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

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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/)
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 (CO₂) and sulfur dioxide (SO₂) 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.

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 for Atmospheric Research under sponsorship of the NSF.
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 pinpointed 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.
Light and Plant Growth

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.

Two Hubble Fellowships, a Carnegie-Princeton Fellowship, a National Science Foundation (NSF) Astronomy and Astrophysics Postdoctoral Fellowship, and grants from NSF, BCS, 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 Cotrell 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 Oak Ridge National Laboratory, the Weizmann Institute of Science, the TANGO Program of the National 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.
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 Na3Cl, Na2Cl, Na3Cl2, and NaCl7, 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.”

Science published their work in December.

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).

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.
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.

Astrobiology published their work.

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.
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, non-governmental 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.

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

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.

Developmental Cell published their work in December.
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. □
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.

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

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

The Smoking Gun: Fish Brains and Nicotine

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

Background Image courtesy George Hodan, publicdomainpictures.net

Smoking Gun: Fish Brains and Nicotine

Marnie Halpern
Elim Hong

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).
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 (MfA 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 MfA 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. Some time later, he met several “passionate and talented educators” from MfA 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, MfA 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!”

MfA 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 MfA DC Master Teacher.”

Above: Master Teacher and the 2014 D.C. Teacher of the Year Bill Day (left) participates in a MfA professional development session in November 2013.
TRUSTEES AND ADMINISTRATION

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.

Fodor 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.

Embryology

Director Allan Spradling 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.

Joe Gall presented a lecture at U. North Carolina

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.

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.

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.

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.

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?”

Gall graduate student Gaelle Gayinskaya received a J. Brien Key Award from The Johns Hopkins U. to participate in a scientific meeting or conference.

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 Alcacer 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.

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.
Dunstan joined the Halpern lab.

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.

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.

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

Research Scientist Muhetai Alhaiat was elected to the board of editors for the Optical Society of Korea’s Journal of Optics and Photonics.

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).

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.

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

GLOBAL ECOSYSTEM

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.


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 Modeling International Research Training Group and the Center for Applied Geoscience at U. Tübingen, Germany; and at the fall AGU meeting.
On Nov. 7 the Caldeira lab went on a team-building kayaking excursion at Elkhorn Slough, near Santa Cruz.

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

- 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.

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

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.

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

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. [Video](http://video.pbs.org/video/2365082592/)

- Arrival: Grayson Badgley, a Stanford U. Ph.D. student, joined the Field lab in Sept. Ricardo 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 Vaughan joined the CAO group in Nov. Dawn Ross began as administrative assistant in the Caldeira lab in Jan.

- 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 Föret 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.

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**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.

- 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. 8.
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.”

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.”

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

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

Hubble-Carnegie-Princeton fellow Mansi Kasiwal 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.

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

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 “Quantitative 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.

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.”

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

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.”

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.

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

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

**TERRESTRIAL MAGNETISM**

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.

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.

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.

In Oct. Scott Sheppard presented a talk at the AAS Division of Planetary Sciences Conference at NASA’s Ames Research Center.
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 at U. Science Institute), Johanna Teske (now at U. Science Institute), John Debes (now at Space Telescope Science Institute), Evgenya Shkolnik (now at Lowell Observatory), and longtime friend Ambassador Porter. Their Formation and Diversity II.”

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 (IPOP), and she gave a talk at the fall AGU meeting in San Francisco on mantle heterogeneities.

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.

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.

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

Arrivals: Visiting investigator Tetsuo Takano
turned 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 Leff ure 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.

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

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.

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.
Carnegie has had over 110 years of extraordinary discoveries. To continue this tradition, Carnegie scientists need your support. To help sustain our research, contact Rick Sherman at the Office of Advancement through the Web at www.CarnegieScience.edu/support, via phone at 202-939-1114, or write Rick Sherman, Carnegie Office of Advancement, 1530 P St., N.W., Washington, D.C. 20005-1910.

CARNEGIE
Ranked Top Charity
13 Years Running

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.