapping project is a joint effort among the Carnegie Airborne Observatory (CAO), led by Asner, the Ministry of Environment of Peru, and Wake Forest University.

Historically two obstacles have slowed accurate carbon inventories at national scales. The first is the inadequate resolution of satellite mapping data, and the second is the inaccuracy of on-the-ground surveys. These barriers have to be overcome to support policies and markets that depend on timely knowledge of where carbon is stored on land. With its huge range of environments from cold Andean deserts to hot Amazonian rainforests, Peru is an ideal country for advancing high-tech carbon inventories.

Asner remarked, "The international community wants to use a combination of carbon sequestration and emissions reductions to combat climate change. Some 15% of global carbon emissions result from deforestation and forest degradation, which releases carbon dioxide to the atmosphere as trees are destroyed. Our cost-effective approach allows us to accurately map the carbon in this incredibly diverse country for the first time. It opens Peru's door to carbon sequestration agreements and is an enormous boon to conservation and monitoring efforts over vast areas for the long term."

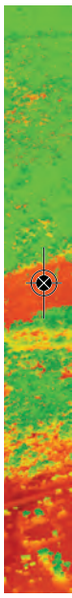
The critical resolution for carbon monitoring is the hectare (2.5 acres). It is the world's most common unit of land tenure and policy enforcement, yet very few countries have advanced their carbon monitoring efforts at such high resolution. The team integrated field data with airborne laser-mapping technology using the Carnegie Airborne Observatory (CAO) and coupled this with publicly available satellite imagery to scale carbon inventories up to the national level. The CAO sweeps laser light across the vegetation canopy to image it in 3-D, to determine the location and size of each tree at a resolution of 3.5 feet (1.1 meter). By combining the CAO laser information with satellite maps of forest cover, deforestation, and other environmental variables generated by the Peruvian Ministry of Environment's Directorate of Land Management, the group established a cost-effective means to monitor the country into the future.

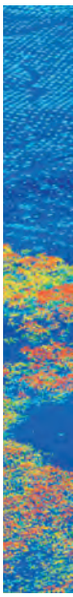
The new map reveals that the total aboveground carbon stock of the country is currently 6.9 billion metric tons, but the carbon stocks vary by region and land ownership. The average carbon density for Peruvian rainforests is 99 metric tons of carbon per hectare, with the maximum density of 168 metric tons of carbon per hectare. The largest stocks are in the northern Peruvian Amazon and along the Brazil-Peru border. Regions of deforestation, such as Peru's Puerto Maldonado where gold mining has ravaged the area, had low to no carbon storage. The team also assessed 174 protected areas, finding that—for every hectare of forest put into protection—an average 95 metric tons of carbon are stored on land, with even more carbon sequestered below the soil surface.

Miles Silman, report coauthor from Wake Forest University, added, "The Carnegie map is a monumental effort—from field to remote sensing to computation—that honestly lays out the methods, predictions, and their reliability for each hectare in Peru. It should ignite the imaginations of ecologists and earth scientists and provide a road map for decision makers. The report also adds another exclamation point to the value of protected areas. If you choose carbon as your currency, parks in Amazonian Peru are the banks, and the bigger the area the closer it gets to being Fort Knox." □

An interinstitutional working agreement between Carnegie Institution's Department of Global Ecology and the Peruvian Ministry of Environment's Directorate of Land Management supported this research. John D. and Catherine T. MacArthur Foundation and Gordon and Betty Moore Foundation funded the study.

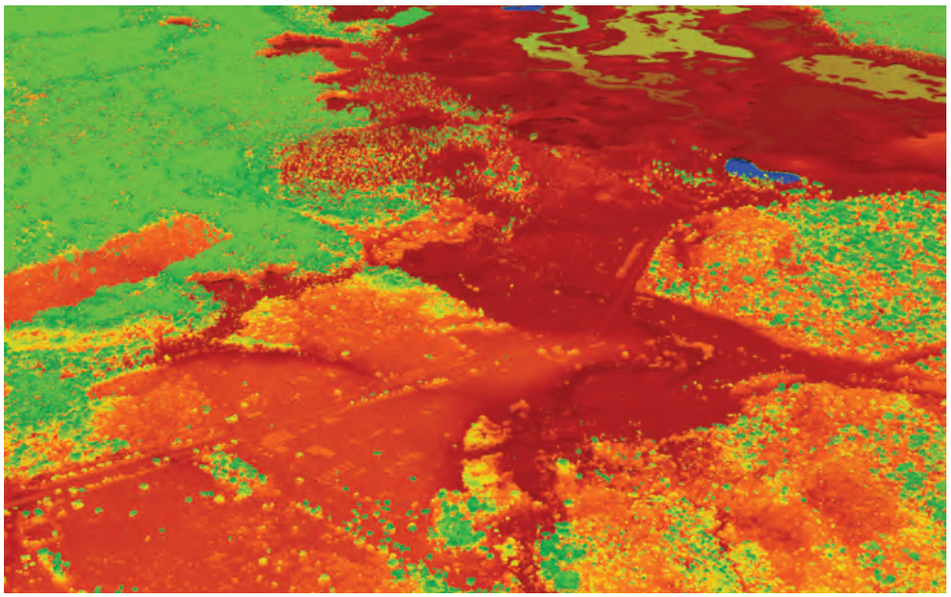
Avatar Alliance Foundation, John D. and Catherine T. MacArthur Foundation, Grantham Foundation for the Protection of the Environment, Gordon and Betty Moore Foundation, W. M. Keck Foundation, Margaret A. Cargill Foundation, Mary Anne Nyburg Baker and G. Leonard Baker Jr., and William R. Hearst III made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

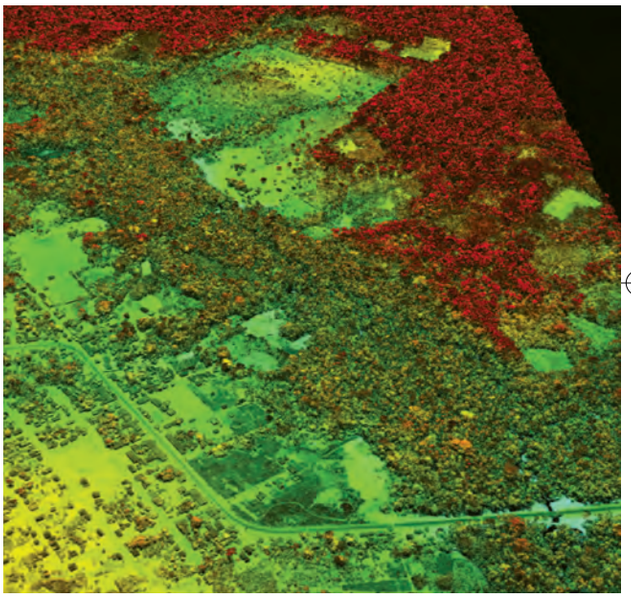


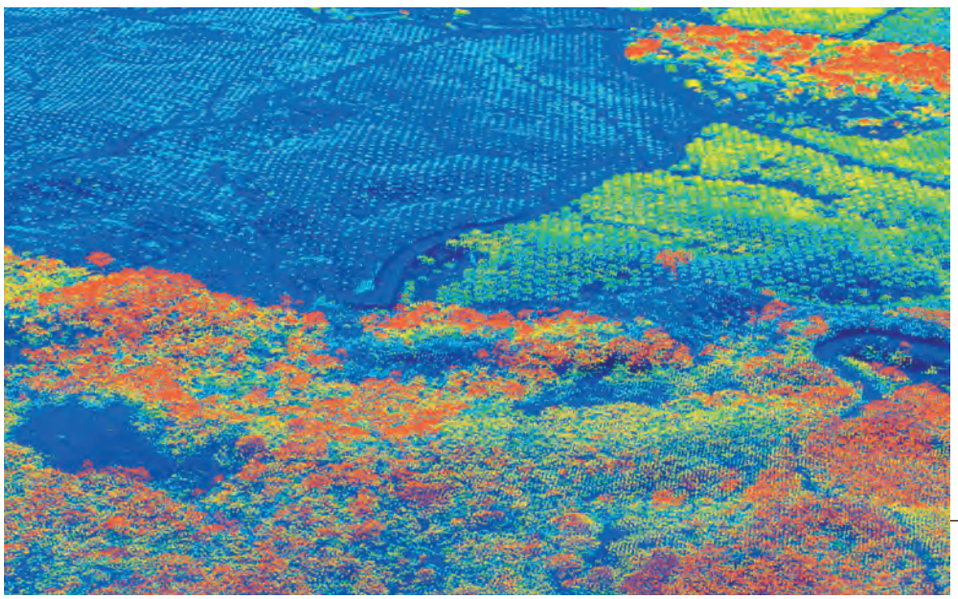


Carnegie and Peruvian researchers quantified the carbon stocks throughout the entire country of Peru (left); red is highest carbon, dark blue is lowest.

The Carnegie Airborne Observatory members pose with their Peruvian partners and the airplane (right). Greg Asner is in the front row, center, in an orange vest and a black short-sleeved shirt.







These 3-D images are produced by the Carnegie Airborne Observatory, which sweeps laser light across the vegetation canopy to image it in 3-D and combines it with satellite imagery and information from the field. The image at top left shows major disturbance by gold mining in Peru (deep red). The image on top right shows Peru's Puerto Maldonado region. The developed areas are in green. The farther away from disturbance the less damage there is to the forest, shown in red.

This image (left) shows the regular patterns of an oil palm plantation. The colors represent height from the ground. Blue is at ground level; red represents treetops.

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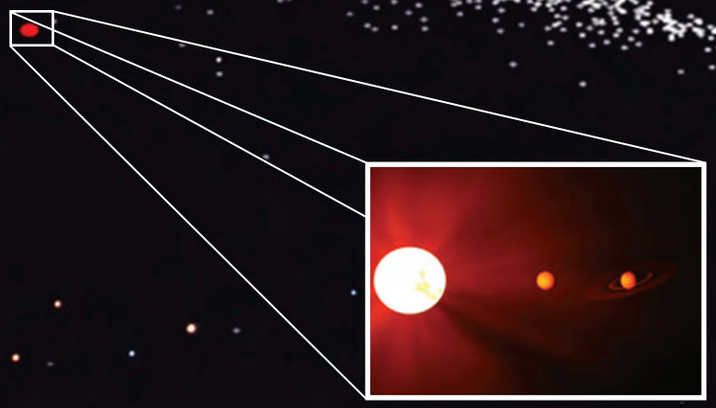


Steve Shectman

Paul Butler

Pamela

Kapteyn's star and its planets likely come from a dwarf galaxy now merged with the Milky Way. The artwork shows characteristic streams of stars resulting from such a galactic merging event.

Image courtesy Victor Robles, James Bullock, and Miguel Rocha of the University of California-Irvine and Joel Primack of the University of California-Santa Cruz.

Two Planets ORBIT ANCIENT STAR

An international team of astronomers, including five Carnegie scientists, discovered two new planets orbiting a very old star that is near to our own Sun. One of these planets orbits the star at a distance where liquid water could exist on its surface, a key ingredient to support life. *Monthly Notices of the Royal Astronomical Society* published the team's work.

Kapteyn's star, named after the Dutch astronomer Jacobus Kapteyn who discovered it at the end of the 19th century, is the second fastest-moving star in the sky and belongs to the Galactic halo, an extended group of stars circling our galaxy in very elliptical orbits. With a third of the mass of the Sun, this red dwarf can be seen with an amateur telescope in the southern constellation of Pictor.

The astronomers—including Carnegie's Pamela Arriagada, Paul Butler, Steve Shectman, Jeff Crane, and Ian Thompson—used new data from the High Accuracy Radial velocity Planet Searcher (HARPS) spectrometer at the European Southern Observatory's La Silla Observatory, the Planet Finding Spectrometer at Carnegie's Las Campanas Observatory in Chile, and the High Resolution Echelle Spectrometer (HIRES) at the W. M. Keck Observatory in Hawaii to measure tiny periodic changes in the motion of the star. The Doppler effect—the frequency change of an object caused by its motion—enabled the scientists to deduce the planets' masses and orbital periods.

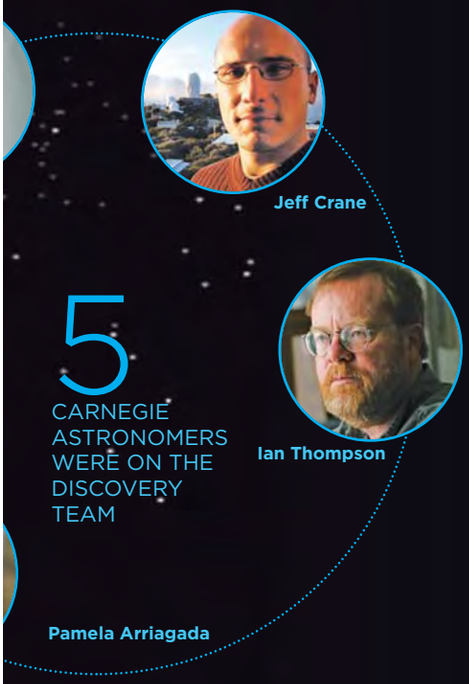
"That we can make such precise measurements of such subtle effects is a real technological marvel," said Jeff Crane of the Observatories.

"We were surprised to find planets orbiting Kapteyn's star. Previous data showed some irregular motion so we were looking for very short period planets when the new signals showed up loud and clear," explained lead author Guillem Anglada-Escude, a former Carnegie postdoc now at Queen Mary University of London.

The planet called Kapteyn b might support water. It is at least five times the mass of the Earth and orbits its star every 48 days. This means the planet is warm enough for water to exist on its surface. The second planet, Kapteyn c, is a more massive super-Earth. Its year lasts for 121 days, and astronomers think it's too cold to support liquid water. At the moment, only a few properties of the planets are known: approximate masses, orbital periods, and the distances from their host star. By measuring their atmospheres using instruments that are currently under development, astronomers will verify the presence or lack of water.

"Finding a stable planetary system with a potentially habitable planet orbiting one of the very nearest stars in the sky is mind-blowing. This is one more piece of evidence that nearly all stars

This research was funded by the National Science Foundation, NASA, and the Carnegie Institution for Science.

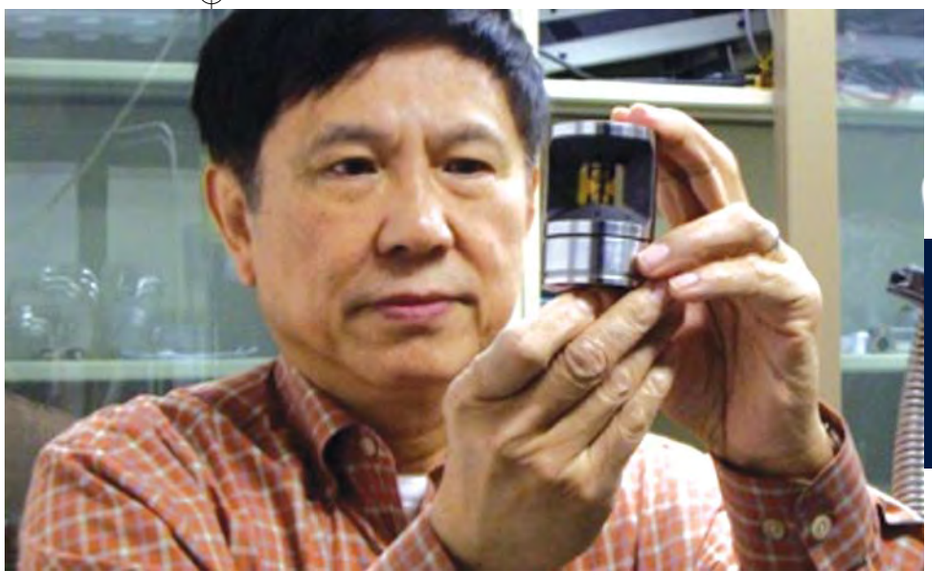


have planets and that potentially habitable planets in our galaxy are as common as grains of sand on a beach," said Pamela Arriagada, the second author and a Carnegie postdoctoral researcher.

The planetary systems detected by NASA's Kepler mission are usually hundreds of light years away. In contrast, Kapteyn's star is the 25th nearest star to the Sun—only 13 light years away from Earth. What makes this discovery special, however, is the peculiar story of the star. Researchers think that Kapteyn's star was born in a dwarf galaxy that was long ago disrupted and absorbed by the Milky Way; this galactic cannibalization set the star on a new path, making it part of the Milky Way's halo.

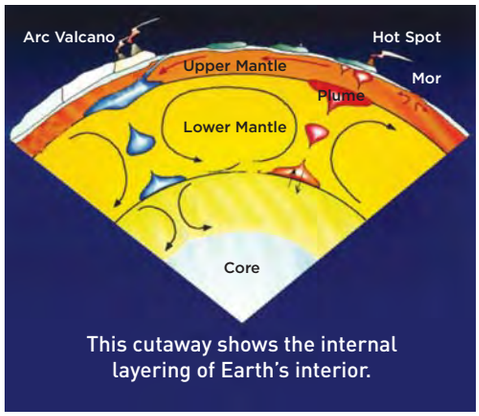
The likely remnant core of the original dwarf galaxy is Omega Centauri, an enigmatic group of stars 16,000 light years from Earth that contains hundreds of thousands of similarly old suns and was long thought to be a globular cluster. This sets the most likely age of Kapteyn's star and its planets at 11.5 billion years, which is 2.5 times older than Earth and "only" 2 billion years younger than the universe, which is 13.7 billion years old.

"It does make you wonder what kind of life could have evolved on those planets over such a long time," Anglada-Escude added. □



Carnegie's Dave Mao led the work.

Lower Mantle Surprise



This cutaway shows the internal layering of Earth's interior.

Image courtesy Yingwei Fei

A team of scientists led by Carnegie's Ho-kwang "Dave" Mao found that the composition of the Earth's lower mantle may be significantly different than previously thought. *Science* published the results.

The Earth's lower mantle makes up 55% of the planet by volume and extends from about 415 to 1800 miles (670 and 2900 kilometers) in depth, as defined by the so-called transition zone and the core-mantle boundary. Pressures in the lower mantle start at 237,000 times atmospheric pressure (24 gigapascals) and reach about 1.3 million times atmospheric pressure (136 gigapascals) at the core-mantle boundary.

The prevailing theory has been that the majority of the lower mantle is made up of a single ferromagnesian silicate mineral commonly called perovskite. It was thought that perovskite didn't change structure over the enormous range of pressures and temperatures spanning the lower mantle.

Recent experiments that simulate the conditions of the lower mantle using laser-heated diamond anvil cells, at pressures between 938,000 and 997,000 times atmospheric pressure (95 and 101 gigapascals) and temperatures between 3500 and 3860°F (2200 and 2400 K), now reveal that iron-bearing perovskite is, in fact, unstable in the lower mantle.

The team found that the mineral disassociates into two phases, a magnesium silicate perovskite missing iron, which is represented by the Fe portion of the chemical formula, and a new mineral that is iron rich and hexagonal in structure called the H-phase. Experiments confirm that this iron-rich H-phase is more stable than iron-bearing perovskite, much to everyone's surprise. This means it is likely a prevalent and previously unknown species in the lower mantle. This may change our understanding of the deep Earth.

"We still don't fully understand the chemistry of the H-phase," said lead author Li Zhang, also of Carnegie. "But this finding indicates that all geodynamic models need to be reconsidered to take the H-phase into account. And there could be even more unidentified phases down there in the lower mantle as well, waiting to be identified." □

National Science Foundation (NSF) grants EAR-0911492, EAR-1119504, EAR-1141929, and EAR-1345112 supported the research. This work was performed at HPCAT (Sector 16), Advanced Photon Source (APS), Argonne National Laboratory. The U.S. Department of Energy-Basic Energy Sciences-National Nuclear Security Administration (DOE-BES-NNSA) under Award DE-NA0001974 and DOE-Basic Energy Sciences (BES) under Award DE-FG02-99ER45775, with partial instrumentation funding by NSF, support HPCAT operations. EFree, an Energy Frontier Research Center funded by DOE-BES under grant DE-SC0001057, supports HPSynC. Portions of this work were performed at GeoSoilEnviroCARS (Sector 13), APS, supported by the NSF-Earth Sciences (EAR-1128799) and DOE-GeoSciences (DE-FG02-94ER14466), at 34ID-E beamline, APS, and at 15U1, Shanghai Synchrotron Radiation Facility. DOE- BES under contract DE-AC02-06CH11357 supported the use of the APS facility. The Materials Research and Engineering Center program of the NSF under award DMR-0819885 also partially supported this work. Part of this work was carried out in the Characterization Facility of the University of Minnesota.

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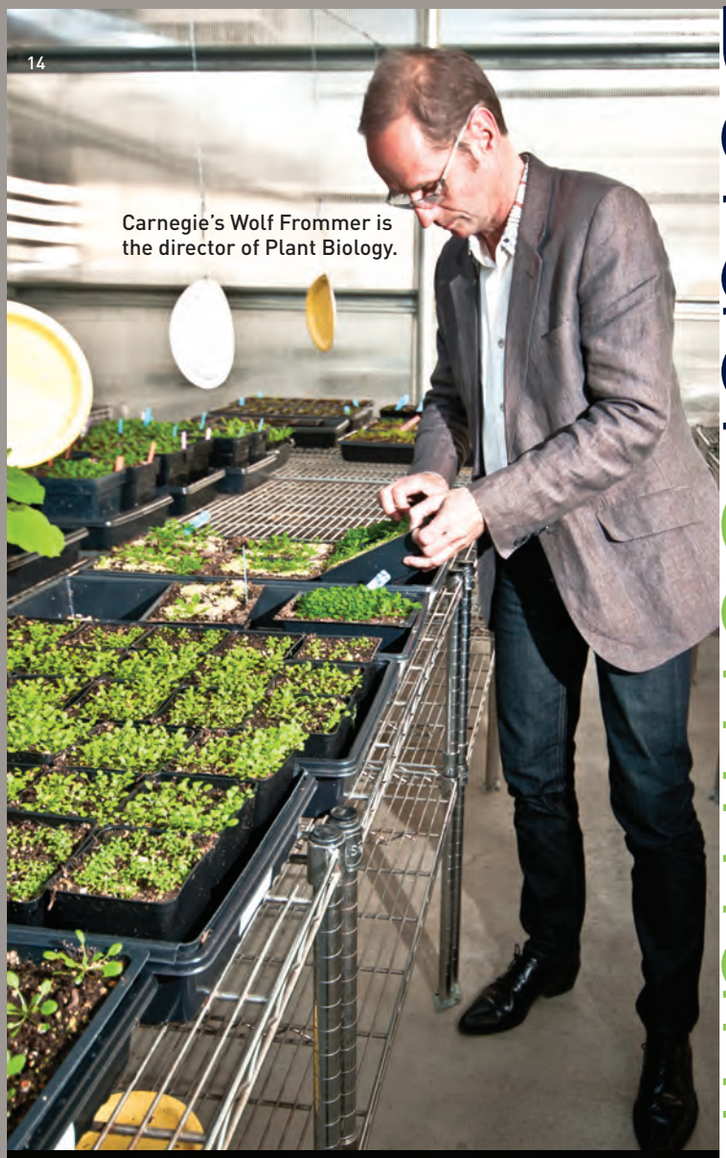
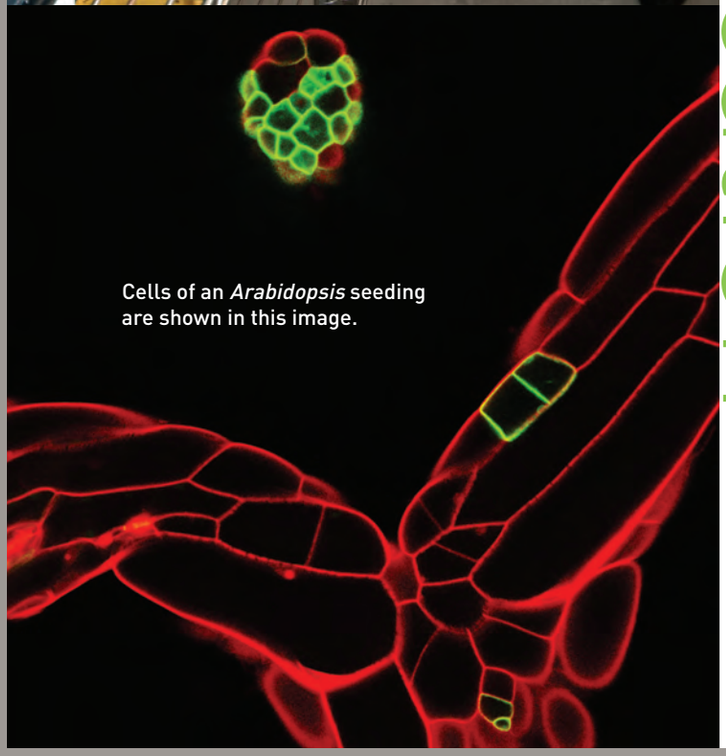
Border Communication



Carnegie's Wolf Frommer is the director of Plant Biology.

Image courtesy Robin Kempster



Cells of an *Arabidopsis* seeding are shown in this image.

Image courtesy Tie Liu

MEMBRANES HOLD CELLS TOGETHER. They provide a barrier to nutrient transport and a communication platform that connects the outside to the cell's interior control centers. Thousands of proteins reside in membranes. They control the flow of select chemicals and mediate the flow of nutrients and information. Almost all of these pathways work by protein handshakes—one protein "talking" to another, for example, to encourage the import of a nutrient, to block a compound from accumulating to a toxic level, or to alert the cell's interior to changes in the environment.

Little has been known about the relationships among membrane proteins and interior proteins. Now, a team led by Carnegie's Wolf Frommer has revealed how membrane proteins are networked with each other and with the signaling proteins inside the cell. *Science* published their work.

The messages conveyed to membrane proteins by signaling proteins, and vice versa, form the basis of cell communication between cells and between the organism and the outside world. The Frommer team carried out a massive screen for protein-to-protein interactions between predicted membrane proteins and predicted signaling proteins. They used the model plant *Arabidopsis*, a mustard green.

The team performed millions of tests and discovered over 10,000 interactions. The work is the first of its kind in any organism and has implications for both plant and animal sciences.

Technical difficulties in studying membranes have meant that only a few cross-membrane protein-to-protein signals are known. Frommer's team developed a different process that was able to yield a greater diversity of results. The vast majority of the thousands of potential membrane protein-signaling protein interactions they found had never before been identified. The team's aim was to use their new protein interaction network to identify interactions important for protein-to-protein messaging and help assign possible functions to them.

"Our findings can serve as an important resource for gene discovery and will be applicable to the animal kingdom, as well as to plants," Frommer said. "In plants, it could help lead to discoveries that will improve crop yields. ☐

The National Science Foundation supported this work.

In Brief

❶ Carnegie trustee Mary-Claire King

❷ Carnegie's new president, Matthew P. Scott

❸ Marnie Halpern

❹ Steve Farber

❺ Vanessa Quinlivan-Repasi

❼ Tim Strobel

❻ In July Bob Hazen performed fieldwork in the ancient Pilbara Complex in Western Australia accompanied by a film crew from NOVA TV.
Image courtesy Bob Hazen

TRUSTEES AND ADMINISTRATION

❶ Carnegie trustee **Mary-Claire King**, professor at the U. of Washington, will receive the highly prestigious 2014 Lasker-Koshland Special Achievement Award in Medical Science "for bold, imaginative, and diverse contributions to medical science and human rights—she discovered the *BRCA1* gene locus that causes hereditary breast cancer and deployed DNA strategies that reunite missing persons or their remains with their families."

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❷ Carnegie president **Matthew Scott** officially started his new position Sept. 1, 2014, with a packed schedule. He held one-on-one meetings with staff scientists and other personnel in the Washington, area. He attended a salon event in N.Y. featuring a talk by Nobel Laureate, astrophysicist Brian P. Schmidt. The event was sponsored by five Giant Magellan Telescope Organization (GMTO) partners on Sept. 9. Scott also met with the Chilean ambassador and Carnegie's Miguel Roth on Sept. 16, in Washington, D.C. In mid-and-late Sept., he visited with Carnegie staff at Baltimore's Embryology Department and Carnegie's Department of Global Ecology and the Observatories in CA.

EMBRYOLOGY

Director **Allan Spradling** presented a lecture at Rockefeller U. and attended the 2014 David and Lucile Packard Foundation annual meeting.

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❸ In June **Marnie Halpern** and several lab members presented their work at the 11th International Conference on Zebrafish Development in Madison, WI. Halpern was an invited lecturer and instructor at the Zebrafish Neurobiology course and symposium held at U. Helsinki in Aug.

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Yixian Zheng presented her work at the Ellison Medical Foundation annual meeting at Woods Hole, MA.

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In Aug. **Alex Bortvin** was an invited speaker at the Gordon Research Conference on Mammalian Reproduction.

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❹ In June **Steve Farber** and several lab members presented their work at the 11th International Conference on Zebrafish Development. Farber also presented his work in July at the Federation of American Societies for Experimental Biology conference "Molecular Mechanisms of Intestinal Lipid Transport and Metabolism" in Snowmass, CO.

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❺ Farber graduate student **Vanessa Quinlivan-Repasi** was awarded a National Research Service Award predoctoral fellowship for three years for her project on alcoholic fatty liver disease.

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Christoph Lepper was a coorganizer of the Society for Developmental Biology Mid-Atlantic Regional Meeting held at the Johns Hopkins U. in May.

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Fred Tan co-organized the 4th Annual Practical Genomics: From Biology to Biostatistics Workshop. The Aug. workshop was held at the department to introduce biologists to hands-on programming, analysis techniques, and statistics.

GEOPHYSICAL LABORATORY

❻ In May **Robert Hazen** was the keynote speaker on mineral evolution at the Nordic Astrobiology Conference in Bergen, Norway. He presented lectures at Rensselaer Polytechnic Institute and at the Goldschmidt Conference in Vancouver, where he was awarded fellowship in the Geochemical Society. Hazen was named the 2014 F. Earl Ingerson Lecturer of the Geochemical Society. He presented keynote lectures on the co-evolution of minerals and life at the Gordon Research Conference on Biomineralization in New London, NH, and at the Dallas Mineral Collecting Symposium. In July he conducted fieldwork in the 3.5-billion-year-old Pilbara Complex of Western Australia, accompanied by a film crew from NOVA TV. He also presented three talks at the International Mineralogical Association meeting in Johannesburg, South Africa, in Aug.

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Andrew Steele was on sabbatical at the Max Planck Institute for Solar System Science in Germany this summer and presented two talks. Steele also gave a talk at U. Gottingen, Germany and became a coinvestigator for the Mars 2020 mission on the SHERLOC instrument.

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❼ **Timothy Strobel** gave a keynote lecture at the 2014 Consortium for Materials Properties Research in Earth Science (COMPRES) Annual Meeting at Skamania Lodge, WA, June 16-19. He presented the Young Investigator Lecture at the 2014 Gordon Research Conference on Research at High Pressure in Biddeford, ME, June 22-27.

—

Douglas Rumble attended Professor Naohiro Yoshida's Isotopomer 2014 meeting at Tokyo Institute of Technology in June and presented talks on high-resolution mass spectrometry of the atmospheric gases N_2O, O_2, and CH_4. He served as visiting adjunct professor at Dartmouth College in July and Aug.

—

Research scientist **John Armstrong** organized and cochaired a two-day symposium at the 6th quadrennial meeting of the International Union of Microbeam Analysis Societies (IUMAS) held with the Microscopy & Microanalysis 2014 conference in Hartford, CT, Aug. 2-7. He presented papers on advances in high-precision analyses of geological materials and on correction procedures for quantitative analysis with electron microprobes. He was coauthor on several other presentations.

—

Microbeam specialist **Katherine Crispin** was social media coordinator for the recent IUMAS-6 meeting held with the Microscopy & Microanalysis 2014 conference Aug. 2-7. Crispin presented a talk at the Microscopy & Microanalysis 2014 and was elected as a new member of the Education, Outreach, and Infrastructure committee for COMPRES.

—

Research scientist **Kadek Hemawan** presented a talk at the New Diamond and Nano Carbons Conference in Chicago, May 25-29.

—

BioEyes K-12

The General Motors Corporation presented a $5,000.00 award to Carnegie's BioEYES K-12 educational program on September 11, 2014, to deliver a two-week environmental curriculum, *Your Watershed, Your Backyard*. The program is one of several BioEYES programs using live zebrafish to learn about local watersheds, pollution, and the Chesapeake Bay. ☐

EFree Energy Frontier Research in Extreme Enviroments Center

Renewed!

The DOE renewed Carnegie's Energy Frontier Research Center, Energy Frontier Research in Extreme Environments (EFree), headquartered at Carnegie and directed by **Russell Hemley**. EFree's goal is to use extreme conditions as a means to discover new materials to address major energy challenges faced by the nation, principally through the design, synthesis, and stabilization of revolutionary materials for energy conversion, storage, and transport.

More than 200 proposals competed for the 32 projects. Carnegie was the only nonprofit to receive funding. Of the 32, 10 projects are new, while the others are renewals. ☐

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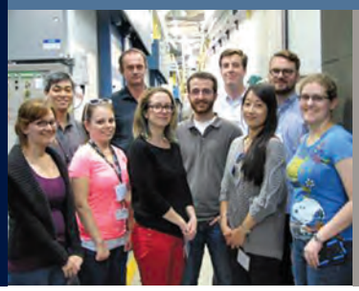
Neurtron & Xray School 2014



Changyong Park and **Dmitry Popov** hosted a group of eight graduate students from the 2014 National School on Neutron and X-ray Scattering at the HPCAT 16BM-D beamline, June 19-20. The hands-on training classes were about high-pressure X-ray diffraction experiments using a diamond anvil cell. □

❽ Michelle Scholtes meets with Japanese to discuss laboratory business and systems practices.
Image courtesy Michelle Scholtes

❾ In Aug. Craig Schiffries represented the DCO at the opening ceremony of the SK-II continental scientific drilling project near Daqing, China; participated in a planning meeting for a multiwell deep underground laboratory in the Songliao Basin, China; and gave talks at China U. Geosciences, Beijing, and the Chinese Academy of Geological Sciences.

❿ Chris Field

❿ Katie Mach

⓫ Robin Martin

⓬ Rebecca Hernandez

Postdoctoral fellow **Charles Le Losq** gave an invited talk at the Goldschmidt Conference on June 12.

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❽ Webmaster **Michelle Scholtes** was invited to visit the Advanced Institute for Materials Research (AIMR) at Tohoku U. in Sendai, Japan, to discuss research support in US and Japanese scientific research institutions. She represented the lab at the AIMR (June 23-July 2) to discuss administration support, including systems and procedures. Scholtes also gave a presentation on lab practices. **Danielle Appleby**, assistant to the director, and **Jeff Lightfield**, controller, were also invited.

—

HPCAT/HPSynC/NSLS/SNS

Jason Baker, a Ph.D. student from U. Nevada-Las Vegas, visited HPCAT in May. **Wesley Chang**, a senior at Iowa State U., joined HPCAT as a summer intern.

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❾ **Deep Carbon Observatory (DCO)**

The Alfred P. Sloan Foundation will continue support for DCO's secretariat at the Geophysical Laboratory for the next two years. In July **Yael Fitzpatrick**, formerly art director for the *Science* journals, joined the DCO secretariat.

Robert Hazen and **Craig Schiffries** participated in DCO Data Science Day at Rensselaer Polytechnic Institute on June 5. **Brad Foley**, **Eric Hauri**, Hazen, **Russell Hemley**, and Schiffries attended the DCO Workshop on Global Modeling of the Deep Carbon Cycle at the lab, June 6-7. The DCO was heavily involved in the Goldschmidt Conference in Sacramento, CA, June 8-13, organizing sessions and and speaking. **Steve Shirey** organized a workshop on diamonds and mantle geodynamics of carbon in Bristol, UK, July 3-4. **Andrea Mangum** helped organize the first DCO Summer School in Montana and Yellowstone National Park. Postdoctoral Fellow **Xiaoming Liu** attended the DCO Summer School.

Arrivals: Kevin Hernandez, Matthew Rawls, Olivia Reyes-Becerra, Joseph Romero, Brooke Sherman, and **Brandon Wilfong** joined the lab as interns this summer. Other summer interns included **Saelig Khattar** and **Ang Liu**. **Ronit Kessel** and **Valery Levitas** are new visiting investigators.

—

Departures: Alia Awadallah, Roxane Bowden, Matthieu Galvez, Malcolm Guthrie, Karunakar Kothapalli, Subhasish Mandal, Caitlin Murphy, Susana Mysen, Manuvesh Sangwan, Vincenzo Stagno, Xiaojing Tan, and **Yonghui Zhou** left the lab this summer.

GLOBAL ECOLOGY

❿ Director **Chris Field** was awarded the Roger Revelle Medal by the American Geophysical Union. He did outreach for the UN's Intergovernmental Panel on Climate Change (IPCC) in Japan, UK, Germany, Brazil, Norway, and Spain. **Katie Mach** did IPCC outreach in Uganda and Ethiopia. She was also interviewed for 40 minutes on WNYC with Brian Leher.

—

Ken Caldeira attended the European Geosciences Union General Assembly in Vienna in Apr. and went to Berlin for the Climate Engineering Conference in Aug. He contributed an opinion editorial to the *San Francisco Chronicle* in June and was interviewed by CNN World and Motherboard.tv.

—

⓫ **Greg Asner** presented Carnegie Airborne Observatory (CAO) carbon-mapping results to the leadership of US Agency for International Development in Washington, DC. Asner and **Robin Martin** presented new research findings at the Hawaii Ecosystems Meeting in Hilo, HI, and they carried out new fieldwork to assess the ecological impacts of Hurricane Iselle in HI. Asner and postdoctoral fellow **Andrew Davies** worked in Africa darting and placing tracking collars on lions. Asner lab's **Dana Chadwick** and the Carnegie Spectranomics team carried out field research in the Peruvian Amazon.

—

Anna Michalak gave a keynote address to the XX International Conference on Computational Methods in Water Resources held at U. Stuttgart, Germany, in June and participated in launch activities for the Orbiting Carbon Observatory-2 (OCO-2) satellite at Vandenberg Air Force Base, CA, in July. In Apr. Michalak lab's **Jovan Tadic** gave a presentation at the European Space Agency's workshop on solar-induced fluorescence in Paris. In May the lab's **Yuntao Zhou** gave presentations at the 46th International Liege Colloquium on Low Oxygen Environments in Marine, Estuarine, and Fresh Waters in Liege, Belgium, and at the 57th Annual Conference of the International Association for Great Lakes Research (IAGLR) held at McMaster U. in Canada. In May the lab's **Jeff Ho** gave presentations to the UN's Economic Commission for Europe at a workshop in Geneva and at the 57th Annual Conference of the IAGLR.

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⓬ Postdoctoral fellow **Rebecca Hernandez** successfully defended her Ph.D. thesis.

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The Amazon

Joe Berry and **Ari Kornfeld** participated in a planning meeting for new research projects on the measurement of photosynthesis in the Amazon basin using new satellite and atmospheric sampling approaches. They visited research sites near Manaus and at Fazenda Tanguro in Mato Grosso. □

Field Notes

(Top) Caldeira and lab members **Lester Kwiatkowski** and **Yana Nebuchina** conducted ocean biogeochemistry fieldwork in Bodega Bay, CA, in collaboration with the UC-Davis Bodega Marine Laboratory.

(Bottom) Caldeira and **Rebecca Albright** (shown) had a field expedition at One Tree Island, Australia. □

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⓬ John Mulchaey


⓭ Barry Madore

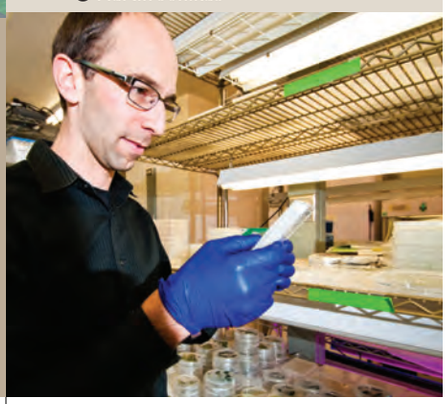

⓮ Josh Simon


⓯ Mansi Kasliwal


⓰ Arthur Grossman


⓱ David Ehrhardt


⓲ Kathy Barton


⓳ Martin Jonikas

Arrivals: Kai Zhu started as a postdoc in the Field and Fukami labs. The Berry lab welcomed visitor **Mary Whelan**, an NSF postdoctoral fellow from UC-Merced. The Caldeira Lab hosted former postdocs **Ho-Jeong Shin** from Korea and **Long Cao** from Zhejiang U., **Bala Govindasamy** from the Indian Institute of Science, **Geeta Pershad**, a doctoral student from Princeton U., and **Yana Petri**, a high school student. Asner lab hosted research visitors **Izak Smit** from the South African National Parks, **Carla Staver** of Yale U., and **Colonel Xavier Molina** from U. Madrid. The Caldeira Lab welcomed two new postdocs, **Rebecca Albright** and **Soheil Shayegh**.

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Departures: Peter Frumhoff concluded his sabbatical and returned to the Union of Concerned Scientists in June; **Marion O'Leary** re-retired on July 1, switching to consulting status; **Abby Bethke** moved with her family to Illinois on July 1 and **Eren Bilir** switched on July 1 from Field lab/IPCC to become the department's operations specialist. The Caldeira lab said good-bye to postdoc **Ivana Cvijanovic**.

THE OBSERVATORIES

⓬ Staff member **John Mulchaey** organized the 12th Annual Carnegie Observatories Lecture Series. He gave a talk at Columbia U. titled "Tracing Baryons at the Edge of Galaxy Clusters," and a lecture at Pasadena Valley Hunt Club about astronomy, from Mount Wilson to the Giant Magellan Telescope. He served as a panel chair for NASA's review of its Astrophysical Data Analysis Program. With several postdocs, he hosted astronomy nights at four Pasadena-area schools and completed a science classroom at Don Benito Fundamental School for grades K-5.

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⓭ Senior Research Associate **Barry Madore** spoke about the Las Campanas program to map the 100 largest galaxies in the Southern Hemisphere at the International Astronomical Union (IAU) Symposium 309: "Galaxies in 3-D Across the Universe" in Vienna on July 7-11.

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Staff astronomer **Michael Rauch** gave invited talks at the conference "Intergalactic Matters" in Heidelberg in June and at the European Week of Astronomy and Space Science meeting in Geneva in July. In Aug. he attended the workshop "Lyman Continuum Leakage and Cosmic Reionization" in Stockholm.

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The George Ellery Hale Distinguished Scholar **Andrew Benson** gave a talk on galaxy formation at the Institute for Advanced Studies in Princeton, NJ, and at JPL in Pasadena. In May he gave a public lecture about dark matter for the Carnegie Observatories Lecture Series. He and gave a talk on semi-analytic modeling of galaxy formation at "nIFTy Cosmology" in Madrid.

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⓮ Staff astronomer **Josh Simon** gave an invited talk about dark matter at the 3rd Dark Matter in Southern California meeting on Apr. 17. On Apr. 30 he gave a Carnegie Evening lecture about dark matter in Washington, DC. On June 10 he gave a talk about the first stars at The Town Club in Pasadena.

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Staff astronomer **Luis Ho** was appointed Distinguished Research Fellow of the Chinese Academy of Sciences, and he received an honorary Distinguished Professor title from Nanjing U. Ho gave invited talks at the 8th Joint Meeting of Chinese Physicists Worldwide meeting in Singapore in June, at the Southern China Technical Astronomy Development meeting in Kunming, at the Sino-China Workshop "From Dark Matter to Galaxies" in Xian in May, and at IAU Symposium 312 in Beijing in Aug. He gave colloquia at Nanjing U. and the Space Science Institute of Macau U. of Science and Technology. He gave a series of lectures at a summer school at U. Science and Technology of China in Hefei. He attended the symposium "The World According to Fred Kavli" at the World Science Festival in New York.

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⓯ Hubble-Carnegie-Princeton Fellow **Mansi Kasliwal** gave colloquia at UC-Santa Cruz, UCLA, and U. Washington-Seattle. She also gave a plenary presentation at the Large Synoptic Survey Telescope annual meeting.

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Postdoctoral research associate **Rik Williams** presented a poster at the conference Future Directions in Galaxy Cluster Surveys in Paris, June 23-27. He also spoke at the "X-ray View of Galaxy Ecosystems" workshop held in Boston July 9-11. He will begin an AAAS Science and Technology Policy Fellowship on Sept. 1 at the USAID in Washington, DC.

PLANT BIOLOGY

The department coorganized the Joint Cell Biology Across the Bay/American Society of Plant Biologists (ASCB) Local Meeting and 2014 Western Sectional ASCB Meeting at Santa Clara U. May 3-4. Chairing various sessions were **Heather Cartwright**, **Jim Guo, Masayochi Nakamura**, **Ankit Walia**, and **Renate Weizbauer**. Speakers were **Ruben Rellan-Alvarez**, **Flavia Bossi**, **David Ehrhardt**, **Caryn Johansen**, **Alexander Jones**, **Yongxian Lu**, **Neil Robbins**, and **Thorsten Seidel**. Posters were presented by **Wolf Frommer**, **David Ehrhardt**, **Sue Rhee**, **José Dinneny**, **Lee Chae**, **Shahram Emami**, **Jue Fan**, **Jianjun Guo**, **In-Seob Han**, **Cheng-Hsun Ho**, **Taehyong Kim**, **Ricardo Nilo-Poyanco**, **Charlotte Trontin**, **Rui Wu**, **Chuan Wang**, **Renate Weizbauer**, **Meng Xu**, and **Muh-ching Yee**.

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Director **Wolf Frommer** gave an invited keynote talk at the 2014 Plant Protein Phosphorylation Symposium at U. Missouri-Columbia, May 27-30. On July 29-Aug. 1 he attended the 25th International Conference on *Arabidopsis* Research (ICAR) at U. British Columbia and was the Cell Biology Session Overview speaker.

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Winslow Briggs spoke about blue light-induced proteomic changes in *Arabidopsis* seedlings at Plant Biology 2014 in Portland, OR, on July 12-16.

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⓰ **Arthur Grossman** presented "Comparative Analysis of Three Planctomycete Genomes Associated with the Blades of the Red Alga *Porphyra umbilicalis*" at the May 18-23 Phycological Society of America meeting in Portland, OR. He attended the 16th International Conference on the Cell and Molecular Biology of *Chlamydomonas* in Pacific Grove, CA, June 8-13, chairing the metabolism session and giving a talk about the metabolism of *Chlamydomonas* in the dark.

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⓱ **David Ehrhardt** attended and spoke at the EMBO Conference Series on Microtubules: Structure, Regulation, and Functions, May 28-31 in Heidelberg, Germany.

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Zhiyong Wang gave a talk about light and hormones at a symposium honoring Elaine Tobin at UCLA. He also gave a talk at the 25th ICAR at U. British Columbia.

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⓲ On July 28-Aug. 1, **Kathryn Barton** spoke at the 25th ICAR at U. British Columbia. She was also the session chair and overview speaker for the development session.

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José Dinneny presented a seminar about root biology and the soil environment at the Society for Experimental Biology Annual Meeting in Manchester, England, June 29-July 8. He also spoke about the regulation of salt stress at the 25th ICAR at U. British Columbia. He was a copresenter of the workshop "Phenomics in *Arabidopsis*: From Phenese to Genes." On July 20-26 he attended the Gordon Research Conference on Plant Molecular Biology in Holderness, NH, and spoke about the response to the abiotic environment session.

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⓳ **Martin Jonikas** presented the poster "High-Throughput Genotyping of *Chlamydomonas* Mutants Reveals Random Distribution of Mutagenic Insertion Sites and Endonucleolytic Cleavage of Transforming DNA" at Chlamydomonas 2014. On Aug. 11-15 he attended the Gordon Research Conference on Photosynthesis at Mount Snow Resort, VT, and spoke about engineering photosynthesis.

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Plant Biology Hosts Interns

The department hosted summer interns for 10 weeks. They worked with mentors, attended seminars, and ended the program with a poster session on the work they learned in the program. □

TAIR Project

The *Arabidopsis* Information Research (TAIR) project officially ended June 30. Director **Eva Huala** formed a new nonprofit, Phoenix, in Redwood City, CA, to carry on the work. TAIR group members Tanya Berardini, Donghui Li, and Robert Muller joined Phoenix as well. □

In Memory

Aida Wells, receptionist/secretary at the department from 1977 to 1999, died Aug. 9. Aida had many friends at the department, and everyone during her tenure was familiar with her smiling face and outgoing, gregarious personality. □

Briggs senior researcher, **Rajnish Khanna** attended the 25th ICAR at U. British Columbia and led the discussion "Global Marketing Software Connecting Local Foods Socially" with Wolf Frommer and Winslow Briggs.

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Frommer lab postdoctoral associate **Cheng-Hsun Ho** presented a poster about fluorescent sensors at the 25th ICAR conference at U. British Columbia. Postdoctoral associate **Alexander Jones** gave a talk about visualizing long-distance transport of ABA and GA in living plants with biosensors at Plant Biology 2014. Jones also presented this talk at the Gordon Research Conference on Plant Molecular Biology in Waterville, NY, July 20-25.

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Postdoctoral associate **Ruben Rellan-Alvarez** attended the Frontiers in Plant Research workshop in Norwich, England, on July 6-9 and spoke about root function and shape and on new imaging for root physiology at Plant Biology 2014.

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Rhee lab curator **Peifen Zhang** presented a talk about bioinformatics resources at Plant Biology 2014. Postdoctoral researcher **Jianjun Guo** spoke about a comprehensive QTL mapping approach at the 25th ICAR at U. British Columbia.

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Two postdoctoral researchers in Matt Evans' lab spoke at Plant Biology 2014. **Yongxian Lu** presented a talk about a pollen gene regulating reproductive isolation between maize and teosinte, and **Antony Chettoor** gave a talk on auxin signaling and cell proliferation and survival in maize.

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In the Jonikas lab, postdoctoral researcher **Xiaobo Li** spoke at Chlamydomonas 2014 about a mutant library to transform *Chlamydomonas* research. **Leif Pallesen** also gave a talk on the identification of *Chlamydomonas* genes involved in photosynthesis. **Luke Mackinder** presented a poster about localization of *Chlamydomonas* carbon concentrating mechanism at the Gordon Research Conference on CO_2 Assimilation in Plants: Genome to Biome, June 8-13 at Waterville Valley Resort, NH.

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Barton lab postdoctoral researcher **Tie Liu** presented a talk about target genes involved in *Arabidopsis* leaf development at the Development Mini-Symposium of Plant Biology 2014**. Nidhi Sharma** presented a paper about a role of abscisic acid with the KANADI gene family in regulating plant growth and development.

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Grossman lab postdoctoral researchers also speaking at Chlamydomonas 2014 were **Claudia Catalanotti**, about the role of pyruvate-ferredoxin-oxidoreductase in *Chlamydomonas* metabolism, and **Munevver Aksoy,** about *Chlamydomonas* responses to sulfur deficiency. Posters included graduate student **Tyler Wittkopp**'s about a GreenCut redox protein reaction and postdoctoral researcher **Ru Zhang**'s about growth measurement of mutants in pooled culture to identify those deficient in photosynthesis and photoprotection. Also presenting posters were postdoctoral researcher **Wenqiang Yang**, on acetate production pathways during the dark and the role of chloroplasts in fermentative acetate production, and postdoctoral researcher **TingTing Xiang,** about *Symbiodinium* transcriptome changing light levels.

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Postdoctoral researcher **Ankit Walia**, spoke at the Frontiers in Plant Research conference about the regulation of acentrosomal microtubule nucleation in plant cells. Postdoctoral researcher **Renate Weizbauer** attended Plant Biology 2014 and presented a talk in the Cell Biology Mini-Symposium.

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Arrivals: Frommer lab postdoctoral researcher **Joelle Schlapfer** joined the lab July 1 from U. Zurich. **Jessica Foret** started as laboratory technician July 7. Visiting researcher **Ya-Chi Yu** arrived from National Taiwan U. May 19. **Soeren Gehne** arrived Aug. 4 from U. Potsdam, Germany. Postdoctoral researcher **Yuval Kaye** arrived from Ben-Gurion U., Israel, July 1 to join the Grossman lab. **David Quint**, a visiting researcher, arrived from Syracuse U. June 5 to the Ehrhardt lab. Swiss National Science Foundation Fellow **Pascal Schlapfer** joined the Rhee lab June 1. The Wang lab welcomed two visiting researchers from Fujian Agriculture and Forestry U., China—**Wenfei Wang** on June 1 and **Xuelian Yang** on July 1. Postdoctoral researcher **Veder Garcia** arrived from UC-Berkeley Aug. 8 to join the lab. **Shavon Jones-Mansaw** joined the IT support group for both departments July 29.

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Departures: Visiting researcher **Thorsten Seidel** left the Frommer lab June 30 to return to Bielfeld U., Germany. Postdoctoral researcher **Viviane Lanquar** left Aug. 15 for a position in San Francisco. Postdoctoral graduate **Zubin Huang** left the Grossman lab Aug. 15 to pursue a career in industry.

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Postdoctoral researcher **Lee Chae** left the Rhee lab May 2 to become Director of Research at Hampton Creek Food in San Francisco. Predoctoral student **Ricardo Nilo Poyanco** returned to Chile for university, and lab assistant **Caryn Johansen** left Aug. 1 for graduate school at NYU. Visiting researcher **Shoulei Bu** departed the Wang lab May 20 to return to university in China. Visiting researcher **Pierre-Luc Pradier** returned to Bordeaux U., France, from the Dinneny lab June 12. On June 30 postdoctoral graduate **Rui Wu** left for the Max Planck Institute in Tuebingen, Germany, as a postdoctoral fellow. The Jonikas lab held a farewell party for lab technician **Keith Frazer** May 8; he will be a graduate student at UC-Davis. On Aug. 7 visiting student **Gregory Reeves** departed for TX where he is a Ph.D. candidate. The administration held a farewell luncheon for **Turkan Eke**, AP specialist, who departed July 31 to pursue a different career.

TERRESTRIAL MAGNETISM

Rick Carlson participated in the Mongolia project workshop at Lehigh U. in May, co-organized a geoneutrino workshop at UC-Santa Barbara in June and attended the Goldschmidt Conference in Sacramento and associated Geochemical Society Board meetings in June. He participated in the NASA- and NSF-sponsored Fecundity of the Early Earth workshop at the Smithsonian in Aug.

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Alan Boss attended the AAS Topical Workshop on Dense Cores in Monterey in July and presented his and **Sandy Keiser**'s work on the formation of binary and multiple protostars. In Aug. Boss chaired a review at the NASA Goddard Space Flight Center of the infrared detectors to be used in NASA's WFIRST/AFTA space telescope, for launch in 2023.

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This summer Keiser and **Michael Acierno** joined the Carnegie Astrometric Planet Search (CAPS) team. Boss and **Alycia Weinberger** showed them how to perform remote observing with the CAPS camera, on the du Pont telescope at Carnegie's Las Campanas Observatory in Chile.

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Alan Linde was an invited lecturer for the Numerical, Experimental and Stochastic Modeling of Volcanic Processes and Hazard Field School held in Iceland Aug. 22-29.

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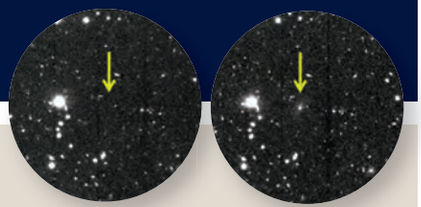

⑳ Scott Sheppard and colleague Chad Trujillo discovered the comet Sheppard-Trujillo, using the CTIO 4-m telescope. The comet is currently about 13 AU from the Sun.

㉑ Alycia Weinberger is onboard NASA's SOFIA airborne observatory.

㉒ Hubble fellow Jacqueline Faherty is shown (image left) at Cool Stars 18.

Former and current postdoctoral associates (image right) reunited at the Lowell Observatory June Cool Stars 18 workshop in Flagstaff, AZ. First row are Jacqueline Pamela Arriagada, Evgenya Shkolnik, and Jacqueline Faherty. Second row are Guillem Anglada-Escude, Hannah Jang-Condell, Steve Desch, Kaspar von Braun, and Joleen Carlberg.

Larry Nittler gave an invited talk at the AAS meeting in Boston in June; an invited talk at a symposium on cosmic dust at the European Week of Astronomy and Space Science in Geneva in July; and was appointed to the Planetary Science Subcommittee of the NASA Advisory Council in Aug.

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In late Apr. **Diana Roman** ran a NSF-funded volcano seismology workshop in Anchorage, AK. She presented in a session at the Seismological Society of America Annual Meeting, also in Anchorage. In May, she gave a BBR Neighborhood Lecture, "The Secret Life of 'Quiescent' Volcanoes." She conducted fieldwork at Popocatepetl volcano, Mexico, in June and July. In July she also conducted fieldwork at Hekla volcano, Iceland, and in Aug. she attended a volcano seismology workshop at Oxford U.

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⑳ **Scott Sheppard** gave a presentation at the Asteroids, Comets, Meteors conference in Helsinki in June. Sheppard, along with colleague Chad Trujillo, discovered a comet, now named Sheppard-Trujillo, using the Cerro Tololo Inter-American Observatory (CTIO) 4-m telescope.

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Steven Shirey attended the Goldschmidt Conference in June where he presented his work with **Erik Hauri** on the water content of mantle minerals in superdeep diamonds and attended Mineralogical Society of America board meetings. He and postdoctoral fellow **Marion Garçon** conducted fieldwork in the Superior Province of the Canadian Shield. In July, Shirey coorganized a workshop of the Diamonds and Mantle Geodynamics of Carbon group at which 40 diamond researchers met in Bristol, UK, to discuss the latest findings of their Deep Carbon Observatory (DCO) research.

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㉑ In June **Alycia Weinberger** flew aboard NASA's airborne Stratospheric Observatory for Infrared Astronomy (SOFIA). Weinberger and **Timothy Rodigas** hosted the 5th National Capital Area Disks (NCAD) Meeting in July, held at DTM; **Scott Sheppard** gave a talk.

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㉓ Hanika Rizo (in red) and former postdoctoral fellow Jonathan O'Neil (U. Ottawa) perform fieldwork in Labrador along with local Inuit guide Tuumasi Annack (right).

㉒ Fellows **Pamela Arriagada**, **Joleen Carlberg**, and **Jacqueline Faherty** attended the 18th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun (Cool Stars 18), in June in Flagstaff, AZ. Carlberg presented a poster. Faherty gave a contributed plenary talk on Brown Dwarfs at the Exoplanet Mass Boundary.

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Joleen Carlberg had a last LCO observing run in Chile. Carlberg was awarded time on the Kitt Peak's Mayall 4- m telescope for Dec. 2014/Jan. 2015. In July she gave an invited review talk at the local DC/MD/VA Astrophysics meeting at George Washington U., and in Aug. she attended the annual Baltimore Project ASTRO workshop.

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Brad Foley gave an invited lecture on the coupling between climate and tectonics at the DCO's Workshop on Global Modeling of the Deep Carbon Cycle, held at BBR in June. He presented a poster on the initiation of plate tectonics on the early at the 2014 Study of Earth's Deep Interior (SEDI) Symposium in Kanagawa, Japan, in Aug.

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㉓ **Hanika Rizo** presented a poster at the June Goldschmidt Conference and convened a session about the Archean mantle. **Jemma Davidson**, **Mary Horan,** and **Marion Le Voyer** also presented. In Aug. Rizo conducted geological fieldwork in the Eoarchean terrains of northern Labrador.

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In May postdoctoral fellow **Timothy Rodigas** gave talks at the American Museum of Natural History, Harvard-Smithsonian Center for Astrophysics, and U. Virginia.

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In July Origins fellow **Johanna Teske** gave a talk at the Characterizing Planetary Systems Across the HR Diagram conference at the Institute of Astronomy in Cambridge, UK. Also Teske received the first "Bring One, Get One" grant through Gemini Observatory for travel expenses of an early-career observer. She went to Gemini North with Steve Howell, Principal Investigator of the Differential Speckle Survey Instrument (DSSI) visiting instrument, which validates Kepler objects of interest and characterize host star binarity. This travel was also supported by Johanna's NASA Astrobiology Early Career Collaboration award. In Sept. she attended and presented a poster at the Towards Other Earths II conference in Porto, Portugal.

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On May 6 DTM hosted a postdoctoral fellowship workshop on "How to Write a Nature Paper" presented by *Nature* senior editor Leslie Sage.

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In July DTM hosted a session of the Smithsonian Science Education Academy for Teachers, during which **Steve Shirey**, **Tim Mock**, **Marion Garçon**, and **Karen Smit** demonstrated the principles of geochronology to about 20 K-12 teachers from around the country.

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Former postdoctoral fellows **Liping Qin** and **Matthew Jackson** received awards at the June Goldschmidt Conference in Sacramento. Qin received the European Association of Geochemistry's Houterman's Award, and Jackson was awarded the Geochemical Society's F.W. Clarke Medal. Jackson was also the winner of the 2014 Kuno Award of the AGU's Volcanology, Geochemistry, and Petrology section.

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Former postdoctoral fellow (now assistant professor in geology at U. Maryland) **Nick Schmerr** was awarded the prestigious Doornbos Memorial Prize in Aug. at the 2014 SEDI in Kanagawa, Japan.

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Arrivals: In Aug. new staff scientist **Lara Wagner** arrived from the U. North Carolina-Chapel Hill. Steve Shirey hosted visiting investigators **Andrew Thomson** (U. Bristol) and **Karen Smit** (Gemological Institute of America). Former postdoctoral fellow **Mark Behn** and former Tuve fellow **David Bercovici** attended the June 6-7 DCO Workshop on Global Modeling of the Deep Carbon Cycle. Visiting investigator **Leonard Ancuta** of Lehigh U. arrived in June and Aug. to collaborate with Rick Carlson on research in Mongolia. Former postdoctoral fellow and current visiting investigator **Jessica Warren** from Stanford U. arrived with students **Katie Kumamoto** and **Megan D'Errico** to collaborate with Steve Shirey, Mary Horan, and Erik Hauri. Visiting investigator **Kiyoshi Suyehiro** (JAMSTEC) visited for ongoing collaborative work on an earthquake prediction program with Selwyn Sacks and Alan Linde. In July Carnegie's

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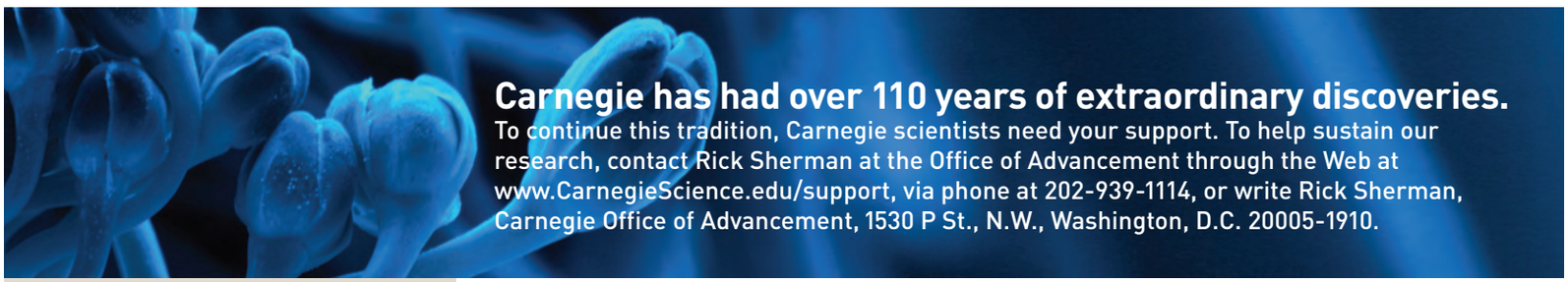

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DTM staff member emerita Vera Rubin's work on dark matter is featured in the season finale of Cosmos: A Spacetime Odyssey, titled "Unafraid of the Dark."

Visitors tour the new archives during a special open house in Apr.

Origins fellow **Johnanna Teske** began as a joint DTM/Observatories fellow. Also in July and Aug. **Ashraf Gafeer**, a student from the U. of Missouri, worked with Steve Shirey. In Aug. **Dmitri Ionov** (U. Montpellier) arrived to work with Rick Carlson on the Mongolian upper mantle.

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Departures: Postdoctoral fellow **Terry Blackburn** departed for a position at UC-Santa Cruz. Postdoctoral fellow **Brian Jackson** departed in July for a faculty position at Boise State U. Also in July MESSENGER postdoctoral fellow/visiting investigator **Shoshana Weider** departed for London. Intern **Laura Flagg** departed in July for graduate work at Northern Arizona U. following a collaboration with Alycia Weinberger. Vera Rubin fellow **Joleen Carlberg** departed in late Aug. for a postdoctoral fellowship at Goddard Space Flight Center.

DTM/GL

Shaun Hardy participated in a GeoScienceWorld strategic planning retreat at Sundance, Utah in May. A new campus archives was dedicated at Broad Branch Road in Apr. Established with support from the Robert and Margaret Hazen Foundation, the archives preserve a century of historic records from DTM and the Geophysical Laboratory.

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DTM hosted incoming Carnegie president **Matthew Scott**'s visit to Broad Branch Road on June 18. In Aug. Gary Bors was appointed Broad Branch Road facilities manager. ☐

Carnegie Alumnus and Supporter JAN DROWN DIES

Jan Brown, staff member alumnus at the Department of Plant Biology, died August 16, 2014, in Palo Alto, CA. She had been at Carnegie for almost 30 years studying chlorophyll, the pigment that absorbs sunlight for photosynthesis. She received her B.S. and M.S. from Cornell and then obtained her Ph.D. from Stanford University in 1952. She then worked part time as a research associate at Plant Biology. After time off to accompany her husband abroad and attend to three children, she returned to Carnegie in 1958 and became a staff member in 1960. Brown retired from Carnegie in 1987.

After her retirement, Brown volunteered for numerous causes including writing the Web news page for the Department of Global Ecology. She was also very generous in her financial support of the institution. She contributed to Plant Biology and Global Ecology science, the Global Ecology building, the Singer Building in Baltimore, and the headquarters building renovations in Washington, D.C. She also supported instrumentation, the McClintock Fellowship, and the Vannevar Bush Scientific Chair. The institution is tremendously grateful for Brown's contributions to Carnegie through her research and her broad and sustained support. Contributions like hers are critical for continuing the exceptional research for which Carnegie is known. For the full obituary, please visit https://dpb.carnegiescience.edu/article/jan-brown-passes-away-august-16th. ☐