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The Newsletter of the Carnegie Institution

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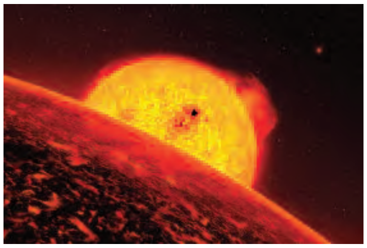
On the Inside

Primeval Bacterial Ecosystems 7

Gold Mining Ravages Peru 8

Skimming a Star's Surface 10

The Smoking Gun: Fish Brains and Nicotine 12



CARNEGIE INSTITUTION FOR SCIENCE

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

202.387.6400
www.CarnegieScience.edu

LETTER FROM THE PRESIDENT

Deep Carbon Observatory at Midpoint

In 2007, the Geophysical Laboratory's Robert Hazen gave a talk in New York City about the origins of life. His talk caught the attention of Jesse Ausubel of the Alfred P. Sloan Foundation, who emailed Bob to inquire further about his work. Beginning with this interaction, the Deep Carbon Observatory (DCO) eventually emerged in 2009. It is an international program that is based at Carnegie with Hazen at the helm. The 10-year initiative to advance deep-carbon science was launched with a pledge of $50 million in seed funding from the Sloan Foundation over the duration of the project. It now benefits from an abundance of resources from others as well. This year marks the halfway milestone of the project.

What started as a casual communication has dramatically expanded to include over 1,000 scientists in 39 countries with partners spanning academia, government, and the private sector. But why carbon? Carbon is the basis of all life and is important to energy, climate, materials science, and environment and health. Strikingly, much is not known about this pervasive element as it exists in the deep Earth. In the Carnegie tradition, the DCO teams have been studying deep carbon across many disciplines including deep life, deep energy, deep reservoirs (including the fluxes of carbon among the reservoirs and with the surface), and its physics and chemistry at the temperatures and pressures of the deep Earth.

So what have these researchers discovered? Deep life provides intriguing examples. DCO researchers have found microbial communities deep underground that have similar populations in places as far-flung as South Africa and Finland. Deep viruses in the crust and subsea sediment may be vital to the genetic diversity of microbial life. Some deep microbes have extraordinarily low rates of respiration, possibly resulting in "microbial zombies" that may not divide cells for millions of years. One particularly big surprise was the discovery of deep fungi—organisms with complex cell structures.

Given the importance of increasing concentrations of carbon dioxide in the atmosphere, it is surprising how little is known about the reservoirs of carbon in the deep Earth and how carbon moves among these reservoirs and is cycled to the surface. DCO researchers are working to install monitoring stations on 25 of the world's most active volcanoes on five continents. Scientists are monitoring the outgassing from hot springs and other diffuse sources. The overall aim is to understand the complete carbon cycle model through deep time—beyond the atmosphere, oceans, and shallow crustal environments, which have drawn most previous attention—to include the entire planet, including the earliest Earth and the co-evolution of the geosphere and the biosphere.

The study of uncharted territory requires the development of new measurement tools. DCO researchers are developing a radically new high-resolution mass spectrometer to distinguish methane derived from fossils (biotic) from methane derived from abiotic sources. Perhaps most importantly, the DCO is developing integrated databases to sort through the complex web of information that researchers worldwide are gathering.

These highlights are just a few that are arising from this path-breaking program. But they suggest how this bold, international venture could redefine what we think about our planet, life, and even evolution. All of us at Carnegie look forward to the next five years of astounding discoveries. (If this sampling has piqued your interest, I suggest you learn more at http://deepcarbon.net/)

Richard A. Meserve, *President*

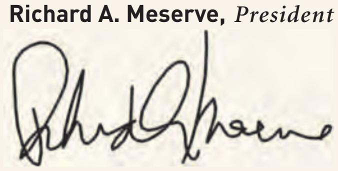
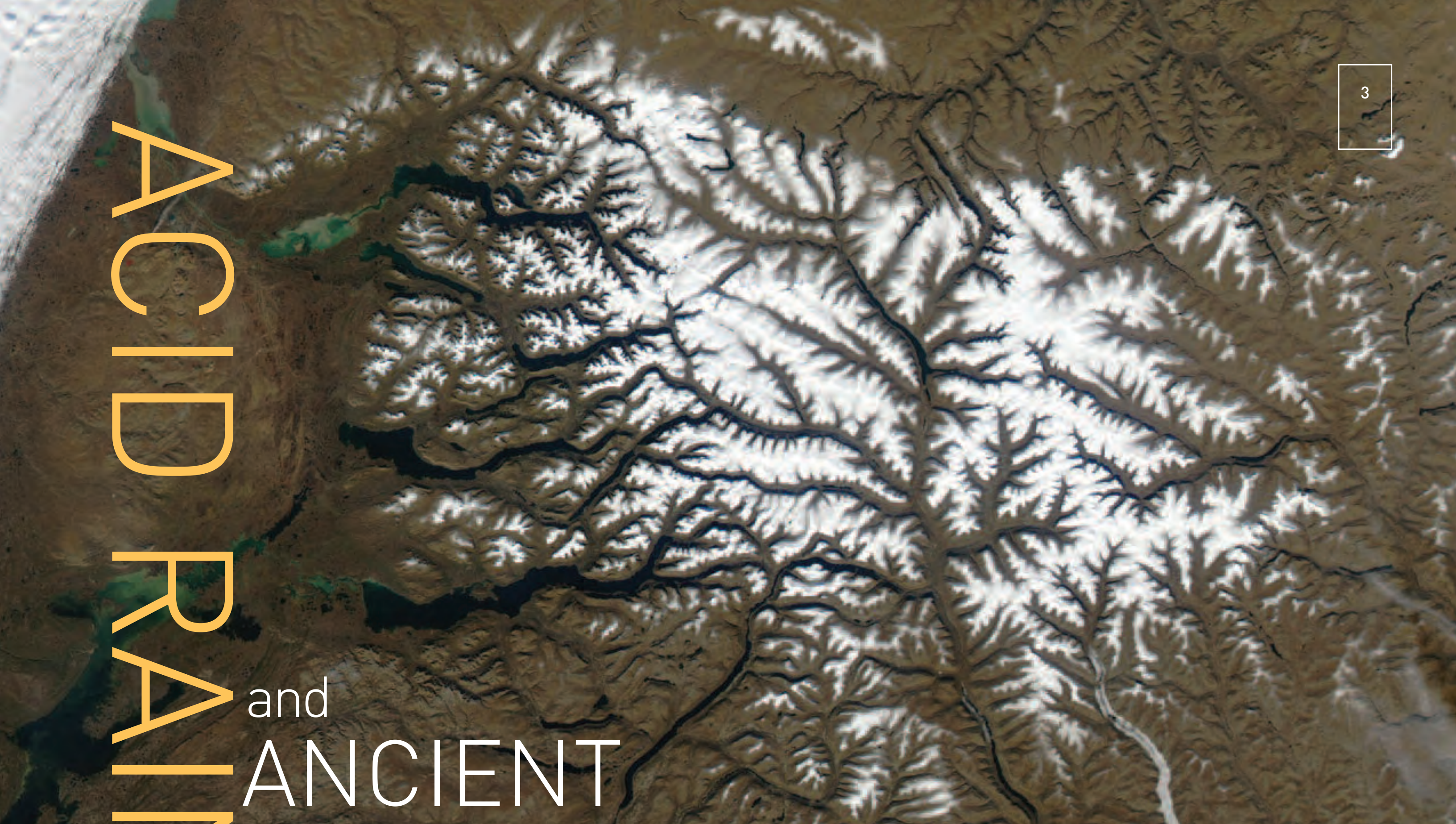


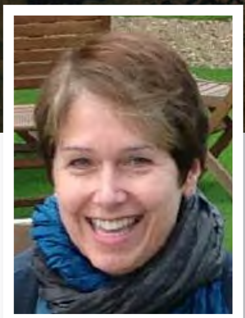
Image courtesy Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC



ACID RAIN and ANCIENT EXTINCTION

The moonlike landscape of the mountains reveals the volcanic origins of Siberia's Putorana Plateau.

Image courtesy Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSF



Director Linda Elkins-Tanton

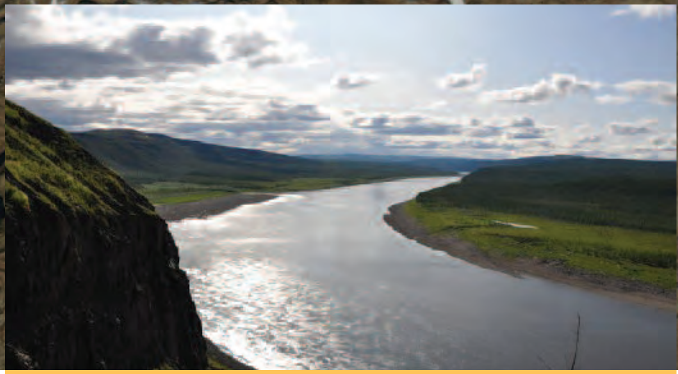


Image courtesy Benjamin Black, MIT

This is a photo of the Kotuy River in Arctic Sibera, showing the base of the Siberian Traps volcanic sequence.

Around 250 million years ago, at the end of the Permian period, there was a mass extinction so severe that it remains the most traumatic known species die-off in Earth's history. Some researchers have suggested that this extinction was triggered by contemporaneous volcanic eruptions in Siberia. New results from a team including Carnegie's Department of Terrestrial Magnetism director Linda Elkins-Tanton show that the atmospheric effects of these eruptions could have been devastating.

The mass extinction included the sudden loss of more than 90% of marine species and more than 70% of terrestrial species. It set the stage for the rise of the dinosaurs. The fossil record suggests that ecological diversity did not fully recover until several million years after the main pulse of the extinction. One leading candidate for the cause of this event is gas released from a large swath of volcanic rock in Russia called the Siberian Traps. Using advanced 3-D modeling techniques, the team was able to predict the impacts of gas released from the Siberian Traps on the end-Permian atmosphere.

Their results indicate that volcanic releases of both carbon dioxide (CO_2) and sulfur dioxide (SO_2) could have created highly acidic rain, potentially leaching the soil of nutrients and damaging plants and other vulnerable terrestrial organisms. Releases of halogen-bearing compounds such as methyl chloride could also have resulted in global ozone collapse.

The volcanic activity was likely episodic, producing pulses of acid rain and ozone depletion. The team concluded that the resulting drastic fluctuations in pH and ultraviolet radiation, combined with an overall temperature increase from greenhouse gas emissions, could have contributed to the end-Permian mass extinction on land. □

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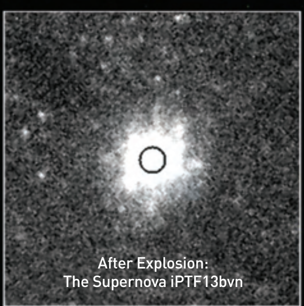
Geology published their work.

Grant EAR-0807585 from the National Science Foundation (NSF) Continental Dynamics program funded this study. The CESM project (which includes CAM-Chem) is supported by NSF and the Office of Science (Biological and Environmental Research) of the U.S. Department of Energy. The National Center for Atmospheric Research is operated by the University Corporation of Atmospheric Research under sponsorship of the NSF.

New Tool for Celestial Explosions



This image shows the location of supernova iPTF13bvn before and after the explosion.

Images courtesy Iair Arcavi of the Weizmann Institute of Science, using data from the Keck II Telescope and the Hubble Space Telescope

A team of researchers including Carnegie's Mansi Kasliwal and John Mulchaey used a novel astronomical-survey software system—the intermediate Palomar Transient Factory (iPTF)—to link a new stripped-envelope supernova named iPTF13bvn to the star from which it exploded. This is the first time this type of supernova, Type Ib, has been linked to its parent star. The iPTF team also pin-pointed the first afterglow of a gamma-ray burst found by the Fermi Gamma-ray Space Telescope (FGST).

About a third of all massive star supernovae are Type Ib, and there are several theoretical models as to how they form. Scientists think that the progenitors are either massive helium stars or a type of very large, very hot stars known as Wolf-Rayet stars. Pinpointing a progenitor star at exactly the same location as a Type Ib supernova is the best way to test the theories about the genesis of this type of explosion.

The iPTF13bvn supernova was discovered in mid-June; scientists did not detect an explosive light source even a day earlier. Telescopes in the radio, X-ray, ultraviolet, and infrared wavelengths promptly took pictures of the one-day-old supernova, providing vital clues about its origins.

Detailed analysis of the different types of observations of the supernova confirmed that it was, indeed, Type Ib and that it reached full luminosity two weeks after its initial explosion. The team detected in Hubble Space Telescope imaging a progenitor candidate for the explosion, linking the supernova to its predecessor star. Future imaging will help identify whether this progenitor was a single star, a binary star, or a star cluster. The team thinks that their observations are consistent with a Wolf-Rayet star progenitor. If so, this would be a breakthrough discovery.

The team also used the new software system to study a gamma-ray burst afterglow named iPTF13bxl.

Gamma-ray bursts are high-energy explosions that form some of the brightest celestial events. They can signify energy released during a supernova. Each burst is followed by an afterglow, which emits lower wavelength radiation than the original explosion.

Soon after the FGST detected the gamma-ray burst, the team started hunting for the afterglow over a huge field more than 360 times the size of the full Moon. They then had to narrow a list of more than 27,000 gamma-ray burst candidates down to a single afterglow. Follow-up research confirmed the relationship between the iPTF13bxl afterglow and a particular gamma-ray burst named GRB130702A.

The team then used the Magellan telescope to find the afterglow's so-called redshift value, which is a measurement of how much the light that reaches Earth has been stretched by the expansion of the universe. The redshift value reveals the afterglow's distance and tells astronomers where to look for an object, such as a supernova, which might emerge in the wake of the explosion. □

Image courtesy Scott Rubel

Mansi Kasliwal (left) and John Mulchaey were part of the team using the new software system—the intermediate Palomar Transient Factory (iPTF)—to penetrate the details of transient celestial objects.

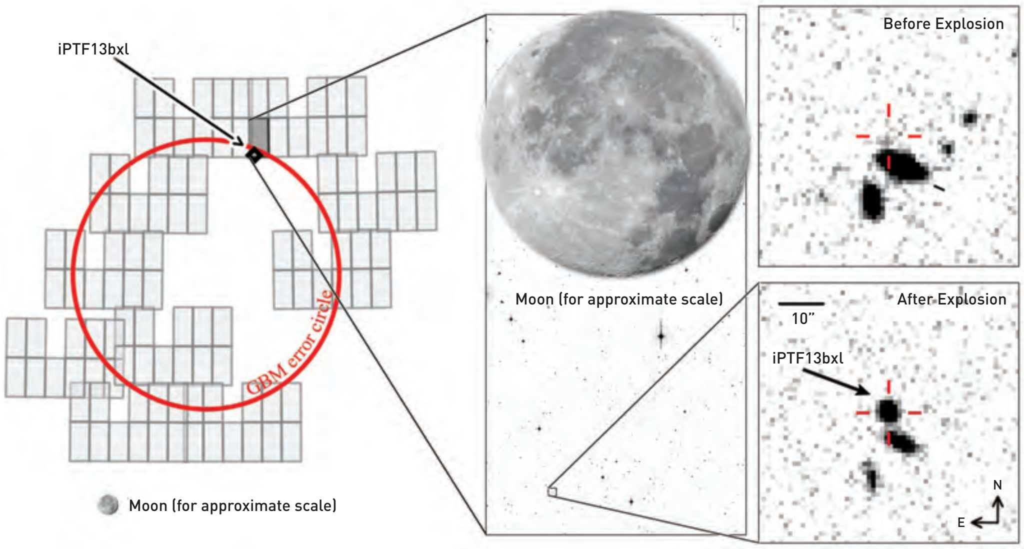


Image courtesy L. Singer, Caltech

The Astrophysical Journal Letters published their work in two papers.

Two Hubble Fellowships, a Carnegie-Princeton Fellowship, a National Science Foundation (NSF) Astronomy and Astrophysics Postdoctoral Fellowship, and grants from ISF, BSF, GIF, Minerva, the European Union's Seventh Framework Program for Research, and the NSF, in addition to a Helen and Martin Kimmel Award for Innovative Investigation, supported the iPTF13bvn work.

NSF, the Hubble Fellowship, the Carnegie-Princeton Fellowship, the Israeli Ministry of Science, the I-CORE program, and the Research Corporation for Science Advancement Cottrell Scholar Award supported the iPTF13bxl work.This work was based on observations obtained with the Palomar Observatory's 48-inch Samuel Oschin Telescope and 60-inch telescope as part of the intermediate Palomar Transient Factory project, a scientific collaboration among the California Institute of Technology (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.The intermediate Palomar Transient Factory (iPTF)—led by Caltech—started searching the skies for certain types of stars and related phenomena in February 2013. 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.

Image courtesy L. Singer, Caltech

This image shows the discovery of optical transient iPTF13bxl/GRB 130702A. In the left panel, the red circle shows the location of the gamma-ray burst determined by the Fermi Gamma-ray Space Telescope. The black diamond shows the precise location of the optical afterglow, iPTF13bxl. Squares in gray illustrate patches of the sky observed by iPTF. The middle panel shows one iPTF image, with the Moon for approximate scale. The two right panels show the site of the explosion, before (top) and after (bottom).

Light and Plant Growth

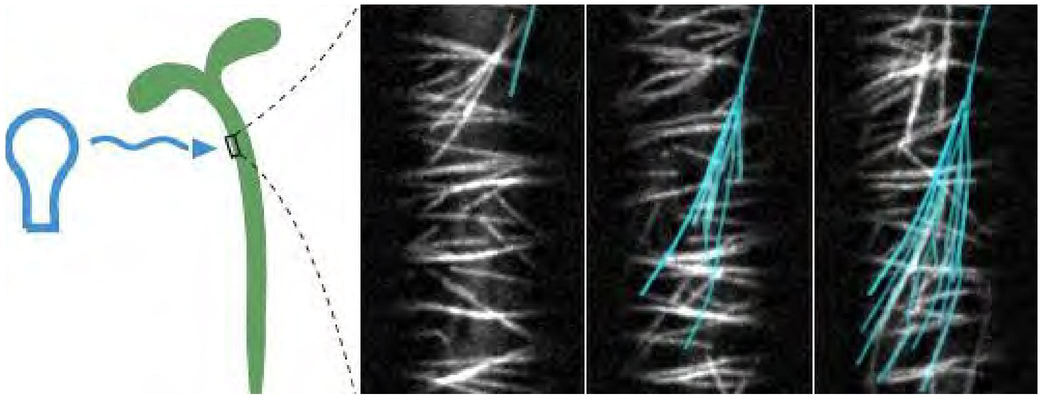


Image courtesy David Ehrhardt

Image courtesy Robin Kempster

David Ehrhardt

Above: On the left is an illustration of a plant under blue light. On the right is a microtubule array visualized by live-cell imaging. The blue overlay shows a cascade of new microtubules generated from a single progenitor. Sequential rounds of severing by the protein katanin and subsequent growth of the severed ends build a new array roughly orthogonal to the original.

Inside every plant cell, the cytoskeleton provides an interior scaffolding to direct construction of the cell's walls and thus the growth of the organism as a whole. Environmental and hormonal signals that modulate cell growth cause reorganization of this scaffolding. New research led by Carnegie's David Ehrhardt provides surprising evidence as to how this reorganization process works and important evidence as to how the direction of a light source influences a plant's growth pattern.

The cytoskeleton undergirding each cell includes an array of tubule-shaped protein fibers called microtubules. This scaffold directs cell growth and development, and it is crucial for supporting important plant functions such as photosynthesis, nutrient gathering, and reproduction.

The cytoskeleton does not appear to be remodeled by moving these microtubules around in the cell. Rather, it is altered by changes to the way these fiber arrays are assembled or disassembled. Ehrhardt's team—including lead author Jelmer Lindeboom, Masayoshi Nakamura, Ryan Gutierrez, and Viktor Kirik, all from Carnegie—used advanced tools to watch the reorganization process of these microtubule arrays under different conditions.

These imaging data, combined with the results of genetic experiments, revealed a mechanism by which plants orient microtubule arrays. A protein called katanin drives this mechanism by redirecting microtubule growth in response to blue light. Katanin severs the microtubules where they intersect with each other, creating new ends that can regrow and themselves be severed, resulting in a rapid amplification of new microtubules lying in another, more desired, direction.

This type of restructuring is required for the plant to bend toward a light source as it grows, a phenomenon called phototropism. This type of restructuring also has broader implications for the construction of cytoskeletons in other types of cells, including human cells, because katanin is found in animals and plants.

"This exceptional work draws upon decades of pioneering discoveries made by Carnegie's Winslow Briggs on blue-light perception," said Wolf Frommer, director of the Department of Plant Biology. □

Science Express published their work.

National Science Foundation award 1158372, Carnegie Institution for Science, the Foundation for Fundamental Research on Matter—which is financially supported by The Netherlands Organization for Scientific Research, the European Union's New and Emerging Science and Technology CASPIC award 28974, the TOYOBO BIOFOUNDATION, and the Human Frontier Science Program supported this work.

THROW OUT THE TEXTBOOK: SALT *Surprise*

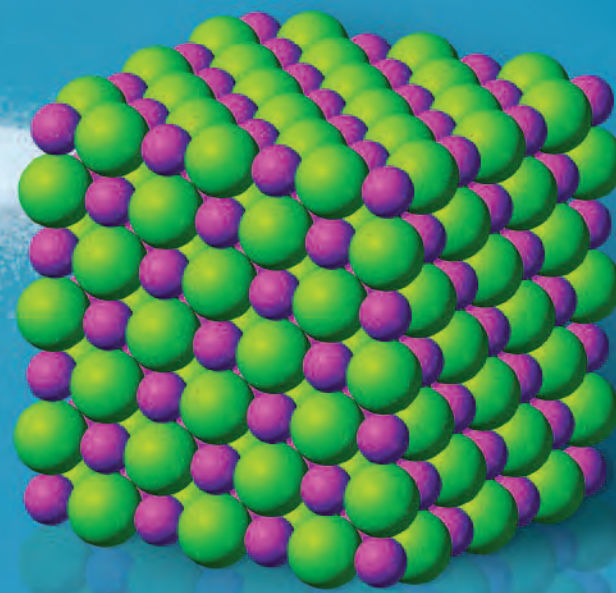


Image courtesy Wiki

This art depicts the crystalline structure of salt (NaCl).

Alexander Goncharov

Table salt, sodium chloride, is one of the first chemical compounds that schoolchildren learn. New research from a team including Carnegie's Alexander Goncharov shows that under certain high-pressure conditions, plain old salt can take on some surprising forms that violate standard chemistry predictions and may hold the key to answering questions about planet formation.

The team, which also included Carnegie's Elissaios Stavrou and Maddury Somayazulu, among others, combined new computational methods and structure-prediction algorithms with high-pressure experiments to study the range of changes that simple sodium chloride undergoes under pressure. They predict some unanticipated reaction results under high pressure that could help scientists reconcile ongoing mysteries involving minerals found in planetary cores.

The team first used advanced algorithms to identify an array of possible stable structural outcomes from compressing rock salt. They then attempted to verify these predictions, using a diamond anvil to put salt mixed with molecular chlorine or metallic sodium under high pressure.

They discovered that the standard chemistry textbook rules broke down. The well-understood rock salt, NaCl, turned into stable compounds of Na_3Cl, Na_2Cl, Na_3Cl_2, and $NaCl_7$, all of which have highly unusual chemical bonding and electronic properties.

"If this simple system is capable of turning into such a diverse array of compounds under high-pressure conditions, then others likely are, too," Goncharov remarked. "This could help answer outstanding questions about early planet cores, as well as create new materials with practical uses." □

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Science published their work in December.

The National Science Foundation (NSF), Defense Advanced Research Projects Agency, the government of the Russian Federation, China's Foreign Talents Introduction and Academic Exchange Program, Germany's Federal Ministry of Education and Research, China Agricultural University's Young Teachers Development Project, the U.S. Army Research Office, and EFree (a Basic Energy Science (BES)–Energy Frontier Research Center at Carnegie) supported this work.

Calculations were performed on XSEDE facilities and on the cluster of Brookhaven National Laboratory's Center for Functional Nanomaterials, which is supported by the U.S. Department of Energy (DOE)–BES. X-ray diffraction experiments were performed at GeoSoilEnviroCARS (Sector 13), Advanced Photon Source (APS), Argonne National Laboratory, and DESY's Petra III, Hamburg, Germany. GeoSoilEnviroCARS is supported by NSF–Earth Sciences and DOE–Geosciences. DOE–BES supported the use of APS. PETRA III at DESY is a member of the Helmholtz Association (HGF).

Robert Hazen

Primeval Bacterial Ecosystems

Earth's oldest sedimentary rocks are not only rare, they are also almost always altered by hydrothermal and tectonic activity. This makes it challenging for scientists to use the geological record to reconstruct the rise of life. A study from a team including Nora Noffke, a visiting investigator, and Carnegie's Robert Hazen revealed the well-preserved remnants of a complex ecosystem in a nearly 3.5 billion-year-old sedimentary rock sequence in Australia.

The Pilbara district of Western Australia constitutes one of the famous geological regions that allow insight into the early evolution of life. Scientists have described mound-like deposits created by ancient photosynthetic bacteria called stromatolites and bacterial microfossils. However, researchers had not previously seen a phenomenon called microbially induced sedimentary structures, or MISS, in this region. These structures are formed from mats of microbial material, much like mats seen today on stagnant waters or in coastal flats.

The team described various MISS preserved in the region's Dresser Formation. Advanced chemical analyses point toward a biological origin of the material. These results extend the geological record of MISS by almost 300 million years.

The Dresser MISS fossils resemble strongly in form and preservation the MISS from several other younger rock samples, such as a 2.9 billion-year-old ecosystem that Noffke and her colleagues found in South Africa.

The team proposes that the sedimentary structures arose from the interactions of bacterial films with shoreline sediments from the region.

"The structures give a very clear signal on what the ancient conditions were and what the bacteria composing the biofilms were able to do," Noffke said. "Complex mat-forming microbial communities likely existed almost 3.5 billion years ago."

MISS are among the targets of Mars rovers, which search for similar formations on that planet's surface. Thus, the team's findings could have relevance for studies of our Solar System as well. □

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Astrobiology published their work.

The National Science Foundation's Paleobiology and Sedimentary Geology Program, NASA's Astrobiology Institute, NASA's Exobiology and Evolutionary Biology Program, the Deep Carbon Observatory, and the Carnegie Institution for Science supported this work.

Image courtesy NASA, created by Jesse Allen of the Earth Observatory, using data obtained from the University of Maryland's Global Land Cover Facility

This satellite image composite (left) is of the Pilbara region of Western Australia, where Noffke and Hazen's microbially induced sedimentary structures (MISS) were discovered.

A rock surface (above) displays polygonal oscillation cracks" in the 3.48 billion-year-old Dresser Formation in the Pilbara region of Western Australia. This and similar sedimentary structures are of biological origin; they document ancient microorganisms that formed carpet-like microbial mats on the former sediment surface. The Dresser Formation records an ancient playa-like setting; similar environments are occurring on Mars as well. These microbially induced sedimentary structures (MISS) constitute a novel approach to detect and to understand Earth's earliest life.

Image courtesy Nora Noffke

For the first time, researchers have been able to map the true extent of gold mining in the biologically diverse region of Madre de Dios in the Peruvian Amazon. The team combined field surveys with airborne mapping and high-resolution satellite monitoring to show that the geographic extent of mining has increased 400% from 1999 to 2012 and that the average annual rate of forest loss has tripled since the Great Recession of 2008.

The team, led by Carnegie's Greg Asner in close collaboration with officials from the Peruvian Ministry of Environment, used the Carnegie Landsat Analysis System-Lite (CLASlite) to detect and map both large and small mining operations. CLASlite differs from other satellite mapping methods. It uses algorithms to detect changes to the forest in areas as small as 10 square meters, about 100 square feet, allowing scientists to find small-scale disturbances that cannot be detected by traditional satellite methods.

The team corroborated the satellite results with on-ground field surveys and Carnegie Airborne Observatory (CAO) data. The CAO uses Light Detection and Ranging (LiDAR), a technology that sweeps laser light across the vegetation canopy to image it in 3-D. LiDAR can determine the location of single standing trees at 3.5 feet (1.1 meter) resolution. This level of detail was used to assess how well CLASlite determined forest conditions in the mining areas. The CAO data were also used to evaluate the accuracy of the CLASlite maps along the edges of large mines, as well as the inaccessible small mines that are set back from roads and rivers to avoid detection. The field surveys and CAO data confirmed up to 94% of the CLASlite mine detections.

The results revealed far more rainforest damage than previously reported by the government, nongovernmental organizations (NGOs), or other researchers. In all, they found that the rate of forest loss from gold mining accelerated from 5,350 acres (2,166 hectares) per year before 2008 to 15,180 acres (6,145 hectares) each year after the 2008 global financial crisis that rocketed gold prices.

In addition to wreaking direct havoc on tropical forests, gold mining releases sediment into rivers, with severe effects on aquatic life. Other recent work has shown that Peru's gold mining has contributed to widespread mercury pollution affecting the entire food chain, including the food ingested by people throughout the region.

As of 2012, small illicit mines accounted for more than half of all mining operations in the region. Large mines of previous focus are heavy polluters, but they are taking a subordinate role to the thousands of small mines in degrading the region's tropical forest. □

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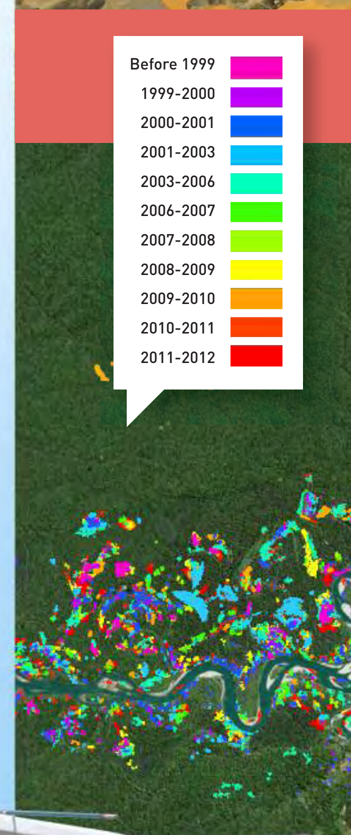
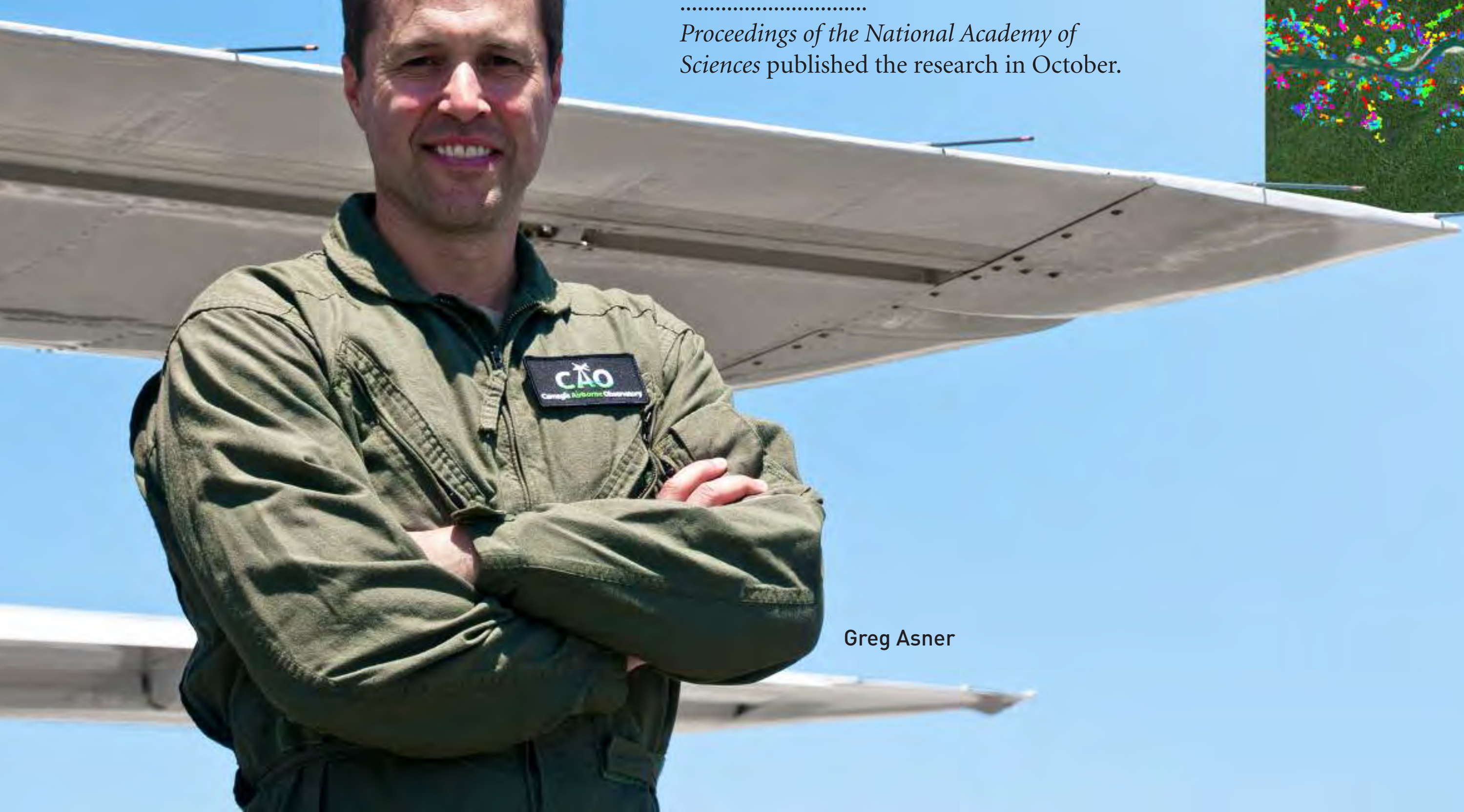
Proceedings of the National Academy of Sciences published the research in October.

Gold Mining Ravages Peru

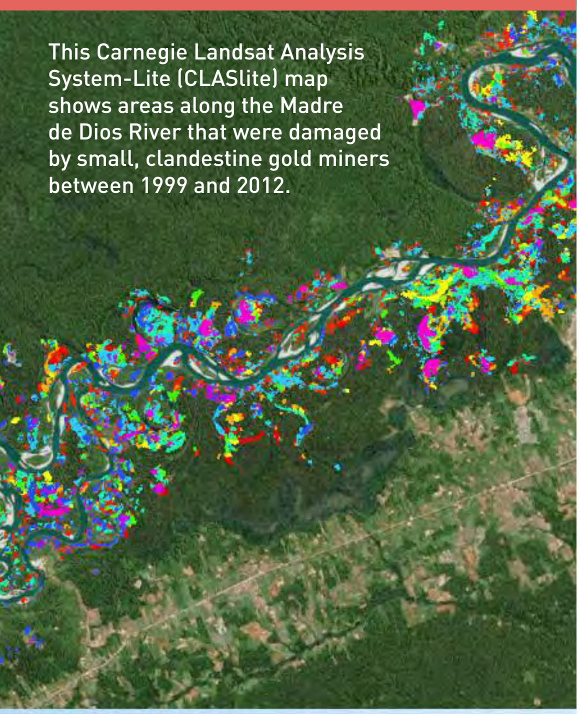




Greg Asner

Image courtesy Carnegie Airborne Observatory

The Carnegie Airborne Observatory flies over the Madre de Dios region of Peru, where vast areas are deforested and polluted as a result of gold mining.



This Carnegie Landsat Analysis System-Lite (CLASlite) map shows areas along the Madre de Dios River that were damaged by small, clandestine gold miners between 1999 and 2012.

Image courtesy CLASlite Team

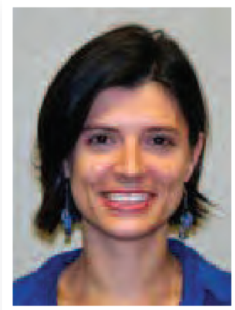
The Carnegie Airborne Observatory is made possible by the Avatar Alliance Foundation, Andrew Mellon Foundation,John D. and Catherine T. MacArthur Foundation, Grantham Foundation for the Protection of the Environment, Gordon and Betty Moore Foundation, W. M. Keck Foundation, Margaret A. Cargill Foundation,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

An inter-institutional working agreement between the Carnegie Institution's Department of Global Ecology and the Peruvian Ministry of Environment's Directorate of Land Management supported this research.

Fatty Acids Crucial to Embryos

A classic question in developmental biology is how do different tissue types arise in the correct position in a developing embryo. One signaling pathway—the molecular bucket brigade that controls this process—has been well described, but unexpected findings from a team led by Carnegie's Steven Farber reveal the importance of polyunsaturated fatty acids—the good fatty acids—in this process.

Steven Farber



RosaLinda Miyares

Fatty acids serve as sources of energy, as the building materials of cellular membranes, and as signals for sending messages between cells. Enzymes are needed to activate free fatty acids so that they are useful for cellular processes. The enzymes that perform this function are called acyl-CoA synthetases, shortened to ACS.

One member of the ACS family, ACSL4, activates special fatty acids called polyunsaturated fatty acids. Mammalian and fruit fly ACSL4 enzymes play roles in brain development and embryonic survival. Mutations in ACSL4 are linked to human developmental disorders, including a type of mental retardation that is linked to the X chromosome.

Researching roles for mammalian ACSL4 in embryonic development has been confounded by the maternal delivery of polyunsaturated fatty acids to the developing embryo, as well as the need for polyunsaturated fatty acids in embryo implantation and uterus development.

Farber and his team, including lead author RosaLinda Miyares, uses the zebrafish to understand what ACSL4 does during embryogenesis. They demonstrated that ACSL4 is essential for embryos to develop with proper tissue organization; ACSL4 enzyme activity regulates a specific protein in the bone morphogenic protein (BMP) signaling pathway, which is essential for proper embryo organization. The team's findings connect polyunsaturated fatty acid metabolism with a fundamental signaling pathway in the early embryo and demonstrate why fatty acids are so critical for prenatal health.

Their results lay the groundwork for further research on polyunsaturated fatty acid metabolism and its various roles in development and disease. □

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Developmental Cell published their work in December.

A side-by-side comparison of a normal zebrafish embryo (left) and a zebrafish embryo lacking the enzyme ACSL4 (right).

Images courtesy RosaLinda Miyares

National Institutes of Health, Carnegie Institution for Science, G. Harold and Leila Y. Mathers Foundation, German Research Foundation, and the European Union's Seventh Framework Program for Research supported this work.

SKIMMING A STAR'S SURFACE

Brian Jackson

Brian Jackson's study focuses on planetary candidates with orbital periods so close to their host stars that they nearly skim the stellar surface. This artist's conception depicts the exoplanet Corot-7b. Corot-7b's mass is five times that of Earth's and is the closest known exoplanet to its Sun-like host star. It is so close to its host star that it must experience extreme conditions; theoretical models suggest that the planet might have lava or boiling oceans on its surface.

A **new planet-hunting survey** has revealed planetary candidates with orbital periods as short as four hours and so close to their host stars that they are nearly skimming the stellar surface. If confirmed, these candidates would be among the closest planets to their stars discovered so far.

Carnegie's Brian Jackson presented his team's findings, based on data from NASA's Kepler mission, during a press conference at the American Astronomical Society's Division of Planetary Sciences meeting in October.

Most gas giant exoplanets with orbital periods less than or equal to a few days are unstable, due to orbital decay caused by the effects of their star's proximity. This decay could bring a rocky or icy planet so close to its star that its own gravity could no longer hold it together in the face of the star's gravity.

Motivated by these considerations, Jackson's team conducted a search for very short-period transiting objects in the publicly available Kepler dataset. Their preliminary survey revealed several planetary candidates, all with periods of less than 12 hours. Even with masses of only a few times that of Earth, the short periods mean these candidates might be detectable by currently operating ground-based facilities.

If confirmed, these planets would be among the shortest-period planets ever discovered, and, if common, such planets would be particularly amenable to discovery by the planned Transiting Exoplanet Survey Satellite (TESS) mission. This mission will look for, among other things, short-period rocky planets.

The team includes Carnegie's Christopher Stark and Alan Boss. □

Carnegie Institution for Science's Department of Terrestrial Magnetism provided funding for this work.

Image courtesy European Southern Observatory/L. Calçada

Methane Emissions Topple Estimates

Image by Sharee Basinger courtesy publicdomainpictures.net

Right: Agriculture is another major source of methane emissions.

Below: Emissions from oil and gas drilling and processing in the south central U.S. could account for half of the regional total.

Anna Michalak

Government calculations of total U.S. methane emissions may underestimate the true values by 50%, according to a study from a team including Carnegie's Anna Michalak. The results cast doubt on a recent Environmental Protection Agency decision to downscale its methane emissions estimate.

The team used 2007 and 2008 atmospheric methane observations from across North America to improve estimates of methane gas emissions from a variety of human sources, including agriculture and fossil fuel drilling and refining.

Their study found large discrepancies with government estimates in some regions of the United States, particularly in the south central U.S. where total methane emissions were 2.7 times greater than those reported in most inventories. Emissions from oil and gas drilling and processing in this region could account for 50% of that total, representing a source of methane almost 5 times higher than in the most commonly used global emissions database.

The team used modeling tools developed by Michalak's lab to trace variations in atmospheric methane measurements back to emissions sources and to relate the emissions to known economic sectors. Their methods provide a direct constraint on total emissions, as well as provide insight into what is behind them.

Methane is the second-most important greenhouse gas after carbon dioxide, and the team's findings may help inform national and state greenhouse gas reduction strategies. □

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Proceedings of the National Academy of Sciences published their paper in November.

Image by Andrew Schmidt courtesy publicdomainpictures.net

The American Meteorological Society Graduate Student Fellowship/Department of Energy (DOE) Atmospheric Radiation Measurement Program, a DOE Computational Science Graduate Fellowship, and the National Science Foundation (NSF) Graduate Research Fellowship Program supported this work. The Atmospheric Composition and Climate Program and the Carbon Cycle Program of NOAA's Climate Program Office funded NOAA measurements in part. NASA Grants NNX08AR47G and NNX11AG47G, NOAA Grants NA09OAR4310122 and NA11OAR4310158, NSF Grant ATM- 0628575, and Environmental Defense Fund Grant 0146-10100 (to Harvard University) provided support for this research. A California Energy Commission Public Interest Environmental Research Program grant to Lawrence Berkeley National Laboratory through the DOE under Contract DE-AC02-05CH11231 supported in part measurements at Walnut Grove. The Office of Biological and Environmental Research of DOR under Contract DE-AC02-05CH11231 as part of the Atmospheric Radiation Measurement Program (ARM), ARM Aerial Facility, and Terrestrial Ecosystem Science Program supported DOE flights. NSF Grant ATM-0836153, NASA, NOAA, and the US intelligence community funded Weather Research and Forecasting–Stochastic Time-Inverted Lagrangian Transport model development at Atmospheric and Environmental Research.

Hong and Halpern's research could help explain the brain circuitry underlying nicotine addiction.

The Smoking Gun:
Fish Brains and Nicotine

Background Image courtesy George Hodan, publicdomainpictures.net

When researching neural pathways, it helps to establish an analogous relationship between a region of the human brain and the brains of more easily studied animal species. New work from a team led by Carnegie's Marnie Halpern hones in on one particular region of the zebrafish brain that could help us understand the circuitry underlying nicotine addiction.

The mammalian habenular nuclei, in a little-understood and difficult-to-access part of the brain, are involved in regulating both dopamine and serotonin, two neurotransmitters involved in motor control, mood, learning, and addiction. But unlike the mammalian habenulae, the habenular nuclei of fish are located dorsally, making them easy for scientists to access and study.

However, some outstanding questions remained about the properties of the zebrafish habenulae, creating a roadblock for a determination that these structures as analogous in fish and humans. In particular, it was unresolved whether zebrafish habenular neurons produce the neurotransmitter acetylcholine, which is enriched in this region of the mammalian brain and activates the same receptors to which nicotine is known to bind.

The new work by lead author Elim Hong and colleagues confirms that not only does the habenula utilize acetylcholine in zebrafish, as in humans, but also the pathway shows a remarkable left-right difference in the fish brain. The purpose of this asymmetry is unknown, but it results in differences in neural activity between the brain hemispheres. Other research in Halpern's lab indicates that such left-right differences could influence behavior.

The team further showed that this acetylcholine pathway in zebrafish responds in a similar way to nicotine, as the analogous pathway in the mammalian brain. This makes the zebrafish a good model for studying the brain chemistry of nicotine addiction.

In addition to Halpern and Hong, Courtney Akitake, Kirankumar Santhakumar, and Sang Jung Ahn, formerly of Carnegie, are also co authors on the study. □

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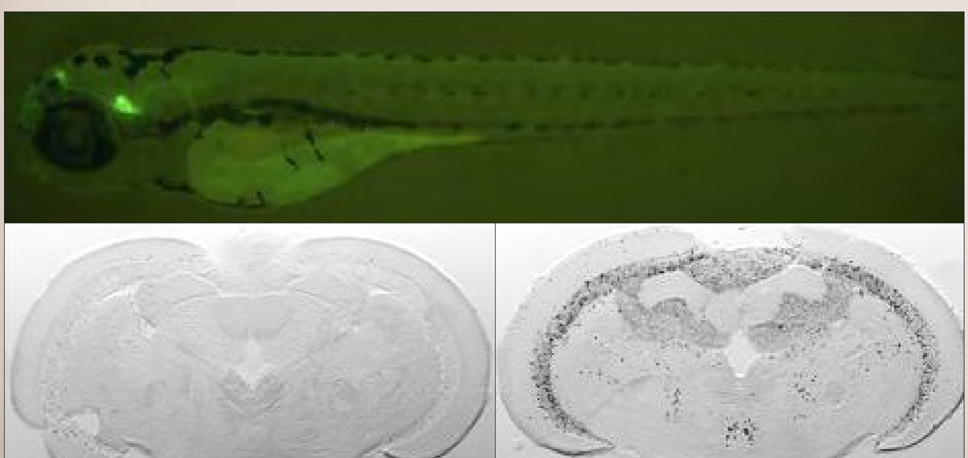
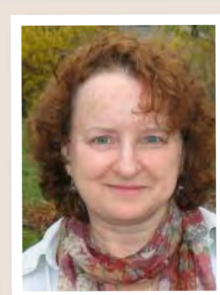
Proceedings of the National Academy of Sciences published their work in December.

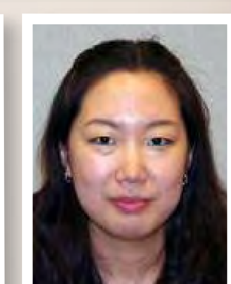
Below left: The upper panel shows fluorescently labeled neural projections in a larval zebrafish, from the habenular nuclei in the forebrain to the interpeduncular nucleus in the midbrain, a pathway known to be involved in nicotine addiction. The lower panels demonstrate neural activity (black cells) in cross sections of brains following exposure of adult zebrafish to control water (left) or to water containing nicotine (right).



Images courtesy Courtney Akitake and Elim Hon



Marnie Halpern



Elim Hong

European Molecular Biology Organization Short-Term Fellowship, University of Virginia Q:24 funds, and National Institutes of Health supported this study.

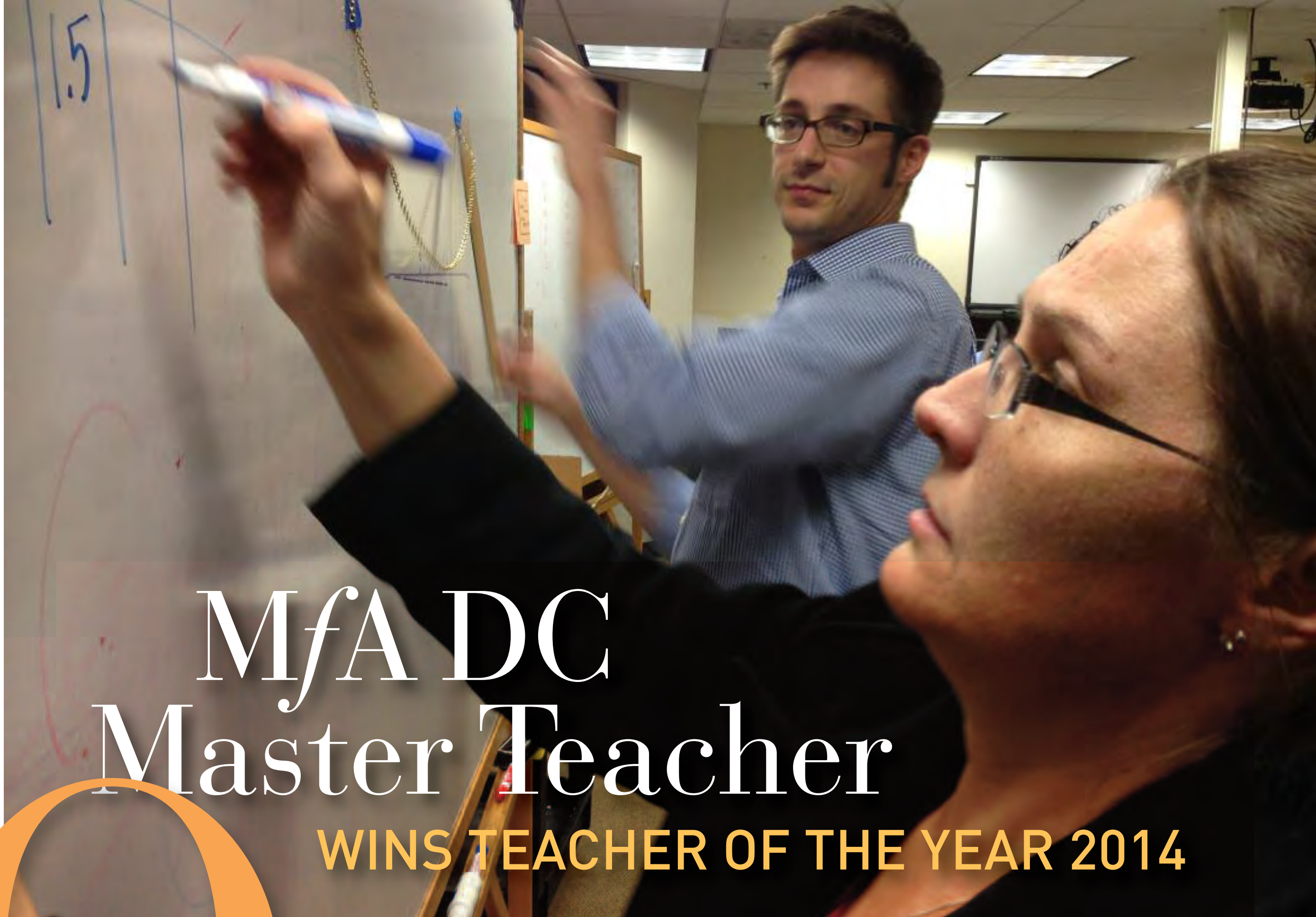


Image courtesy Bianca Abrams

MfA DC Master Teacher

WINS TEACHER OF THE YEAR 2014

On December 20, 2013, mathematics teacher Bill Day, currently teaching at the Two Rivers Public Charter School in northeast Washington, D.C., and enrolled in the Master Teacher Program of Math for America DC (M*f*A DC), received a surprise visit by D.C. Mayor Vincent Gray and the superintendent of D.C. schools Jesús Aguirre at an all-school assembly. They presented Day with District of Columbia Teacher of the Year 2014 award and $5,000 prize.

The D.C. Teacher of the Year award is given to a public school teacher "in recognition of outstanding teaching in the District of Columbia and professional leadership within and beyond the classroom."

Day has been teaching math for nine years, three at the highly rigorous Two Rivers charter school. He was accepted to the Masters Teacher Program, hosted by the Carnegie Institution for Science in 2012. The M*f*A DC Master Teacher Fellowship is a five-year program that rewards outstanding and experienced secondary public school mathematics teachers. The program includes stipends and financial support for over five years, as well as leadership and professional development opportunities. Teachers receive training grants and stipends and continue to teach in a Washington, D.C., public or public charter secondary school.

Day decided to pursue teaching mathematics in his final semester at Bowdoin College because it sat squarely at the intersection of his two interests—math and people. Sometime later, he met several "passionate and talented educators" from M*f*A at the Park City Mathematics Institute (PCMI) in Park City, Utah, and decided to look into the program. Although concerned about an overcommitment of his time on becoming a Master Teacher, M*f*A director Bianca Abrams assured him that it could be workable.

Day's biggest surprise of the program is "how much I enjoy having student teachers in my classroom. At first, I was nervous about having impressionable teachers bear witness to my every misstep, but, after a string of three tremendous student teachers, I can say that the experience has made me a much better teacher."

The D.C. Teacher of the Year is chosen by a panel of D.C. educators and parents from a group of nominees coming from both traditional and charter schools. As the 2014 District of Columbia Teacher of the Year, Day will represent the District in a variety of educational capacities with other state teachers of the year, which started in January by attending the 2014 State Teacher of the Year Conference in Scottsdale, Arizona.

When asked how he saw his career in ten years, Day said, "I can see myself working in a hybrid role as an active teacher and a teacher-of-teachers. I really like the idea of remaining an active secondary teacher because I feel like it keeps me humble—nothing like middle schoolers to keep an ego in check!"

M*f*A DC board president Maxine Singer remarked, "Bill Day is a teacher who delights in his students and math. We are very proud that he is a M*f*A DC Master Teacher." □

Above: Master Teacher and the 2014 D.C. Teacher of the Year Bill Day (left) participates in a M*f*A professional development session in November 2013.

InBrief


❶ Richard A Meserve


❶ Michael Gellert


❶ Stephen Fodor


❶ Mary-Claire King


❶ Michael Long


❶ Mary Lou Zoback


❷ Joe Gall has been with Embryology for 30 years.


❸ Yixian Zheng

TRUSTEES AND ADMINISTRATION

❶ Carnegie president **Richard A. Meserve** attended meetings of the Council of the National Academy of Engineering in Washington, DC, Oct. 4-5 and in Irvine, CA, on Feb. 5-6. He attended meetings of the Council and Trust of the American Academy of Arts and Sciences (AAAS) in Cambridge, MA, on Oct. 11. He made a presentation on Carnegie science at the Carnegie Medal of Philanthropy events in Edinburgh, Scotland, on Oct. 14-18; trustee **Michael Gellert** also attended. Meserve cochaired a conference on nuclear technologies of the National Academies' Keck Futures Initiative in Irvine, CA, on Nov. 15-17. Meserve cochaired the National Academies' Committee on Science, Technology, and Law in Washington, DC, on Nov. 18-19 and chaired an International Atomic Energy Agency meeting of the International Nuclear Safety Group and its International Technical Advisors Group in Vienna, Austria, on Dec. 4-6. He attended Carnegie's Plant Biology Visiting Committee meeting on Dec. 12-13 in Stanford, CA, with Carnegie trustees **Stephen Fodor** and **Mary-Claire King**. He cochaired a meeting of DOE's Nuclear Energy Advisory Committee in Washington, DC, on Dec. 19. Meserve visited the Las Campanas Observatory in Chile on Jan. 9-11 with board member **Michael Long** and guests. He gave the keynote speech at a Nikkei Symposium on Japanese Nuclear Energy Policy in Tokyo on Jan. 20. He participated in a Carnegie-sponsored panel in Stanford, CA, on Jan. 24 concerning the challenges at the intersection of energy and climate-change policy, moderated by Carnegie trustee **Mary Lou Zoback**, with former Secretary of Energy Steven Chu and Global Ecology director **Chris Field**. He participated in meetings of the AAAS Judicial Fellow Selection Committee in Washington, DC, on Jan. 29 and Feb. 20. He hosted a presentation by Greg Asner on the Carnegie Airborne Observatory (CAO) in New York City on Mar. 4.

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Andrea Wilson recently joined the administration as the new financial manager.

EMBRYOLOGY

Director **Allan Spradlin**g gave a talk at the Beckman Center Symposium titled "Comparing Growth Control in Plants and Animals" at Stanford U. on Oct. 14. That month he presented the keynote lecture at the 2013 Developmental Biology Symposium at U. Georgia-Athens. Spradling also lectured at the Galton Institute Symposium on insect and zoonose genomes and human health at the Royal Society in London and at Oxford U.

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❷ **Joe Gall** presented a lecture at U. North Carolina

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Marnie Halpern became coeditor-in-chief of *Current Opinion in Genetics & Development*. Halpern and postdoc **Erik Duboué** attended the Janelia Workshop on Zebrafish Genetics, Transgenesis, and Systems Biology on Nov. 3-5 in VA.

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❸ **Yixian Zheng** presented her work at the Cold Spring Harbor Asia Stem Cell Meeting. She and lab members attended a conference on geroscience at the National Institutes of Health (NIH) and the annual American Society for Cell Biology (ASCB) meeting in New Orleans.

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Christoph Lepper presented a poster at the 2013 Common Fund High Risk-High Reward Research Program Symposium at NIH. He was an invited speaker for The Johns Hopkins U.'s Biology Department Colloquium series.

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Spradling lab postdoctoral fellow **Steve Deluca** received a three-year fellowship from the Helen Hay Whitney Foundation for his studies titled "How are Mutagenic Transposons and Retroviruses Appropriately Controlled to Prevent Genetic Diseases Like Cancer?"

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Gall graduate student **Gaelle Talhourne** presented a poster at the annual meeting of the ASCB in New Orleans in Dec.

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Halpern postdoc **Elim Hong** gave a talk at the Dec. Mid-Atlantic Regional Zebrafish meeting. Graduate student **Abhi Subedi** presented a poster at the Nov. Society for Neuroscience meeting in San Diego.

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Bortvin graduate student **Valeriya Gaysinskaya** received a J. Brien Key Award from The Johns Hopkins U. to participate in a scientific meeting or conference.

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❹ **Arrivals: Antara Ghosh** from Shivaji U., India, joined the Halpern lab as a postdoc. Baltimore Polytechnic Institute high school intern **Mayah Dunstan** joined that lab to work with graduate student **Sara Roberson**. **Alexandria Brown** from Amherst College joined the Farber lab as a postdoc. Visiting scientist **Rosa Alcazar** received a Ford Foundation Fellowship to support her research in the Tan lab. Student volunteer **Macey Williams** joined the Fan lab. Business manager **Mary Best** joined the department, and animal technician **Simen Vlasov** joined the mouse facility.

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Departures: Staff scientist **Nick Ingolia** and his lab relocated to UC-Berkeley. He is an assistant professor in the Department of Molecular and Cell Biology. Staff associate **Jeff Han** accepted a faculty position at Tulane U. on Sept. 1. Postdoc **Axel Horn** also moved to Tulane U. Spradling lab postdoc **Jianjun Sun** became an assistant professor in the Department of Physiology and Neurobiology at U. Connecticut. Former Spradling graduate student **Alexis Marianes** received her Ph.D. and left in Sept. to continue her training at the College of Charleston, SC. Technician **Chun Dong** left the Han lab.

Honoring Employees

In Dec. the department recognized several employees for their years of service at the annual ceremony: Rafael Villagaray, 10 years; Rejeanne Juste and Allen Strause, 15 years; Connie Jewell and Christine Pratt, 25 years; Joseph Gall, Earl Potts (below left), and Dianne Williams, 30 years; and Ona Martin, 35 years. □

Deep Carbon Observatory

Craig Schiffries (GL) and **Diana Roman** (DTM) participated in a Deep Carbon Observatory (DCO) workshop on volcanic gas monitoring instrumentation at Mt. Etna, Italy, on Sept. 2-5. **Yingwei Fei** and **Sergey Lobanov** (GL) spoke at the Deep Carbon Cycle Symposium in Novosibirsk, Russia, on Sept. 27-Oct.1. **Andrea Mangum** and Craig Schiffries (GL) participated in the DCO Executive Committee Meeting at the Royal Society in London on Sept. 19-20. More than a dozen Carnegie scientists participated in DCO workshops, technical sessions, and other events at the American Geophysical Union (AGU) meeting in San Francisco Dec. 7-13. Highlights included the "DCO Extreme Physics and Chemistry Pre-AGU Workshop" at Stanford U. on Dec.7, the "DCO Workshop on Tectonic Fluxes of Carbon" on Dec. 8, and the "DCO DECADE Town Hall Meeting" on Dec. 10. **Robert Hazen** joined several DCO colleagues as invited speakers at an AGU session on data-driven discovery. □

Images courtesy Craig Schiffries

Diana Roman (right), Craig Schiffries (left), and Alberto Behar (Arizona State U.) replace a gas sensor on a volcano-monitoring instrument at the rim of a crater on Mt. Etna, Italy.

The DCO executive committee met at the Royal Society in London.

❹ Sara Roberson (left) and Mayah Dunstan joined the Halpern lab.

❺ John Armstrong presented his research during the AGU session "Innovations and Challenges in Microanalysis and Isotope Mass Spectrometry."

❻ Caitlin Murphy at the AGU

GEOPHYSICAL LABORATORY

Robert Hazen was named a Geochemical Society Fellow. In Oct. he delivered the Arthur D. Storke Memorial Lecture at Columbia U.'s Lamont-Doherty Earth Observatory. His recent book *The Story of Earth* was named finalist for the 2013 Phi Beta Kappa Book Award in Science. Hazen appeared as a "Nifty Fifty" lecturer at Sterling Middle School in Sterling, VA. He also presented lectures at Villanova U. and at the AGU meeting in San Francisco. His 48-lecture video series "Earth's Origins and Evolution" was released as part of the Great Courses series of The Teaching Company.

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Douglas Rumble analyzed meteorites for oxygen isotopes with Nelly Assayag and Pierre Cartigny at the Paris Institute for Earth Sciences from Sept.-Nov.

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Research Scientist **Muhetaer Aihaiti** was elected to the board of editors for the Optical Society of Korea's *Journal of Optics and Photonics.*

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❺ Research scientist **John Armstrong** presented a talk at the AGU on the new capabilities that field emission electron microprobes have for analyzing nanovolumes in geological specimens. He previously gave invited talks on this subject at the Smithsonian Institution and the National Science Foundation (NSF).

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Postdoctoral fellow **Christopher Glein** was awarded the 2013 Bradley Prize by the Geological Society of Washington for best paper. He also gave a seminar on organic geochemistry at U. Washington for the Astrobiology Program Colloquium and presented a poster on carbon isotope exchange in hydrothermal systems at the AGU fall meeting.

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Postdoctoral associate **Sergey Lobanov** attended a DCO meeting in Stanford, CA, and the AGU conference, both in Dec.

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❻ In Sept. postdoctoral fellow **Caitlin Murphy** visited Capitol Hill as part of the Geosciences Congressional Visit Day, organized by AGU and other geoscience societies to discuss the importance of steady federal funding for geoscience research. In Dec. she gave an invited talk on the vibrational properties of iron at core pressures at the fall AGU meeting, where she also received the Mineral and Rock Physics Graduate Research Award for outstanding contributions achieved during her Ph.D. research.

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❼ **Arrivals/Departures:** Anat Shahar hosted **Asami Sano-Furukawa** from the Japan Atomic Energy Agency from Aug. 1-Jan. 31.

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HPCAT/HPSynC/NSLS/SNS

❽ **Wenge Yang** gave an invited lecture at the Shanghai Synchrotron Radiation Facility about advanced synchrotron imaging techniques for static high pressure research Oct. 25. He also gave an invited talk at the 2013 Geological Society of America (GSA) meeting on Oct. 27-30 in Denver on in-situ nanoscale imaging of strain and phase separation under high pressure. He was convener for the fall AGU session "MR44A. Advanced Techniques for Experimental Geophysics and Mineralogy II: Amorphous Materials, Melts, and Melting."

GLOBAL ECOLOGY

Director **Chris Field** visited Pretoria, South Africa, on Oct. 20-22 to train governments and non-governmental organizations in southern Africa to effectively adapt to climate change. On Nov. 4 he gave a keynote at the Coordinated Regional Climate Downscaling Experiment (CORDEX) conference in Brussels. On Nov. 13 he accepted the Max Plank Research Award in Berlin. Field also gave lectures at U. Sydney Law School and U. New South Wales Center of Excellence for Climate System Science on Dec. 4-5.

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Ken Caldeira participated in three National Research Council panels on geoengineering: in Washington, DC, on Sept. 10-12 and in Irvine, CA, on Oct.23-25 and Dec. 16-17. In mid-Sept. Caldeira conducted research at the Potsdam Institute for Climate Impact Research in Berlin.

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Anna Michalak gave invited presentations to the Center for Global Change Science at U. Toronto; the Water Earth System Science Competence Cluster and the Integrated Hydrosystem Modelling International Research Training Group and the Center for Applied Geoscience at U. Tübingen, Germany; and at the fall AGU meeting.

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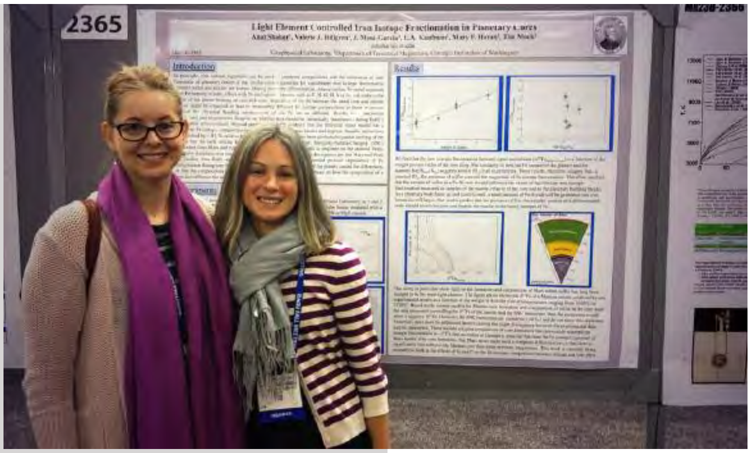
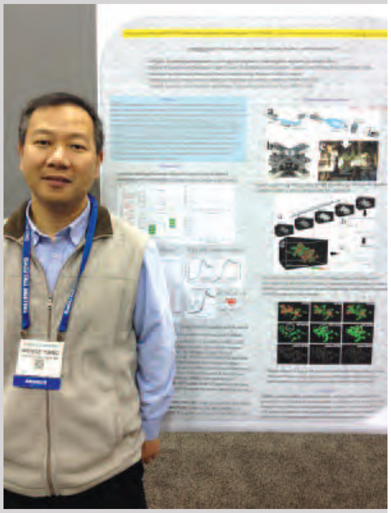
On Nov. 7 the Caldeira lab went on a team-building kayaking excursion at Elkhorn Slough, near Santa Cruz. □



❼ Anat Shahar (right) exhibited her poster during the AGU poster session "Planetary Impacts and Interiors from Experiments and Theory."



❽ Wenge Yang of HPCAT explains his poster "Pressure Induced HP/LP Phase Boundary Investigation in $BiNiO_3$ System Using Nanoscale Tomography."

❾ Luis Ho

Asner lab members **Claire Baldeck**, **Dana Chadwick**, **Jean-Baptiste Féret**, **Mark Higgins**, **Robin Martin**, and **Kelly McManus** each presented results at the AGU in San Francisco.

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Michalak lab's **Anna Michalak**, **Yuanyuan Fang**, **Jeff Ho**, **Chao Li**, **Yoichi Shiga**, **Eva Sinha**, **Vineet Yadav**, and **Yuntao Zhou** attended the Dec. AGU meeting and were coauthors on 17 presentations. Michalak was also a co-organizer and convener on a total of six special sessions, focusing on "Remote Sensing of CO_2 and CH_4: From Missions to Science" and "Model Intercomparisons: Syntheses that Inform Scientific Understanding."

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Ken Caldeira's lab had a banner year at AGU with talks presented by **Ivana Cvijanovic**, **Kate Ricke**, **Jana Maclaren**, **Ricarda Winkelmann**, and **Ken Caldeira**. **Xiaochun Zhang** presented a poster. The lab hosted a lunch attended by many former postdoctoral research associates.

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Field lab members **Rebecca Hernandez** and **Kelly McManus** presented their results at the AGU.

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IPCC's **Katie Mach** and **Mike Mastrandrea** presented talks at the AGU meeting in Dec. In Nov. Katie Mach gave an invited presentation at Cañada College in Redwood City, CA.

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Rebecca Hernandez, Ph.D. student in the Field lab, won the Dory Yochum Scholarship from MentorNet.

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Michalak lab's **Jeff Ho** organized a workshop on epistemological foundations for bridging the gap for interdisciplinary researchers, attended by over 35 people from more than 10 departments at Stanford U.

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Asner lab members explored rain forests in the Hawaiian Islands, the Peruvian Amazon, and Panama.

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IPCC graphic artist **Leslie White**'s animation of a fossil skeleton was featured in the National Geographic documentary *Skeletons of the Sahara* on PBS on Sept. 25 (http://video.pbs.org/video/2365082592/)

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Arrivals: Grayson Badgley, a Stanford U. Ph.D. student, joined the Field lab in Sept. **Ricarda Winkelmann** arrived in Oct. from the Potsdam Institute for Climate Impact Research to work with the Caldeira lab. **Xiaochun Zhang** began as a postdoctoral research associate in the Caldeira lab in Sept., along with visiting researcher **Chun Ma**. **Nick Vaughn** joined the CAO group in Nov. **Dawn Ross** began as administrative assistant in the Caldeira lab in Jan.

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Departures: Jakob Zscheischler and **Emily Solly**, visiting researchers from the Max Planck Institute for Biogeochemistry, completed their visits in Sept. In Dec. postdoctoral research associate **Jean-Baptiste Féret** left the Asner lab for the National Center for Scientific Research in Toulouse, France. Postdoctoral associate **Jana Maclaren** left the Caldeira lab in Dec. Asner lab technician **Byron Tsang** departed in Oct. for Chicago.

OBSERVATORIES

Director **Wendy Freedman** attended the COSMO 2013 Conference in Cambridge, England, on Sept. 2-3, held at the Stephen Hawking Center for Theoretical Cosmology. As chair of the Gruber Foundation Cosmology Selection Advisory Board, she participated in the foundation's ceremony in Cambridge honoring the 2013 Gruber prize winners, Viatcheslav Mukhanov and Alexei Starobinsky. In Sept. Freedman participated in the "Communicating Science Workshop" at the Kavli Institute for Cosmological Physics at U. Chicago led by Alan Alda of the PBS program *Scientific American Frontiers*. She was invited to speak at New York U.'s Center for Cosmology and Particle Physics on her research on the Hubble Constant on Oct. 4. She served on the scientific organizing committee for the 50th anniversary meeting of the Texas Symposium on Relativistic Astrophysics at U. Texas-Dallas on Dec. 8-12 and gave a talk on recent Hubble Constant measurements.

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Freedman and **Patrick McCarthy**, Giant Magellan Telescope (GMT) Organization director, participated in the unveiling of the third of seven 8.4-meter primary mirrors for the GMT at U. Arizona's Steward Observatory Mirror Laboratory on Dec.6.

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Luis Fernandez

In Sept., Oct., and Nov., research associate **Luis Fernandez** gave invited presentations about the Carnegie Amazon Ecosystem Mercury Project (CAMEP) at conferences in Edinburgh, Scotland; Lima, Peru; Winston-Salem, NC; Washington, DC; Suriname; Guyana; and French Guiana. The work was featured in many publications, and Luis appeared on several television news shows. Luis also presented results from CAMEP to the Peruvian Council of Ministers and the Peruvian Ministry of Mines. Here he is shown before the Council. □

Image courtesy Luis Fernandez.

❿ Juna Kollmeier

⓫ Hubble-Carnegie-Princeton fellow Mansi Kasliwal

⓬ Zhiyong Wang

❾ Staff astronomer **Luis Ho** gave an invited talk at "Fifty Years of Quasars at Caltech" and at "Black Hole (g)Astronomy: Exploring the Different Flavours of Accretion" in Brindisi, Italy. He also organized an international workshop in Beijing titled "Active Galactic Nuclei Reverberation: Present and Future."

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In Sept. staff astronomer **Michael Rauch** attended a workshop in Stockholm, Sweden, on Lyman-alpha as an astrophysical tool and gave the invited talk "The Formation of Individual Galactic Halos as Highlighted by Lyman-alpha Emission."

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In May staff astronomer **Andrew McWilliam** served on an NSF visiting panel to evaluate the Joint Institute of Nuclear Astrophysics at U. Notre Dame. In Nov. he gave a colloquium at U. Tennessee-Knoxville titled "Nucleosynthesis and Chemical Evolution from Las Campanas Observatory."

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❿ Staff astronomer **Juna Kollmeier** gave colloquia at Caltech and UC-Berkeley and a public lecture to the San Marino Historical Society.

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Staff astronomer **Joshua Simon** gave the astrophysics colloquium at MIT on Dec. 10.

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⓫ Hubble-Carnegie-Princeton fellow **Mansi Kasliwal** gave a colloquium at MIT, an invited talk at the Explosive Transients Conference, and a colloquium at the National Observatory of Athens. She attended a UT-Austin special seminar and the intermediate Palomar Transient Factory science meeting and workshop.

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⓭ Sue Rhee (left)

⓮ José Dinneny

⓯ Martin Jonikas

Einstein fellow **Selma de Mink** attended 2013 MESA Summer School at UC-Santa Barbara on Aug. 12-16. She gave a talk or seminar at the following meetings: the theory seminar at Caltech on Sept. 24; the massive stars theory network meeting in Los Osos, CA, on Oct. 17-20; the Einstein Fellow Symposium in Cambridge, MA, on Oct. 28-30; and the Palomar Transient Factory Science Meeting at UC-Santa Barbara on Nov.7-9.

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Rik Williams, postdoctoral research associate, gave a talk titled "A Tour of Galactic Suburbia" at the Emergence of Disk Galaxies workshop in Western Cape, South Africa, on Nov. 14.

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Renowned astronomer **Halton Arp**, who was a Carnegie fellow in the 1950s, died in Germany in Dec. at the age of 86.

PLANT BIOLOGY

Director **Wolf Frommer** was an invited speaker at the SFB924 meeting held on Sept. 18-22 in Freising, Germany, with the talk "Quantitive Imaging of Transport Activity and Metabolite Dynamics with Fluorescent Biosensors." He also gave the talk at the Center for Integrative Genomics meeting on Sept. 23 in Lausanne, Switzerland. On Oct. 13 he presented a talk, "Novel Approaches for Visualization of Transport Processes in Vivo," at UC-Berkeley.

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On Nov. 1 the department held a day-long retreat at Tressider Memorial Union on Stanford U.'s campus attended by all scientific staff. **Winslow Briggs** gave the keynote address "Mind the Gap between Guard Cells."

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On Nov. 2 a symposium was held to celebrate **Winslow Briggs's** 85th birthday, followed by a barbeque pig roast dinner.

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Kathryn Barton presented a seminar on Oct. 17 at U. Missouri-Kansas City titled "Leveraging Basic Research on the Genetic Control of Plant Development to Generate Drought Tolerance."

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⓬ **Zhiyong Wang** gave a talk on the central command system for growth control in *Arabidopsis* at the 11th International Conference on the Frontiers of Plant Biology held in Shanghai on Oct. 20. On Oct. 25-26 he gave the same talk at the Lanzhou Branch, Chinese Academy of Sciences and at Lanzhou U. On Nov. 15 Wang gave a seminar "The Central Growth Control Network in *Arabidopsis*" at the John Innes Center, Norwich, UK. He also gave lectures on the same topic at Hanyang U. and Gyeongsang National U. in Korea on Nov. 25 and 28. On Nov. 29 Wang gave a plenary lecture on the brassinosteroid signaling network at the Fifth Asian Symposium on Plant Lipids and the Korean Society of Plant Biologists meeting.

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⓭ **Sue Rhee** gave a seminar at U. Missouri-Columbia on Oct. 22 titled "Towards Better Understanding Plant Metabolism."

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Matt Evans gave an invited talk at the Banbury Center plant reproduction meeting on Sept. 23-25 at Cold Spring Harbor, NY, titled "Mutant Analysis of Maize Antipodal Cells and Auxin Signaling."

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⓮ **José Dinneny** gave an invited faculty talk at UC-Davis on Sept. 27. On Oct. 21-25 he attended the XV National Congress of Biochemistry and Molecular Biology of Plants held in Xcaret, Quintana Roo, Mexico, and gave a talk titled "Hydropatterning: How Local Moisture Controls Branching in Roots."

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⓯ **Martin Jonikas** gave a talk at the AFOSR Program Review meeting in Arlington, VA, on Oct. 27-30 titled "Comprehensive Identification of Key Genes in Algal Photosynthesis and Lipid Metabolism."

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Senior postdoctoral research associate in the Frommer lab **Li-Qing Chen** received the 2013 Tansley Medal for Excellence in Plant Science in recognition of an outstanding contribution to research in plant science by an individual in the early stages of their career. Chen received a prize of £2000 (GBP) and will author a minireview that will be published in *New Phytologist*, accompanied by a comment from the editor-in-chief and Tansley reviews editor.

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Arrivals: After receiving her Ph.D. in July from Stanford U. working under Devaki Bhaya, **Michelle Davison** joined the Bhaya lab as a postdoctoral research associate on Sept. 1. **Shai Saroussi** arrived from Tel Aviv U. for the Grossman lab as a postdoctoral research associate on Nov. 1. On Nov. 25 **Joon-Seob Eom** started as postdoctoral research associate in the Frommer lab from Kyung Hee U., South Korea.

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Departures: Dimitri Tolleter, postdoc in the Grossman lab, left on Sept. 3 for Australian National U. Visiting student **Melina Velasquez** left the Dinneny lab to return to Buenos Aires U. On Sept. 20, lab technician **Tianying Su** left the Frommer lab to return to school. On Sept. 26 postdoc **Yuanhu Xuan** returned to China to be an assistant professor at Wenzhou Medical U. On Oct. 31 **Yu Geng** departed the Dinneny lab for a postdoc position at UC-Berkeley. On Nov. 15 Jonikas postdoc **Mia Tereshima** departed for a new position in Japan, and visiting researcher in the Frommer lab **Roberto De Michele** left to resume his position at U. Palermo, Italy. The TAIR lab said good-bye to curator **Kate Dreher** for her new position at CIMMYT, Inc., in Houston.

TERRESTRIAL MAGNETISM

⓰ Director **Linda Elkins-Tanton** served on the Lowell Observatory Visiting Committee in Sept. She also presented invited talks at the Origin of the Moon workshop at the Royal Society in London and at ETH Zurich. In Oct. Elkins-Tanton hosted a one-day workshop for postdoctoral fellows led by instructors from Stony Brook U.'s Alan Alda Center

16 “Out and About”

▲ The Speaker’s Dinner at The Royal Society included (right) organizers Dave Stevenson (Caltech) and Alex Halliday (Oxford U.), former DTM director Sean and wife Pam Solomon (lower right), and DTM’s Rick Carlson (facing camera on left).

▼ Carnegie trustee Michael Wilson hosted dinner at London’s Science Museum.

▲ This group photo was taken during the seventh annual gathering of Carnegie alumni at the fall AGU meeting in San Francisco.

▼ Linda Elkins-Tanton (left) poses with former DTM postdoc Sarah Stewart-Mukhopadhyay at the Origin of the Moon workshop.

17 From left to right: Steve Kawaler (Iowa State), Dawn Gelino (Caltech), and Alan Boss organized the Second Kepler Science Conference at NASA’s Ames Research Center.

for Communicating Science, and she organized a two-day Workshop on Planetesimal Formation and Differentiation attended by 70 scientists. Also in Oct. she spent a week as the 2013 Astor Fellow at Oxford U. where she presented two lectures. Elkins-Tanton also presented a pre-dinner talk at London’s Science Museum hosted by Carnegie trustee Michael Wilson. In Dec. she presented a seminar at U. Maryland and attended the AGU council meeting and the AGU in San Francisco. In Jan. she gave talks at Arizona State U. and Yale U. Also in Jan. Elkins-Tanton gave the first four of 13 scheduled talks for the year in her role as a Mineralogical Society of America Distinguished Lecturer; these were at Laval U., Carleton U., the Geological Survey of Canada, and U. Western Ontario.

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17 **Alan Boss** co-chaired the Second Kepler Science Conference at NASA’s Ames Research Center in Nov. He also chaired a meeting of NASA’s Astrophysics Focused Telescopes Assets Technical Assessment Committee held at JPL. In Dec. he was interviewed by National Public Radio about exoplanets. In Jan. Boss gave a talk about the formation of binary and multiple star systems at the American Astronomical Society (AAS) meeting in National Harbor, MD. He also chaired the review committee for NASA’s Carl Sagan Fellowships in Jan.

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Rick Carlson presented three lectures at GSA’s annual meeting in Oct. in Denver and received the 2013 Arthur L. Day Medal. In Dec. he participated in the final planning meeting for the 2014 Goldschmidt Conference in Sacramento, presented an invited talk at the AGU meeting, and was one of four speakers invited to celebrate the opening of the Pacific Center for Isotopic and Geochemical Research at U. British Columbia.

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John Chambers presented a paper at the annual AAS Division for Planetary Sciences Conference in Denver in Oct. In Dec. his book *From Dust to Life: the Origin and Evolution of our Solar System* with coauthor Jacqueline Mitton was published by Princeton U. Press.

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In Oct. **Larry Nittler** attended a MESSENGER Science Team Meeting in Boulder, CO, presented a paper at the annual meeting of the AAS Division of Planetary Sciences in Denver, and gave a public talk on the MESSENGER mission at Washington College in Chestertown, MD.

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Diana Roman conducted fieldwork at Telica Volcano, Nicaragua, in Nov., gave a talk and a poster at AGU in Dec., and presented a department seminar at U. British Columbia in Dec.

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In Oct. **Scott Sheppard** presented a talk at the AAS Division of Planetary Sciences

18 DTM's reunion dinner, from left to right: Aki Roberge (now at NASA's Goddard Space Flight Center(GSFC), Evgenya Shkolnik (now at Lowell Observatory), Alycia Weinberger, Chris Stark (now a NASA Fellow at GSFC), T. J. Rodigas, Jackie Faherty, Brian Jackson, John Debes (now at Space Telescope Science Institute), Johanna Teske (now a graduate student at U. Arizona), Hannah Jang-Condell (now at U. Wyoming), Stephen Rinehart (married to Aki Roberge), and Hoshi (Aki and Stephen's daughter).

19 Staff scientist David James enjoyed his farewell party on Sept. 6. Seated next to him is his wife Jeri Thomson and longtime friend Ambassador Pamela Smith.

meeting in Denver. In Nov. he gave a talk at the U.S. Naval Observatory.

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In Oct. **Steven Shirey** presented two talks at the GSA's 125th Anniversary Annual Meeting in Denver, at which time he took over as vice president of the Mineralogical Society of America and incoming president for 2015. He also presented talks at the Lamont-Doherty Earth Observatory, Bryn Mawr College, and U. Maryland-College Park. In Jan. he received Carnegie's 30-year pin at a reception, along with DTM's **Janice Dunlap**, **Michael Acierno**, and **Gary Bors**.

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18 In Nov. **Alycia Weinberger** was a Distinguished Visitor to Haverford College, where she taught two undergraduate classes, gave a colloquium, and met with students and faculty. In Jan. she presented a poster and gave an invited talk to amateur astronomers and undergraduates at the 23rd AAS Meeting. Other attendees from DTM included postdoctoral fellows **Brian Jackson**, **Timothy Rodigas**, and **Jacqueline Faherty**, all of whom gave contributed talks. A reunion dinner brought together current and former postdoctoral fellows and students.

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Tim Mock began his term as president of the Geological Society of Washington.

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Postdoctoral fellow **Paul Byrne** participated in several geology field trips in the DC/MD/VA locale as part of the Carnegie Academy for Science Education First Light program in Sept. In Oct. he presented at the 31st MESSENGER science team meeting in Boulder, CO, and gave two seminars at Arizona State U. At the end of that month he gave two presentations (one of which was invited) at the GSA meeting in Denver. In early Nov. he gave a seminar at U. Chicago. In mid-Nov. he was an invited professor at U. Blaise Pascal, Clermont-Ferrand, France, where he carried out fieldwork and lab work, taught several classes, and—following an introduction by the university president—gave an invited seminar to the city. In Dec. he chaired a special session on Mercury at the AGU fall meeting and presented a talk and a poster paper.

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In Nov. postdoctoral fellow **Joleen Carlberg** presented a talk at the 400 Years of Stellar Rotation Workshop in Natal, Brazil.

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Postdoctoral fellow **Brian Jackson** presented his team's findings from NASA's Kepler mission at the AAS Division for Planetary Sciences meeting in Oct.

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MESSENGER fellow **Christian Klimczak** gave an invited talk and presented a poster at the 125th annual GSA meeting in Denver. He presented Mercury science at U. Colorado-Boulder in Nov. and a poster on Mercury's lava flows at the fall 2013 AGU in Dec. in San Francisco. His poster was highlighted in *NewScientist*. In Dec. He also gave a MESSENGER presentation at UCLA.

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In Oct. DCO fellow **Marion Le Voyer** gave an outreach talk at the Shepherd's Center of Annandale-Springfield, VA. In Dec. she presented a seminar at the Institute of Earth Physics of Paris (IPGP), and she gave a talk at the fall AGU meeting in San Francisco on mantle heterogeneities.

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Postdoctoral fellow **Timothy Rodigas** presented a NASA GSFC Extrasolar Planets Seminar in Nov., and in Dec. he presented the same talk in Kona, Hawaii, at the 5th Subaru International Conference "Exoplanets and Disks: Their Formation and Diversity II." In Jan. he gave a presentation at the winter AAS meeting near Washington, DC. He received the Rodger Doxsey Travel Prize, given to select, recent Ph.D. graduates giving thesis talks.

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In Oct. MESSENGER fellow **Shoshana Weider** spoke at the MESSENGER meeting in Boulder, CO, and at the GSA meeting. Weider also presented her work at the fall AGU in Dec.

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John Emler, a laboratory technician with the geochemical group for 19 years until 1996, died on June 27, 2013, at the age of 79.

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Arrivals: Visiting investigator **Tetsuo Takanami** returned in Aug. for one year to collaborate with Selwyn Sacks and Alan Linde. **Gene Humphreys** (U. Oregon) spent Nov. as a visiting investigator. Geochemistry postdoctoral fellow **Marion Garcon** and Hubble fellow **Jacqueline Faherty** arrived in Sept. Postdoctoral fellow **Timothy Rodigas** joined in Oct. In Jan. **Casey Leffue** was hired as seminar and events coordinator. **Robin Dienel**, hired in Sept. as the webmaster and outreach coordinator, covered the fall AGU meeting in San Francisco for the Web.

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19 **Departures:** A farewell party was held in Sept. for longtime staff scientist **David E. James**, who retired following a 50-year association with DTM, beginning in 1961 following his junior year at Stanford U. Merle A. Tuve Senior Fellow **Douglas Wiens** (Washington U., St. Louis) left following his Tuve Lecture on Nov. 13. Postdoctoral fellows **Ryan Porter**, **Paul Byrne**, and **Kelsey Druken** all left in Dec.

GL/DTM

20 In Oct. librarian **Shaun Hardy** attended the Geoscience Information Society annual meeting in Denver. In Dec. the library launched *Observing Earth and Atom*, a website (http://collection.carnegiescience.edu) highlighting historic photographs of scientific instruments used in the early years at GL and DTM. □

20 Retired staff scientist W. Kent Ford, Jr. (left) was interviewed in Oct. by David DeVorkin, senior curator at the National Air and Space Museum, and Shaun Hardy about his career, especially his work on image intensifiers for astronomical telescopes. Shown here is a variety of "Carnegie image tubes" from the 1960s. Ford's interview will be deposited in the American Institute of Physics' Center for History of Physics.

Staff and postdocs of both departments pitched in to load a shipment of 250 cartons of scientific journals donated by the library to Botswana's Department of Geological Surveys in Dec.

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The Carnegie Institution for Science received the highest rating for sound fiscal management and commitment to accountability and transparency—four stars—from Charity Navigator for the thirteenth consecutive year. Only two organizations out of the 6,903* evaluated this year have received this highest rating for so long.

Charity Navigator is America's largest charity evaluator. Their rating system considers two components—an organization's financial health plus its accountability and transparency.

Ken Berger, president and CEO of Charity Navigator remarked in his letter to Carnegie: "We are proud to announce the Carnegie Institution for Science has earned our thirteenth consecutive 4-star rating. Receiving four out of a possible four stars indicates that your organization adheres to good governance and other best practices that minimize the chance of unethical activities and consistently executes its mission in a fiscally responsible way. Less than 1% of the charities we rate have received at least 13 consecutive 4-star evaluations, indicating that Carnegie Institution for Science outperforms most other charities in America. This 'exceptional' designation from Charity Navigator differentiates Carnegie Institution for Science from its peers and demonstrates to the public it is worthy of their trust."

Carnegie president Richard A. Meserve said: "A four-star rating for thirteen years running from Charity Navigator is a gratifying acknowledgment of our efforts to be efficient in the furtherance of our mission of advancing science. I am sure that Andrew Carnegie, a frugal Scotsman, would be extremely proud that his institution holds this 'exceptional' distinction." □

*Not all 6,903 organizations have been evaluated for 13 consecutive years. For instance, this year Charity Navigator evaluated 1,000 new charities.