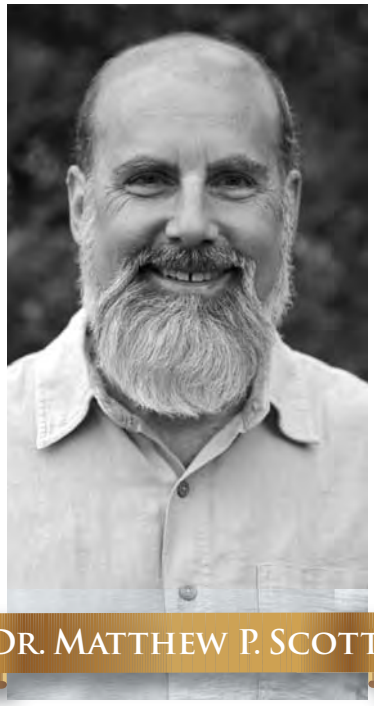
CarnegieScience

The Newsletter of the Carnegie Institution

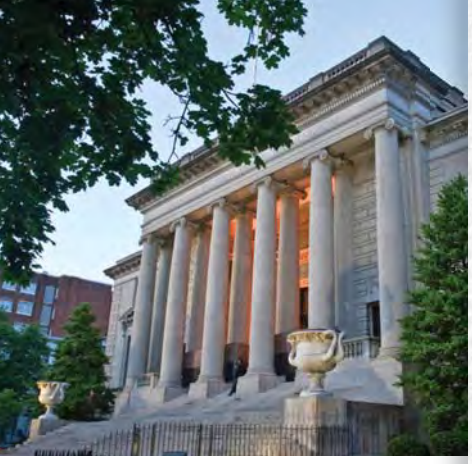
SUMMER 2014

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



Dr. Matthew P. Scott

On the Inside



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LETTER FROM THE PRESIDENT

As my tenure as Carnegie president comes to a close,

I find myself contemplating the cornucopia of Carnegie achievements that I have watched unfold. At my first board meeting as president in the fall of 2003, the Giant Magellan Telescope (GMT) was only a twinkle in Wendy Freedman's eye. Today, we are poised to begin construction of this remarkable instrument. It promises to unlock secrets that currently mystify us, including the repulsive force of dark energy, elusive dark matter, and the search for planets like our own. The GMT will transform astronomy in unimaginable ways.

In 2003 the discovery of extrasolar planets was still a novelty and Carnegie led the way in their discovery. Today over 1,100 exoplanetary systems have been discovered. Most remarkably, it appears that our own Solar System, with planets in mostly circular orbits and on the same plane, may be the anomaly, not the norm.

We have also learned much about our own planetary neighborhood. The tiny MESSENGER spacecraft, launched in 2004, finally arrived at Mercury in 2011 after a tortuous journey. This incredible mission has overhauled what we thought we knew about Mercury and shattered many misconceptions about the Solar System. Just recently another Carnegie discovery—a new dwarf planet—has redefined the outer boundary of our Solar System.

The Department of Global Ecology was a fledgling when I arrived. In just over a decade, this tiny department has vastly expanded our knowledge of global-scale ecological issues. Explorations using the Carnegie Airborne Observatory, leadership of work undertaken by the Intergovernmental Panel on Climate Change, models of the effects of greenhouse gas emissions, and many more landmark achievements have given Carnegie a central role in the understanding of climate science.

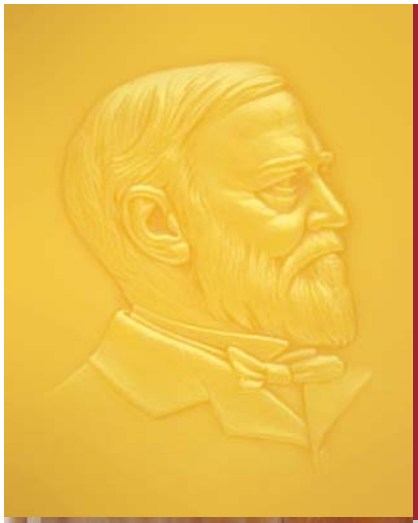
Among the many advances in developmental biology, I recall one particularly memorable day in October 2006. I received a morning "wake-up" call and learned Andy Fire was to share the Nobel Prize for work he conducted at our Department of Embryology on RNA interference.

The Geophysical Lab conducts research on how materials behave under extreme conditions, yielding new materials with many potential applications. The Deep Carbon Observatory, launched by Carnegie with help from the Alfred P. Sloan Foundation, is opening whole new vistas of science. It is yielding incredible surprises about carbon in the deep Earth, including complex organisms at great depth, the movement of carbon from the interior to the surface, and countless other marvels.

Concerns grow over how to feed the world's ever-expanding population. Carnegie plant scientists have made huge inroads in understanding the fundamentals about how plants respond to stress, such as drought and salt. In tandem, they have developed techniques to observe stress responses in real time, providing a means to increase agricultural productivity.

These and other untold discoveries reinforce the fact that science is marvelously fluid and ever changing. I am proud, grateful, and lucky to have been a party to so many astounding changes in the scientific landscape. Thank you for the opportunity!

Richard A. Meserve, *President*



Carnegie's Service to Science *Awards*

President Richard Meserve gave out two Carnegie Service to Science Awards at this year's Carnegie Evening on April 30. One went to **Embryology's Allison Pinder**; the other went to **Mary Horan of Terrestrial Magnetism**.

Embryology's Allison Pinder is awarded the Service to Science medal by Carnegie president Richard Meserve.

Allison Pinder

has managed the Biopolymer Core Facility for over 20 years at the Department of Embryology. She started off learning a variety of molecular biology techniques and experimental approaches as a technician working for then-staff associate Sondra Lazarowitz. She took time off to raise her children, but—when the Biopolymer Core Facility was formed in 1992—then-director Don Brown urged her to return to manage the facility.

Over the years Pinder's career trajectory has paralleled the rapidly changing field of molecular biology, with increasingly larger data sets and increasingly sophisticated equipment. She has excelled at every step.

Largely because of her efforts, the productivity of Carnegie's "deep" or "next generation" sequencing machinery has significantly surpassed that of most other institutions with this same powerful technology. The machinery is an indispensable workhorse, and Pinder continues to develop new applications and methods, keeping the department at the cutting edge.

Because of her broad biological interests, basic knowledge, and expertise in diverse animal models, Pinder readily comprehends the projects and needs of our investigators. In the words of her nominator, "Allison Pinder is a powerful force behind the successful science at the Embryology Department."

Terrestrial Magnetism's Mary Horan receives the Service to Science Award from Carnegie president Richard Meserve.

Mary Horan

has been the Geochemistry Laboratory Manager for over 17 years. Her job involves technique development; training and supervising postdocs, students, and visitors; and keeping the laboratory posed for the research of the geo/cosmochemistry scientific staff. Because of her selfless support, researchers involve her as coauthor on their papers.

Recently Horan diagnosed an excessive airflow through the laboratory fume hoods and refused to accept that the airflow was correct, as suggested by several HVAC contractors. She obtained the necessary equipment to make the airflow measurements herself and then assembled the data that clearly showed that the problem could not be overlooked. A specialized HVAC contractor subsequently confirmed her evaluation of the problem. Horan's oversight of the renovation ensured that the work was completed on time and on budget.

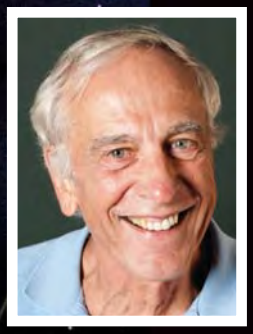
Horan also conducts her own research. She has 46 publications (12 of which she is the first author) with an h-index of 22 and an average citation per page of 35. We know of no other lab manager anywhere with a comparable, high-level research career. She is the consummate professional and takes pride in the progress and success of all the users of the chemistry lab. □

The Service to Science Award was created to recognize outstanding and/or unique contributions to science by employees who work in administration, support, and technical positions at Carnegie. Any individual employed by or officially affiliated with Carnegie may nominate an eligible employee. The panel that reviewed the nominations and selected the award recipients included Alan Dressler, staff astronomer at the Carnegie Observatories; Steven Farber, staff scientist at the Department of Embryology; and Cady Canapp, Manager of Human Resources.

EYING CROPS FROM SPACE

Image courtesy Pat Rawlings, Keck Institute for Space Studies

This artwork illustrates the process of measuring photosynthesis from space.



Carnegie's Joe Berry.

Plants convert energy from sunlight into chemical energy during a process called photosynthesis. Humans and animals eat the plants, making photosynthesis the primary source of energy for life on Earth. But human interaction with the climate is changing photosynthetic activity in various areas, which makes studying large-scale photosynthesis particularly interesting. New research from a team including Carnegie's Joe Berry used a fundamentally new approach for measuring photosynthesis around the planet. *Proceedings of the National Academy of Sciences* published their work.

The team's research is based on the breakthrough ability to use satellite technology to measure light emitted by plant leaves as a photosynthetic by-product. This light, fluorescence, is produced when sunlight excites the photosynthetic pigment chlorophyll. As the satellite passes overhead, it measures this fluorescence. Other approaches to detecting photosynthetic activity on a large scale are less direct, so, until now, computer models have been the primary tools for estimating photosynthetic productivity on a planetary scale. But the accuracy of these models has been difficult to evaluate.

"This new method changes everything," Berry said. "It gives us a direct observation of photosynthesis on a large scale for the first time ever."

The team's paper reports on observations of fluorescence from large croplands in the Midwestern Corn Belt. The data show that the previous model-based estimates of photosynthesis are too low.

What's more, these studies provide a new and improved tool to evaluate the comparative productivity of the breadbaskets of the world, such as the Indo-Gangetic Plain and eastern China. The relationship between fluorescence measured from space and gross primary production—the total amount of photosynthetic biomass—also provides a way for researchers to assess in near real-time photosynthesis in other, non-agricultural areas of the world, including vast expanses of uncultivated forests and grasslands. □

The Emmy Noether Programme (GlobFluo project) of the German Research Foundation, the Carbon Cycle Science Program, and NASA's Soil Moisture Active Passive Science Definition Team supported this work. The Keck Institute for Space Studies funded the New Methods to Measure Photosynthesis from Space workshop at Caltech.

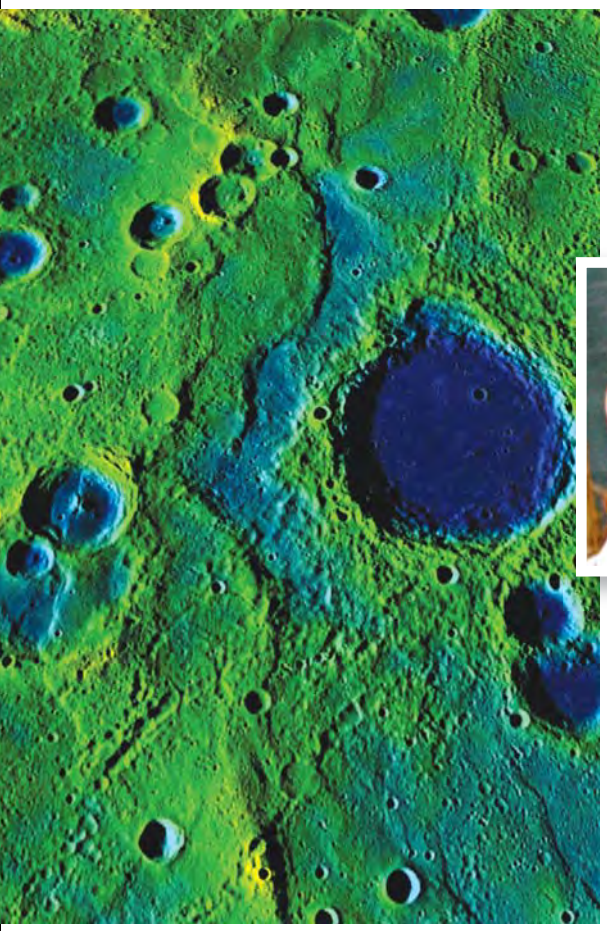


Image courtesy NASA/The Johns Hopkins University Applied Physics Laboratory/Carnegie Institution

MERCURY SHRANK MORE THAN THOUGHT

The above image shows a long collection of ridges and scarps called a fold-and-thrust belt on Mercury. The belt stretches over 336 miles (540 kilometers). The colors correspond to elevation—yellow-green indicates high elevation and blue indicates low.

(Above right) MESSENGER team member Paul Byrne

New global imaging and topographic data from MESSENGER* show that the innermost planet has contracted far more than previously estimated. The results are based on a global study of more than 5,900 geological landforms, such as curving cliff-like scarps and wrinkle ridges resulting from the planet's contraction as Mercury cooled. The findings, published online on March 16, 2014, in *Nature Geoscience*, are key to understanding the planet's thermal, tectonic, and volcanic history and the structure of its unusually large metallic core.

Unlike Earth, with its numerous tectonic plates, Mercury has a single, rigid, top rocky layer. Prior to the MESSENGER mission only about 45% of Mercury's surface had been imaged by a spacecraft. Old estimates—based on this non-global coverage—suggested that the planet had contracted radially, as the planet cooled, by about 0.5 to 2 miles (0.8 to 3 kilometers), substantially less than indicated by models of the planet's thermal history. Those models predicted a radial contraction of about 3 to 6 miles (5 to 10 kilometers), starting from the late heavy bombardment of the Solar System, which ended about 3.8 billion years ago.

The new results, which are based on the first comprehensive survey of the planet's surface, show that Mercury contracted radially by as much as 4.4 miles (7 kilometers)—substantially more than the old estimates but in agreement with the thermal models. Mercury's modern radius is 1,516 miles (2,440 kilometers).

"These new results resolved a decades-old paradox between thermal history models and estimates of Mercury's contraction," remarked lead author of the study, Paul Byrne, a planetary geologist and MESSENGER visiting investigator at the Department of Terrestrial Magnetism. "Now the history of heat production and loss and global contraction are consistent. Interestingly, our findings are also reminiscent of now-obsolete models for how large-scale geological deformation occurred on Earth, when the scientific community thought that the Earth had only one tectonic plate. Those models were developed to explain mountain building and tectonic activity in the nineteenth century, before plate tectonics theory."

Byrne and his coauthors identified a much greater number and variety of geological structures on the planet than had been recognized in previous research. They identified 5,934 ridges and scarps attributed to global contraction, which ranged from 5 to 560 miles (9 to 900 kilometers) in length.

The researchers used two complementary techniques to estimate the contraction from their global survey of structures. Although the two estimates of radius change differed by 0.6 to 1 mile (1 to 1.6 kilometers), both estimates were substantially greater than the old estimates.

"I became interested in the thermal evolution of Mercury's interior when the *Mariner 10* spacecraft sent back images of the planet's great scarps in 1974-1975, but the thermal history models predicted much more global contraction than the geologists inferred from the scarps then observed, even correcting for the fact that *Mariner 10* imaged less than half of Mercury's surface," noted Sean Solomon, principal investigator of the mission, former director of the Department of Terrestrial Magnetism, and current director of the Lamont-Doherty Earth Observatory at Columbia University. "This discrepancy between theory and observation, a major puzzle for four decades, has finally been resolved. It is wonderfully affirming to see that our theoretical understanding is at last matched by geological evidence." □

*MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) is a NASA-sponsored scientific investigation of the planet Mercury and the first space mission designed to orbit the planet closest to the Sun. The MESSENGER spacecraft launched on August 3, 2004, and entered orbit around Mercury on March 18, 2011 (UTC), to begin its primary mission—a year long study of its target planet. MESSENGER's first extended mission began on March 18, 2012, and ended one year later. MESSENGER is currently operating in its second extended mission. Dr. Sean C. Solomon, former director of the Carnegie's Terrestrial Magnetism, now director of the Lamont-Doherty Earth Observatory of Columbia University leads the mission as Principal Investigator. The Johns Hopkins University Applied Physics Laboratory built and operates the MESSENGER spacecraft and manages this Discovery-class mission for NASA.

Authors on the paper are Paul Byrne, Carnegie and the Lunar and Planetary Institute; Christian Klimczak, Carnegie; A. M. Celâl Şengör, Eurasia Institute of Earth Sciences; Sean Solomon, Carnegie and Lamont-Doherty Earth Observatory; Thomas Watters, Smithsonian Institution; and Steven Hauk II, Case Western Reserve University.

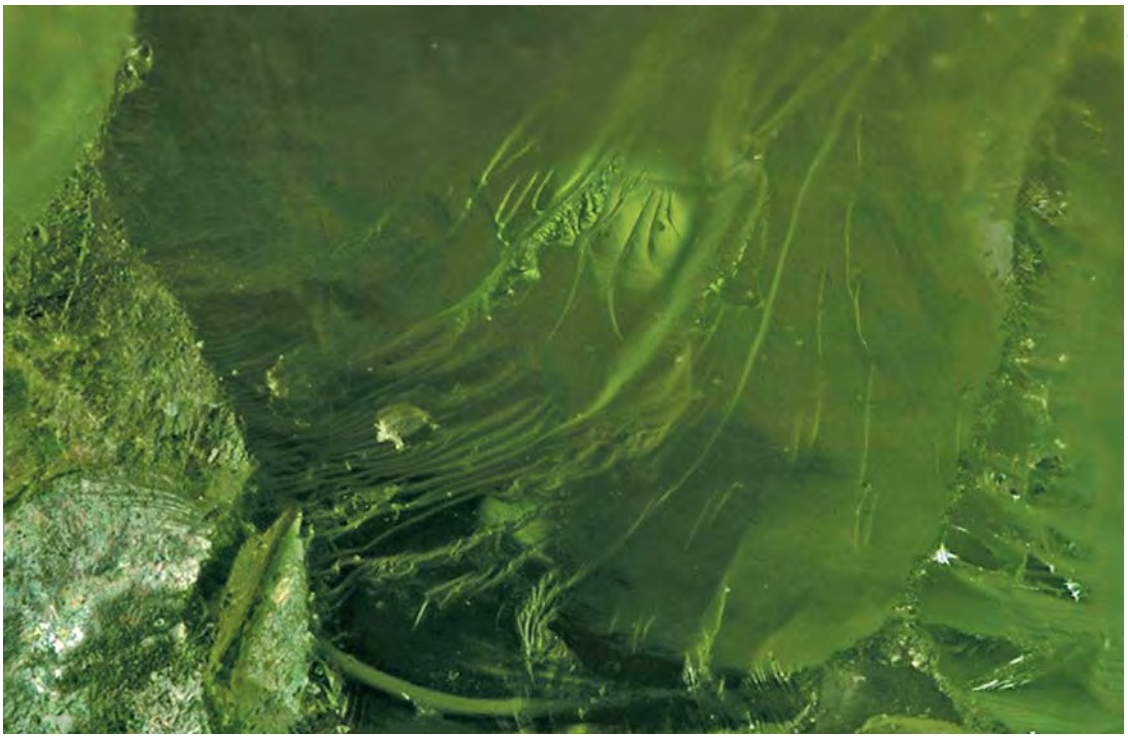


Image courtesy Robert Downs, University of Arizona, Ruff Project

(Left) The magnesium silicate forsterite (shown) was one of the most abundant minerals in the Hadean Eon, and it played a major role in Earth's near-surface processes. The green color of this mineral, also known as the semiprecious gemstone peridot, is caused by small amounts of iron. The iron can react with seawater to promote chemical reactions that may have played a role in life's origins.

(Above) Carnegie's Bob Hazen

Which Minerals Led to Life?

Image courtesy Ron Miller

Early Earth's raw materials were essential to the rise to life. Models of life's origins almost always look to minerals for synthesizing molecular building blocks or for supply of metabolic energy needed for living organisms. But these models assume that the mineral classes found on Earth today are much the same as they were during Earth's first 550 million years—the Hadean Eon—when life may have started to emerge. A new analysis of Hadean mineralogy challenges this assumption. Carnegie's Robert Hazen compiled a list of every plausible mineral species on the Hadean Earth and concluded that no more than 420 different minerals—about eight percent of the nearly 5,000 minerals found on Earth today—would have been present at or near Earth's surface at that time. *American Journal of Science* published the work.

"This is a consequence of the limited ways that minerals might have formed prior to 4 billion years ago," Hazen explained. "Most of the 420 minerals of the Hadean Eon formed from magma—molten rock that slowly crystallized at or near Earth's surface—and the alteration of those minerals when exposed to hot water."

By contrast, thousands of mineral species known today are the direct result of growth by organisms, such as shells and bones, in addition to life's chemical byproducts, such as oxygen from photosynthesis. In addition, hundreds of other minerals that incorporate relatively rare elements such as lithium, beryllium, and molybdenum appear to have taken a billion years or more to first appear, because it is difficult to concentrate these elements sufficiently to form new minerals. So those slow-forming minerals are also excluded from the time of life's origins.

"Fortunately for most origin-of-life models, the most commonly invoked minerals were present on early Earth," Hazen said.

For example, clay minerals—theorized to trigger interesting reactions—were available. Sulfide minerals, including reactive iron and nickel varieties, were also on hand to catalyze organic reactions. However borate and molybdate, which are rare even today, are unlikely to have occurred on the Hadean Earth, and call into question origin models that rely on those groups.

Several questions remain unanswered. For example, unlike today, the Hadean Earth had frequent large impacts of asteroids and comets, which would have caused massive disruption of Earth's crust. Resulting fracture zones, with hot circulating water, could have created complex environments with many exotic minerals.

The study also raises the question of how other planets and moons evolved mineralogically. Hazen suggests that Mars today may have progressed only as far as Earth's Hadean Eon. If so, Mars may be limited to a similar suite of no more than about 400 different mineral species. □

The National Science Foundation, NASA Astrobiology Institute, the Deep Carbon Observatory, and the Carnegie Institution for Science supported this work.

Precocious Galaxies

IN THE EARLY UNIVERSE

Some galaxies grew up in a hurry. Most of the galaxies observed from the early days of the universe are young and actively forming stars. Now an international team of astronomers including Carnegie's Eric Persson and Andy Monson has discovered galaxies that were already mature and massive from early in the universe's history. Fifteen mature galaxies were found at a record-breaking average distance of 12 billion light years, when the universe was just 1.6 billion years old. Their early existence raises new questions about what caused them to grow up so quickly. *The Astrophysical Journal Letters* published their findings in February.

Today the universe is filled with galaxies that have largely stopped forming stars, a sign of galactic maturity. But in the distant past, galaxies were still actively growing by consuming gas and turning it into stars. This means that mature galaxies should have been almost non-existent when the universe was still young.

With lead author Caroline Straatman and principal investigator Ivo Labbe, both of Leiden University, the astronomers used deep images at near-infrared wavelengths to search for red-colored galaxies in the early universe. The characteristic red indicates the presence of old stars and a lack of active star formation. These galaxies are barely detectable at visual wavelengths and are easily overlooked. But in the new near-infrared light images they are easily measured. The astronomers inferred that these early universe galaxies already contained as many as 100 billion stars on average per galaxy.

Mature galaxies have masses similar to that of the Milky Way, which still forms new stars at a slow rate. The newly discovered galaxies must have formed very rapidly in roughly 1 billion years, with explosive rates of star formation. The rate of star formation must have been several hundred times larger than observed in the Milky Way today.

The finding raises new questions about how these galaxies formed so rapidly and why they stopped forming stars so early; they seem to have come out of nowhere. Other big questions are what caused the galaxies to mature at such a young age and whether some dramatic event may have caused premature aging.

The galaxies were discovered after 40 nights of observing with the FourStar infrared camera on the Magellan Walter Baade Telescope at Carnegie's Las Campanas Observatory in Chile, combined with data from Hubble's Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey and the Great Observatories Origins Deep Survey. Using special filters to produce images that are sensitive to narrow slices of the near-infrared spectrum, the team was able to measure accurate distances to thousands of distant galaxies at a time, providing a 3-D map of the early universe. □

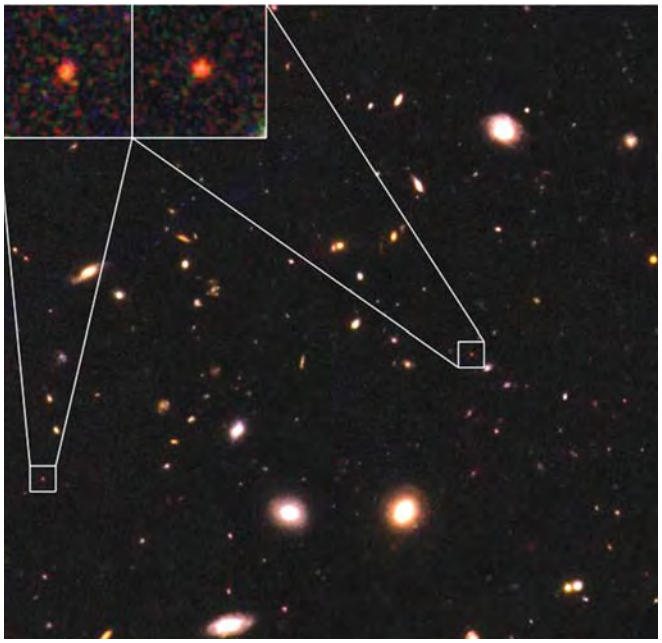
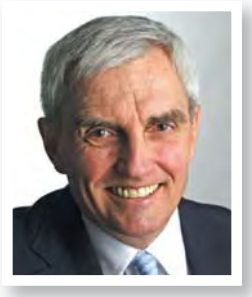


Image courtesy NASA/ESA

This Hubble Space Telescope composite shows the Chandra Deep Field South, with two of the 15 precocious galaxies. They are red, which is typical of older galaxies.

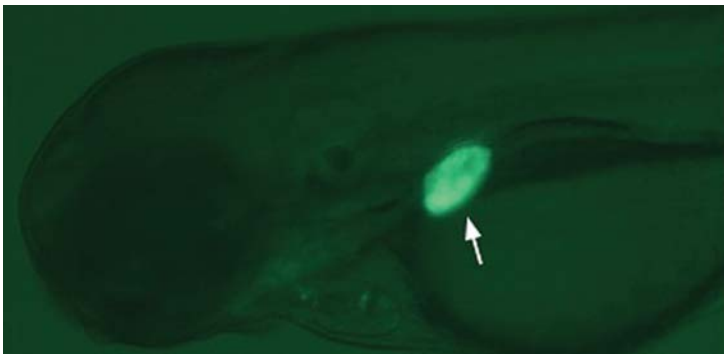


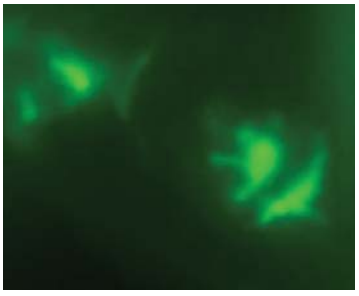
Carnegie's Eric Persson

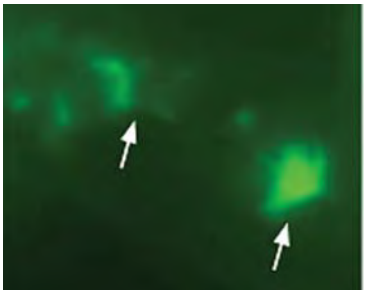
The George P. and Cynthia Woods Mitchell Institute for Fundamental Physics and Astronomy; National Science Foundation grant AST-1009707; European Research Council grant HIGHZ #227749; and the Netherlands Organization for Scientific Research Spinoza supported this research in part. The Australian federal government's National Collaborative Research Infrastructure Strategy supported Australian access to the Magellan Telescopes. This work is based on observations made with Herschel, a European Space Agency's Cornerstone Mission with significant participation by NASA, through an award issued by the Jet Propulsion Laboratory/Caltech.

Environmental Chemicals Bad for Prenatal Heart Valves

Daniel Gorelick was lead author on the study.







Images courtesy Daniel Gorelick

A chemical that mimics estrogen, bisphenol A (BPA), is an environmental endocrine disruptor associated with adverse health effects. BPA is commonly found in plastic bottles and food containers. New research from a team including Carnegie's Daniel Gorelick and Marnie Halpern shows that embryonic heart valves could be particularly in danger from the effects of this chemical. *Environmental Health Perspectives* published the work.

Estrogen hormones are important in all stages of life. They work by binding to receptors inside a cell, which then travel to the nucleus where they act on the cell's DNA by turning select genes on and off. But some synthetic chemicals mimic these estrogen hormones by also binding to the receptors. Exposure to these synthetic chemicals during early development is associated with increased risk of cancers and abnormal formation of the reproductive tract, so detecting such chemicals and identifying their mechanisms of action is greatly important.

Lead author Gorelick, Halpern, and Alice Hung of Carnegie, along with Luke Iwanowicz and Vicki Blazer of the Fish Health Branch of the U.S. Geological Survey, used zebrafish genetically modified to show estrogen receptor activity on a cell's DNA.

Their findings indicate that these specially developed zebrafish are great tools for detecting environmental endocrine disruptors from river water and for identifying which tissues are targeted by these endocrine disruptors.

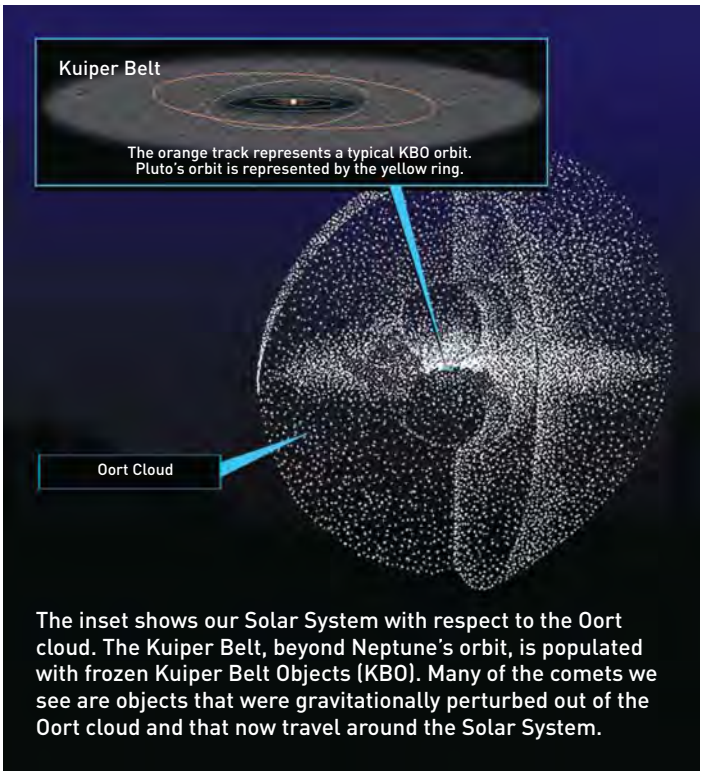
Unexpectedly, some river water samples activated estrogen receptors in the developing heart valves; this had not been previously observed. This raises interesting questions about the role of estrogen in valve formation and whether environmental chemicals could contribute to valve abnormalities. □

(Right) The image at top shows a three-day old zebrafish larva with the fluorescent protein activated in the liver following exposure to an estrogenic compound (arrow). Surprisingly, the developing heart valves also responded. They are shown in their open state (bottom left) and closed state (bottom right).

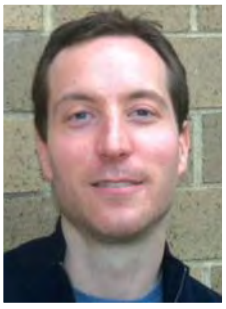
The National Institutes of Health National Research Service Award Postdoctoral Fellowship from the Eunice Kennedy Shriver National Institute of Child Health and Human Development and the U.S. Geological Survey Priority Ecosystems Science-Chesapeake Bay program supported this work.

Solar System's Edge Redefined

Image courtesy NASA



The inset shows our Solar System with respect to the Oort cloud. The Kuiper Belt, beyond Neptune's orbit, is populated with frozen Kuiper Belt Objects (KBO). Many of the comets we see are objects that were gravitationally perturbed out of the Oort cloud and that now travel around the Solar System.



Scott Sheppard

The Solar System has a new most-distant member. Carnegie's Scott Sheppard and Chadwick Trujillo of the Gemini Observatory discovered a distant dwarf planet beyond the known edge of the Solar System. This is likely one of thousands of distant objects that are thought to form the so-called inner Oort cloud. Sheppard and Trujillo's work also indicates the potential presence of a planet, perhaps up to 10 times the size of Earth, which influences the orbit of the new dwarf planet as well as other inner Oort cloud objects. Their findings were published in the March 27 issue of *Nature* and were covered extensively by the media.

The known Solar System consists of the rocky planets like Earth, which are close to the Sun; the gas giant planets, which are farther out; and the frozen objects of the Kuiper belt, which lie just beyond Neptune's orbit. Beyond this, there appears to be an edge to the Solar System where only one object, Sedna, was previously known to exist. But the newly found planet, called 2012 VP113 and affectionately nicknamed "Biden" because of the VP in its name, has an orbit that stays beyond Sedna. Sedna was discovered beyond the Kuiper Belt edge in 2003, but scientists did not know if Sedna was unique. With the discovery of 2012 VP113 it is now clear Sedna is not unique.

2012 VP113's closest orbital point to the Sun brings it to about 80 times the distance between the Earth and the Sun—the distance known as an astronomical unit (AU). The rocky planets and asteroids exist between 0.39 and 4.2 AU. Gas giants are between 5 and 30 AU, and the Kuiper belt ranges from 30 to 50 AU. There is a distinct edge in our Solar System at about 50 AU. Sedna orbits at 76 AU.

"The search for these distant inner Oort cloud objects beyond Sedna and 2012 VP113 should continue, as they could tell us a lot about how our Solar System formed and evolved," remarked Sheppard.

Sheppard and Trujillo used the new Dark Energy Camera (DECam) on the National Optical Astronomy Observatory's 4-meter telescope in Chile for the discovery. DECam has the largest field of view of any 4-meter or larger telescope, giving it unprecedented ability to search large areas of sky for faint objects. The Magellan 6.5-meter telescope at Carnegie's Las Campanas Observatory was used to determine the orbit of 2012 VP113 and to obtain detailed information about its surface properties.

Image courtesy Scott Sheppard

The three colored dots at the right of this image show the movement of the new planet 2012 VP113 (affectionately nicknamed "Biden" because of the VP in its name). It has the most distant orbit known in our Solar System. Three images of the night sky were taken about two hours apart and then combined into one image to show the planet's movement. The first image was artificially colored red, the second green, and the third blue.

Sheppard and Trujillo determined that about 900 objects with orbits like Sedna and 2012 VP113 and with diameters larger than 620 miles (1000 km) may exist and that the total population of the inner Oort cloud is likely larger than that of the Kuiper belt and the main asteroid belt.

"Some of these inner Oort cloud objects could rival the size of Mars or even Earth," said Sheppard. "This is because many of the inner Oort cloud objects are so distant; even very large ones would be too faint to detect with current technology."

The similarity of orbits for the two objects and a few others nearby suggests that an unknown massive perturbing body may be shepherding them into similar orbital configurations. Sheppard and Trujillo suggest a super Earth or an even larger object at hundreds of AU could create this effect since the new objects are too distant to be perturbed significantly by any of the known planets. □

NASA supported the acquisition of data used in this study. Observations were partly obtained at the National Optical Astronomy Observatory's Cerro Tololo Inter-American Observatory, operated by the Foundation of Universities for Research in Astronomy, under contract with the National Science Foundation. This paper also includes data gathered with the 6.5-meter Magellan Telescopes located at Carnegie's Las Campanas Observatory, Chile.

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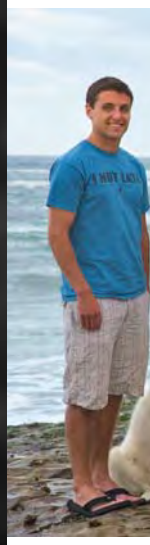


Images courtesy Matthew Scott

Dr. Matthew P. Scott

Named 10th President *of the* Carnegie Institution for Science

THE CARNEGIE BOARD OF TRUSTEES UNANIMOUSLY appointed Dr. Matthew P. Scott the 10th Carnegie president. Scott is Professor of Developmental Biology, Genetics, Bioengineering, and Biology at the Stanford University School of Medicine. He succeeds the current president, Richard A. Meserve, on September 1, 2014.

"THIS IS AN EXTRAORDINARY TIME FOR THE CARNEGIE INSTITUTION FOR SCIENCE," said board cochairs Suzanne Nora Johnson and Stephen Fodor. "The scientific departments are flourishing with strong support from trustees and a well-performing endowment. The trustees and departmental directors all believe Dr. Scott captures the independent spirit of Carnegie Science's long tradition of leading science at the frontiers. We are enthusiastic about his leadership."

Scott did his undergraduate and graduate work at MIT, with Professor Mary Lou Pardue. (Pardue was a Carnegie postdoc in Joe Gall's lab.) Scott moved to Indiana University for his postdoctoral work as a Helen Hay Whitney fellow with Thomas Kaufman and Barry Polisky. After setting up his own lab at the University of Colorado–Boulder, Scott went on to Stanford in 1990 to join the newly formed Department of Developmental Biology and the Department of Genetics.

Scott's research focuses on genes that control development, and how damage to these genes leads to birth defects, cancer, and neurodegeneration. He discovered the "homeobox,"a component of many genes that controls development. His group discovered the genetic basis of the most common human cancer—the skin cancer basal cell carcinoma—and of the most common childhood malignant brain tumor—medulloblastoma.

Scott served as associate chair and chair of Stanford's Department of Developmental Biology for six years. He chaired the multidisciplinary Bio-X program at Stanford from 2001-2007. Scott Delp, Professor of Bioengineering and Mechanical Engineering at Stanford, remarked, "Matt Scott transformed Stanford's bioscience research as an inspirational and effective leader of Stanford's interdisciplinary Bio-X program. The result is a thriving and broad-based research program that brings together hundreds of researchers from diverse disciplines focused on enhancing human health."

Scott is presently cochair of the Center for Children's Brain Tumors. He was elected to the American Academy of Arts and Sciences, the National Academy of Sciences, and the Institute of Medicine, and he has served as president of the Society for Developmental Biology. His awards include the Passano Award (1990), the Conklin Medal of the Society for Developmental Biology (2004), and the Pasarow Award in Cancer Research (2013).

REMARKING ON HIS NEW POSITION, Scott said, "Carnegie, founded in 1902 by a visionary entrepreneur, supports scientists engaged in pursuing an extraordinary range of nature's greatest mysteries, from the origins and evolution of the universe to the formation and dynamics of the Earth, the evolution of life, and the fluid ecosystems that fall increasingly under human influence. Carnegie scientists' investigations of deep history inform our future. To join them in these explorations is an exciting prospect. In undertaking this new job, I will benefit greatly from all that Stanford has taught me in nearly 24 years here. I am deeply grateful to the colleagues, students, and postdocs who have made my research and teaching experiences so rewarding. Carnegie enterprises prosper due to highly collaborative communities of skilled and creative people, a style of research that underlies many of Stanford's successes as well. On the Stanford campus are two Carnegie departments, and my wife Margaret Fuller's stem cell research laboratory, so I look forward to ongoing deep ties between Carnegie and this wonderful university. I am honored to have been given the opportunity to join Carnegie, and I look forward to extending a great heritage of its explorations."

WHEN NOT AT WORK, Scott and his family enjoy cycling, scuba, river running, mountaineering, and wilderness travel. He photographs and videos wildlife and ecosystems that are at risk for habitat destruction to speak out for their protection. (See matthewscottphotography.com).

SCOTT ASSUMES HIS NEW POST FROM world-renowned expert on energy policy and former chairman of the Nuclear Regulatory Commission Richard Meserve, who has been Carnegie president since 2003. Meserve stated, "I am very pleased that such an accomplished individual has been found to serve as the next Carnegie president. He is a wonderful selection to continue the remarkable record of scientific accomplishment that has been achieved by the institution."

Board cochairs Fodor and Nora Johnson remarked that, "Dr. Meserve leaves over a decade-long legacy of dedication to outstanding scientific research and policy." □

Far left, Matthew Scott, Carnegie's next president. Above left, the Scott/Fuller family poses with their Samoyeds on the beach near Santa Cruz, CA. From left to right is son Lincoln; daughter Julia; wife Margaret Fuller, a professor at Stanford University; and Matthew Scott. Above right, he is with a black-browed albatross in the Falkland Islands.

IT'S A "FOSSIL" GALAXY!

One of the twin Magellan 6.5-meter telescopes at Carnegie's Las Campanas Observatory in Chile made some of the observations in the Segue 1 research.

Image courtesy Yuri Beletsky

New work from a team of scientists, including Carnegie's Josh Simon, analyzed the chemical elements in the faintest known galaxy Segue 1 and determined that Segue 1 is effectively a fossil galaxy from the early universe. *The Astrophysical Journal* published their findings in April.

Astronomers hoping to learn about the first stages of galaxy formation after the Big Bang use the chemical composition of stars to help them unravel the histories of the Milky Way and other nearby galaxies. Using these analyses, the team categorized Segue 1's uniquely ancient composition.

Stars form from gas clouds and their composition mirrors the chemical composition of the galactic gas from which they were born. Only a few million years after stars begin burning, the most-massive stars explode in titanic blasts called supernovae. These explosions seed the nearby gas with heavy elements produced by the stars during their lifetimes. The very oldest stars consist almost entirely of the two lightest elements, hydrogen and helium, because they were born before ancient supernova explosions built up significant amounts of heavier elements.

In most galaxies, this process is cyclical, with each generation of stars contributing more heavy elements to the raw material from which the next set of stars will be born. But this is not the case with Segue 1. The new analysis shows that Segue 1's star formation ended at what would ordinarily be an early stage of a galaxy's development. Segue 1 likely failed to progress further because of its unusually tiny size.

"Our work suggests that Segue 1 is the least chemically evolved galaxy known," Simon said. "After the initial few supernova explosions, it appears that only a single generation of new stars were formed, and then for the last 13 billion years the galaxy has not been creating stars."

Because it has stayed in the same state for so long, Segue 1 offers unique information about the conditions in the universe shortly after the Big Bang. Segue 1's uniquely low iron abundance relative to other elements shows that its star formation must have stopped before any of the iron-forming supernovae occurred.

This truncated evolution means that the products of the first explosions in Segue 1 have been preserved. Intriguingly, very heavy elements like barium and strontium are nearly absent from Segue 1's stars.

"The heaviest elements in this galaxy are at the lowest levels ever found," said Anna Frebel of the Massachusetts Institute of Technology, the leader of the team. "This gives us clues about what those first supernovae looked like."

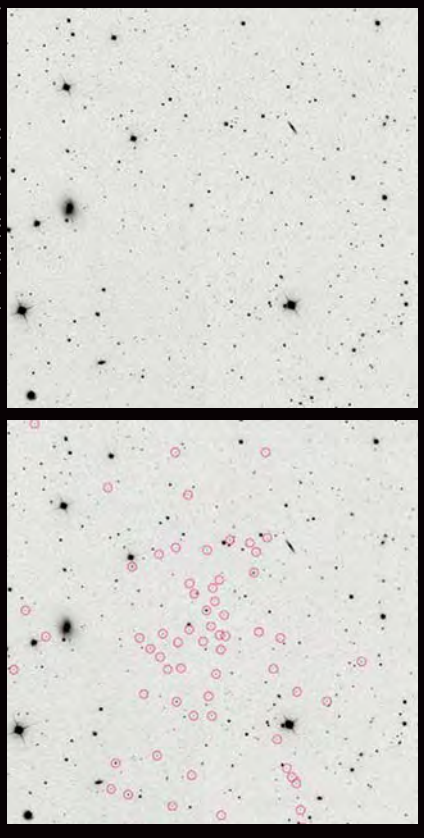
Studying individual stars in dwarf galaxies can be difficult, and Segue 1, which orbits our own Milky Way, is particularly puny, containing only about a thousand stars. Just seven stars in the entire galaxy are in the red giant phase of their lives, making them bright enough for modern telescopes to measure the abundance of each chemical element. Three of the seven red giants have heavy element abundances more than 3,000 times lower than that of the Sun, highlighting the primitive nature of the galaxy.

Along with Simon and Frebel, Evan Kirby of the University of California–Irvine was involved. The team used one of Carnegie's 6.5-meter Magellan telescopes in Chile to observe five of the Segue 1 stars, while one was studied with the 10-meter Keck I telescope in Hawaii. The final star was identified and measured by a competing team using the European Southern Observatory's 8.2-meter Very Large Telescope, also in Chile. □

The National Science Foundation and the Southern California Center for Galaxy Evolution, a research program funded by the University of California Office of Research, supported this work. The work made use of the NASA Astrophysics Data System bibliographic services.

Carnegie Evening with Josh Simon

Josh Simon was this year's Carnegie Evening speaker on April 30 at the administration building in Washington. His talk, *The Dark Side of Galaxies*, introduced the audience to the latest understanding of dark matter, the mysterious nonluminous material that accounts for more than 80 percent of the mass of the universe. Most galaxies consist primarily of this material, he said, which is believed to be a new type of subatomic particle observed though its interaction with gravity. Future telescopes, like the Giant Magellan Telescope, will allow astronomers to test the theories about the elusive stuff.



Images courtesy Marla Geha, Yale University

The top image is the heart of Segue 1; note, you cannot see the entire galaxy. The stars that are circled in red in the bottom image are part of Segue 1.

New Tool Measures Drought Hormones

Floods and droughts are increasingly in the news. Climate experts say the frequency of floods and droughts will also increase. As such, it is crucial for scientists to learn more about how these extreme events affect plants to prepare for and combat the possible resulting risks to food security.

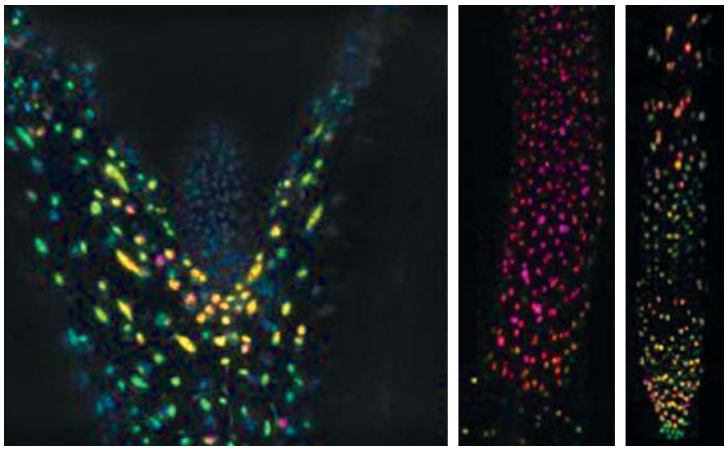
Like animals, plants have hormones that send chemical signals between its cells, relaying information about the plant's development or interactions with the outside world. One particular way in which plants use hormone signals is in reaction to drought or soil saltiness. The responsible hormone for this response is abscisic acid; it controls efficient water use and plays a role in signaling when seeds should remain dormant and when they should germinate, depending on soil conditions.

New work from a team including Carnegie's Wolf Frommer will allow researchers, for the first time, to measure the levels of abscisic acid in individual plant cells in real time. *eLife* published this work in April.

"This will vastly improve our understanding of how abscisic acid works in a plant that is stressed by salt or lack of water," Frommer explained. "This new tool can help engineers and farmers work to increase crop yields, which is especially important as climate change puts plants under increased stress."

The team's new tool uses multiple fluorescently tagged proteins to measure the concentration of abscisic acid found in a plant cell. Their findings indicate that there are likely more proteins responsible for transporting abscisic acid into a cell than are currently known and also that root cells eliminate abscisic acid very quickly after uptake.

"More work should reveal the fine-tuning by which plant cells respond and react to hormone signals. These tools should also have applications for human and animal hormones, as well," Frommer said. □



These images show a seedling of the model plant *Arabidopsis* with the fluorescently tagged abscisic acid sensor.

The National Science Foundation's Early Concept Grants for Exploratory Research (EAGER) program funded this work.

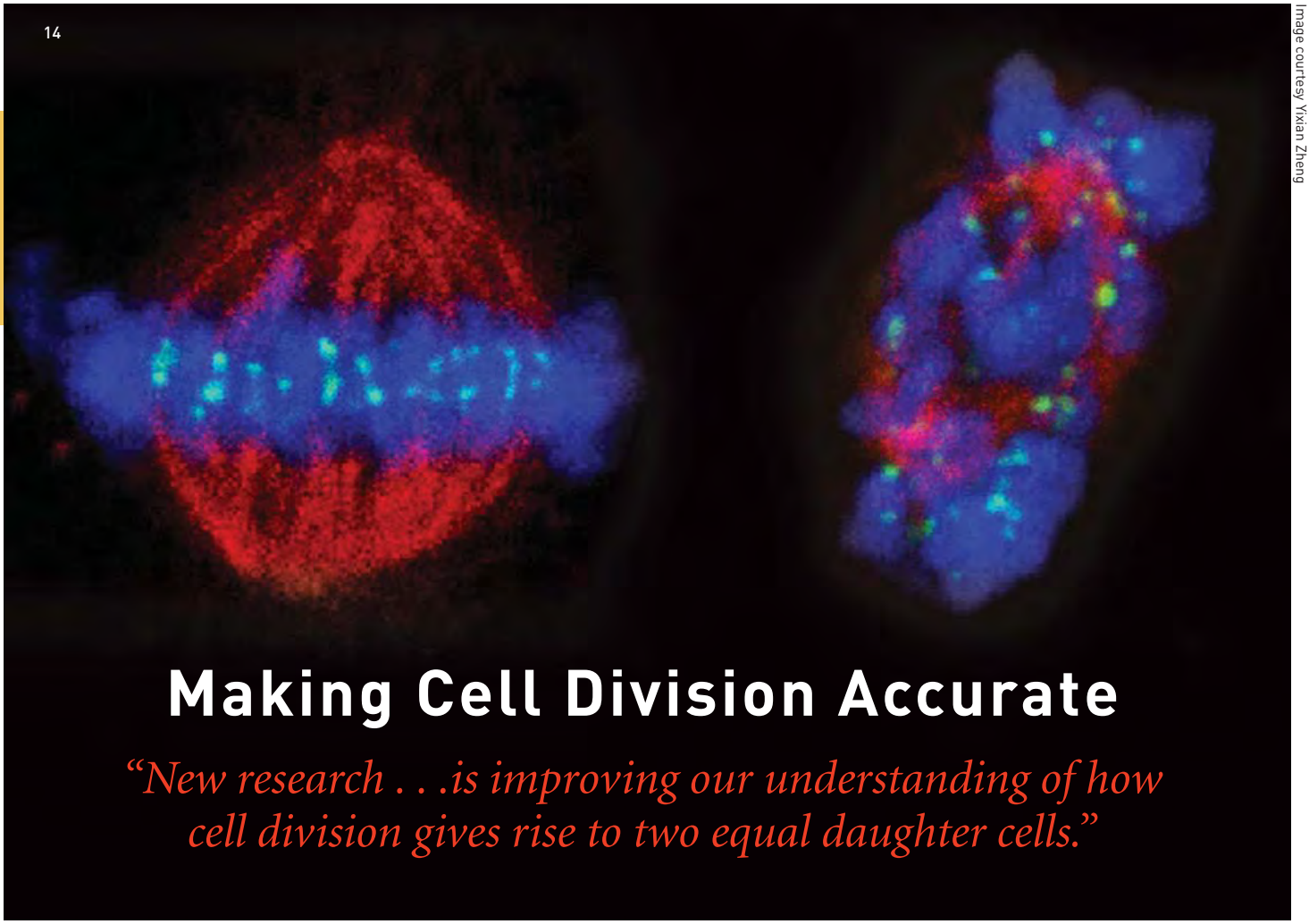


Image courtesy Yixian Zheng

Making Cell Division Accurate

"New research . . .is improving our understanding of how cell division gives rise to two equal daughter cells."

The images show the scaffolding-like microtubule-based spindle fibers (red), chromosomes (blue), and the protein kinetochores (green); the scale bar is 5 microns. Microtubules align chromosomes in the middle of the spindle in the presence of the newly discovered protein called BuGZ (+BuGZ). But in the protein's absence (-BuGZ), the chromosomes are misaligned. Chromosome misalignment leads to improper segregation during cell division, which can cause a host of problems.

Yixian Zheng

Every biology student knows that cells divide using a process called mitosis, a series of phases during which duplicate copies of the cell's DNA-containing chromosomes are pulled apart and separated into two distinct cells. Losing or gaining chromosomes during this process can lead to cancer and other diseases, so understanding mitosis is important for developing therapeutic strategies.

New research, from a team led by Carnegie's Yixian Zheng and published by *Developmental Cell*, focused on one important part of this process and is improving our understanding of how cell division gives rise to two equal daughter cells.

A complex of more than 90 proteins called a kinetochore interacts with scaffolding-like structural fibers called microtubules to help cell division along. Together the kinetochore and microtubules provide the structure and force to pull the two duplicate halves of the chromosome apart and direct them to each daughter cell.

By looking beyond the microtubules and kinetochores themselves, Zheng's team identified a protein that regulates the interactions between the kinetochore and the microtubule fibers. Using super-resolution microscopy, they were able to hone in on one particular phase of this process, namely the way that microtubules are "captured" by the kinetochore to promote proper chromosome alignment that facilitates equal partition of duplicated DNA.

"The study of mitosis has focused on microtubules and kinetochores, the most prominent structure that researchers observe. Our work demonstrates the importance of expanding the scope to include other cellular components because this is critical to achieving an in-depth understanding of the mechanisms underlying chromosome alignment in preparation for dividing the DNA into two new cells," Zheng said.

The team included Carnegie's Hao Jiang, the lead author Shusheng Wang, Junling Jia, and Yihan Wan. Hao Jiang and Yihan Wan are both collaborative postdoctoral fellows in the laboratories of Yixian Zheng of Carnegie and Xueliang Zhu of the Institute of Biochemistry and Cell Biology in Shanghai, China. □

The Chinese Academy of Sciences (XDA01010107), the Ministry of Science and Technology of China (2014CB964803) (X.Z.), the National Science Foundation of China (31010103910) (X.Z. and Y.Z.), and R01 GM056312 (Y.Z.) and R01 GM06023 (Y.Z.) supported this work.

InBrief

Image courtesy Christine Pratt

❶ From left to right, Steve DeLuca, Megha Ghildiyal, and Ethan Greenblatt attend the 2014 GSA Annual *Drosophila* Research Conference. Becca Obniski and Vicki Losick are in the background.

❷ Marnie Halpern presents her talk as a Nifty Fifty speaker as part of the USA Science and Engineering Festival.

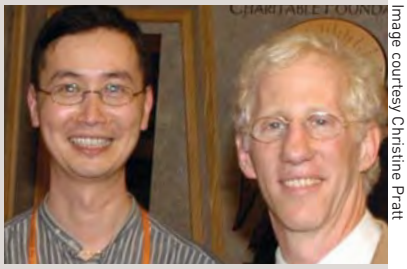


Image courtesy Christine Pratt

❸ Staff scientist Chen-Ming Fan (left) stands with former staff scientist Doug Koshland.

❹ Marnie Halpern (left) and Steve Farber attended the 3rd European Zebrafish Principal Investigator Meeting in Ein Gedi, Israel.

TRUSTEES AND ADMINISTRATION

Carnegie President **Richard A. Meserve** chaired the National Academies' Committee on Assessment of the Governance Structure of the NNSA National Security Laboratories Mar. 12-13 and Apr. 8-10 in Washington, DC. He attended a meeting of the advisory committee for the study of New Models in Science and Technology Policy by the American Academy of Arts and Science on Mar. 26 in Washington DC, and a meeting of the Secretary of Energy Advisory Board on Mar. 27-28 in Washington and on June 19-20 at the Argonne National Laboratory. He attended meetings of the Council and Trust of the American Academy of Arts and Sciences on Apr. 17-18 in Cambridge, MA. He introduced Sir Martin Rees and Dr. Wendy Freedman, director of the Carnegie Observatories, at an event cosponsored by the American Academy of Arts and Sciences and the Royal Academy on Apr. 29 at Carnegie headquarters. He chaired a meeting of the IAEA's International Nuclear Safety Group and its International Technical Advisors Group on May 5-7 in Vienna, Austria. He attended meetings of the Council of the National Academy of Engineering on May 9 in Washington, DC. On May 15, he participated in meetings regarding America's nuclear future at the Bipartisan Policy Center in Washington, DC. He chaired a meeting of the DOE's Nuclear Energy Advisory Committee on June 5 in Washington, DC. He participated in meetings with the Japanese Nuclear Regulatory Authority June 9-11 in Tokyo, and attended a reunion of the Departments of Plant Biology and Global Ecology alumni on June 27-28 in Stanford, CA.

EMBRYOLOGY

❶ **Allan Spradling** attended the National Academy of Sciences annual meeting; lectured at Georgetown U.; was the keynote speaker at the "Mobile Elements and Evolution" Keystone Symposia in Santa Fe, NM; and presented lectures at UC-San Francisco, U. Illinois-Champaign-Urbana, and Rockefeller U. He also presented the Neena B. Schwartz Lectureship in the Reproductive Sciences at Northwestern U.'s Minisymposium on Reproductive Biology; attended the Carnegie board of trustees meetings; and attended the 2014 GSA Annual *Drosophila* Research Conference with lab members **Jui-Ko Chang**, **Steve DeLuca**, **Megha Ghildiyal**, **Ethan Greenblatt**, **Bob Levis**, **Vicki Losick**, **Becca Obniski**, and **Matt Sieber**. Spradling was also appointed to the Scientific Advisory Board of the Johns Hopkins Malaria Research Institute.

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Joe Gall presented seminars at the NIH director's Wednesday afternoon lecture series, the Frederic M. Richards Lecture at Yale U., the "Luminaries of Science" series, and a public lecture at NYU. He was the invited lecturer for the 14th Daniel Nathans Lecture in Molecular Genetics, Johns Hopkins Medical Institutes.

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❷ **Marnie Halpern** gave the talk "Functional Specialization of the Habenulo-Interpeduncular Pathway" at the 3rd European Zebrafish Principal Investigator Meeting in Ein Gedi, Israel, and she attended the 2014 GSA board meeting in San Diego, CA. She was a guest lecturer for a eukaryotic genetics graduate course at the Uniformed Services U. of the Health Sciences, and she talked about her work to students at W.E.B. Dubois High School in Baltimore as a Nifty Fifty speaker for the USA Science and Engineering Festival.

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❸ **Chen-Ming Fan** presented his work at the 2014 UC-Berkeley Koshland Symposium.

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❹ **Steve Farber** gave the lecture "A Method to Visualize Apolipoproteins in Live Zebrafish: Liver-derived APOA-I Localizes to an Apical Domain of Intestinal Enterocytes" at the 3rd European Zebrafish Principal Investigator Meeting in Ein Gedi, Israel. He also gave a lecture at U. Kentucky and attended a Society for Developmental Biology regional meeting in CO.

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❺ Spradling graduate student **Gaelle Talhouarne** attended the Cold Spring Harbor Laboratory course "Cell and Developmental Biology of *Xenopus*."

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Gall postdoc **Jun Wei Pek** attended the 2014 GSA Annual *Drosophila* Research Conference.

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❻ Bortvin graduate student **Valeriya Gaysinskaya** presented a poster at the 2014 Keystone Symposia on epigenetics.

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❼ Farber lab graduate student **Rosa Miyares** completed her Ph.D. and is pursuing postdoctoral research in Tzumin Lee's laboratory at the Janelia Farm Research Campus in Ashburn, VA. Postdoc **Jessica Otis** presented a talk at the Keystone Symposia "Lipid Pathways in Biology and Disease."

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Halpern lab's **Mayah Dunstan**, a Baltimore Polytechnic Institute high school intern, received a third place award from the National Institute for Drug Abuse at the Baltimore Science Fair.

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❽ Yixian Zheng lab members **Haiyang Chen**, **Ankita Das**, and **Joseph Tran** attended the Keystone Symposia "Stem Cells and Reprogramming." Zheng lab postdoc **Ankita Das** participated in "Speak out for Science!" organized by the The Johns Hopkins U. postdoctoral and graduate student associations. Das, with other postdocs and students, met with five of Maryland's Congressional representatives to discuss the need for increased federal funding for basic science and medical research.

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Image courtesy Christine

❺ Gaelle Talhouarne

Image courtesy Christine Pratt

❻ Valeriya Gaysinskaya

❼ Farber lab's Jessica Otis

❽

Ankita Das

Joseph Tran

The group that met with Congressional representatives are (from left to right) Catherine Davis, Stephen Gee, Ankita Das (front), Kirill Gorshkov (back), and Daniel Pham.

Navigating Lipid Research

On April 11 the department hosted the local scientific meeting "Navigating Lipid Research in Baltimore: Cell to System." This meeting was funded by a grant from the American Society for Cell Biology (ASCB). The organizers were **Erin Zeituni** (a collaborative postdoc in Yixian Zheng and Steven Farber's labs), **Jessica Otis** (a postdoc in the Farber lab), **Vanessa Quinlivan-Repasi** (a graduate student in the Farber lab), and **Jessica Ellis** (a postdoc in Michael Wolfgang's lab at Hopkins). The meeting brought together Baltimore's scientists and clinical researchers with an interest in the role that lipids play in cellular processes, metabolism, and pathophysiological conditions. Baltimore hosts several premier research institutions, and the organizers hoped to encourage new collaborations by creating a platform to share knowledge, techniques, and scientific tools. The day included scientific talks, a poster session, and lunchtime talks ranging from clinical applications of lipidomics to the use of non-traditional organisms to study metabolism. Over 80 participants attended, including the executive director of the ASCB, Stefano Bertuzzi. □

(Above) Executive director of the American Society of Cell Biology Stefano Bertuzzi (center) chats with participants at lunch.

Departures: Postdoc **Junling Jia** completed his research in the Zheng lab and accepted a faculty position at the Life Sciences Institute of Zhejiang U. Halpern technician **Estela Monge** left the lab to attend graduate school.

GEOPHYSICAL LABORATORY

Robert Hazen presented lectures on mineral evolution in Tokyo, at Boston U., and at the Space Telescope Science Institute in Baltimore. He was a named keynote lecturer of the 2014 Annual Meeting of the ASCB.

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Russell Hemley presented a talk at the 2014 Annual Stewardship Science Academic Program Symposium on Feb. 20 and a colloquium at the Army National Laboratory–Aberdeen Proving Ground on Apr. 9.

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Ho-kwang Mao, **Agnes Mao**, **Yingwei Fei**, **Ronald Cohen**, and postdoctoral fellow **Caitlin Murphy** attended the Iron Elasticity Workshop in Kobe, Japan, Feb. 25-27. Murphy's talk was about the thermodynamics and elasticity of hexagonal-close packed iron from nuclear resonant inelastic X-ray scattering experiments.

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❾ Chief scientist **Malcolm Guthrie** hosted a visit by Duygu Saraçoğlu and Musa Caglar of the Turkish government's Department of Science, Technology, and Innovation Policies to learn about the Energy Frontier Research Center's (EFRC) EFree initiative; they are considering setting up a similar program in Turkey. They met with Guthrie, **Reinhard Boehler**, and **Timothy Strobel**.

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Principle investigator **John Armstrong** and coinvestigators **Yingwing Fei**, **Anat Shahar**, **Conel Alexander**, and **Steven Shirey** were recently awarded a $1 million, two-year grant from the National Science Foundation (NSF) to purchase a new, state-of-the-art field emission electron microprobe. This instrument will replace the 22-year-old conventional electron microprobe that has been a primary tool for chemically analyzing microscopic samples of synthetic, geological, and extraterrestrial materials. It will extend the lab's capabilities to analyzing nanovolumes in these materials. The new microprobe will be housed with the other electron microscopes in a newly completed microscopy and microanalysis center in the Abelson Building.

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John Armstrong will chair a symposium in Aug. on nanoanalysis with field emission electron microprobes at the joint meeting of the International Union of Microbeam Analysis Societies, the Microanalysis Society, and the Microscopical Society of America.

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Postdoctoral associate **Peng Zhang** gave a talk at the "Physics March Meeting" in Denver, CO, on Mar. 4.

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On Feb. 18-21 research scientist **Vincenzo Stagno** took part in the DCO Early Career Scientist Workshop in Costa Rica (http://deepcarbon.net/feature/meeting-report-early-career-scientist-workshop#.U0hULFeAmHd) where he was awarded a $1,000 prize. He also gave an invited talk at the 11th International Workshop on Water Dynamics in Sendai, Japan, supported by the DCO.

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❿ Webmaster **Michelle Scholtes** attended the 45th Lunar and Planetary Science Conference (LPSC) in Houston to provide science coverage. She collected video interviews and photographs.

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Arrivals: In Jan. postdoctoral associate **Irena Mamajanov** and predoctoral associate **Lei Han** arrived to work with George Cody and Yingwei Fei, respectively. Postdoctoral associate **Mingqiang Hou** arrived in Mar. to collaborate with Yingwei Fei.

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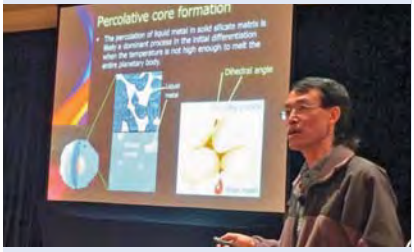
Japanese Visitors

Acting director **George Cody** (front, second from left) and **Bjørn Mysen** (back, second from left) hosted a delegation of top administrators from the Advanced Institute for Materials Research (AIMR) at Tohoku U., Japan, Jan. 22-23. The group wanted to learn how U.S. research, in particular Carnegie's research, is managed day-to-day and how it supports science across disciplines. They met with members of the administration, business office, information technology, library, engineering, machine shop, and electronics staff. □

❾ Malcom Guthrie (left) poses with the Turkish delegation.



❿ Staff scientist Yingwei Fei discussed the "Percolative Behavior of Immiscible Liquids at High Pressure and Temperature: Implications for Composition of Planetary Cores" at the 45th Lunar and Planetary Science Conference in Houston.

GLOBAL ECOLOGY

⓫ **Chris Field** was named recipient of the 2014 BBVA Foundation Frontiers of Knowledge Award in Climate Change. In Mar. Field and the Working Group II group—**Eren Bilir**, **Dave Dokken**, **Yuka Estrada**, **Eric Kissel, Katie Mach**, **Mike Mastrandrea**, and **Leslie White**—were in Yokohama, Japan, for the approval of the group's contribution to the UN's Intergovernmental Panel on Climate Change Fifth Assessment Report.

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⓬ In Mar. **Greg Asner** gave an invited seminar in environmental and evolutionary biology at Princeton U. That month he also spoke at the South African National Park Service annual science meeting on the impacts of elephant populations on African savannas and at the Oxford Megafauna Conference, U.K., about African savannas.

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⓭ In early Jan. **Ken Caldeira** appeared on "Fox Business News with Lou Dobbs" (https://www.youtube.com/watch?v=in9qugXsc7U). In late Jan. he was in Potsdam, Germany, serving on the international advisory panel for a European project called European Transdisciplinary Assessment of Climate Engineering (EuTrace). Caldeira gave two seminars on energy and climate related issues at UC-Berkeley in Feb. In Mar. former governor and wrestler Jesse Ventura interviewed Caldeira for Ventura's online streaming interview

Science Careers in Search of Women Conference 2014

On Apr. 10th HPCAT hosted Chicago-area high school girls for the "Science Careers in Search of Women Conference" at Argonne National Laboratory. The young women attend the conference to learn about the research at the laboratory, to network with professional women scientists and engineers, and to learn about careers in science and technology. After being welcomed to HPCAT by project administrator Freda Humble, the students were given a presentation on the basics of high-pressure science, the high-pressure research conducted at HPCAT, and the career path of the speaker, beamline associate Genevieve Boman. The students were then given a tour of the ID-D experiment station. □

⓫ (Left) Global Ecology director Chris Field is the recipient of the BBVA Foundation Frontiers of Knowledge Award. ⓬ (Right) Greg Asner

⓭ Global Ecology's Ken Caldeira appeared on the "Tavis Smiley Show" in Apr.

⓮ Anna Michalak

program. In Apr. Caldeira participated in a discussion on geoengineering on the KQED "Forum" radio program (http://www.kqed.org/a/forum/R201404150900) and appeared on the "Tavis Smiley Show" in Los Angeles (http://video.pbs.org/video/2365228019.

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⓮ **Anna Michalak** gave two seminars at Yale U. and served on the external review committee for the Earth Science Division at Lawrence Livermore National Laboratory and the Climate Change Science Institute at Oak Ridge National Laboratory.

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Former postdoctoral research associate, **Long Cao**, visited the Caldeira lab in Mar. He now has a faculty position at Zhejiang U. and was awarded the Norbert Gerbier–MUMM International Award 2014 for his paper with Ken Caldeira and Govindasamy Bala about climate response to atmospheric CO_2 and solar irradiance over short time scales. **Ho-Jeong Shin**, also a former postdoctoral research associate, visited the lab in Mar. and Apr. She is now working in Korea. **Rasmus Pedersen**, a Ph.D. student at U. Copenhagen, visited the Caldeira lab Mar.-Apr.

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Visiting researcher **Cecilia Chavana-Bryant**, a Ph.D. student from the Environmental Change Institute at U. Oxford, arrived in Jan. to work with the Asner lab. **Hannes Feilhauer**, a postdoctoral researcher from U. Erlangen-Nuremberg, visited the lab Feb.-Mar.

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⓯ In Mar. **Nick Vaughn**, **Robin Martin**, **Chris Anderson**, **Andrew Davies**, and **Greg Asner** mapped three South African national parks with the Carnegie Airborne Observatory.

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Rebecca Hernandez, a graduate student in the Field lab, presented the talk "Land-Use Efficiency of Big Solar" at the Third Conference on the Physics of Sustainable Energy at UC-Berkeley in Mar.

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⓯ Nick Vaughn gives the thumbs up in the Carnegie Airborne Observatory.

In Feb. **Graham Dow**, a Ph.D. student advised by **Joe Berry** and **Dominique Bergmann**, successfully defended his dissertation "The Physiological Consequences of Altering Genetic Controls in Stomatal Development of *Arabidopsis Thaliana*." Dow is now at Harvard on a NOAA postdoctoral fellowship.

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Alvin Han, a senior at Dougherty Valley High School in San Ramon, CA, won first prize in the Environmental Division at the Contra Costa County/INTEL-Affiliated Science Fair. Alvin worked as a summer intern in **Ted Raab's** lab as part of the American Geophysical Union's Bright STaRS program, which encourages high school students to study environmental and earth sciences. Han will attend Duke U. in the fall.

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Arrivals: Lester Kwiatkowski joined the Caldeira lab as a postdoctoral research associate in Jan. from U. Exeter. **David Marvin** arrived in Feb. to work as a postdoctoral research associate in the Asner lab from U. Michigan. **Andrew Davies**, from U. Pretoria, joined the Asner lab as a postdoctoral research associate in Feb.

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Departures: In Feb. **Mark Higgins**, a postdoctoral research fellow in the Asner lab, left for a position at the World Resources Institute in Washington, D.C. **Ricarda Winkelmann**, a visiting investigator in the Caldeira lab, left in Apr. for a position at the Potsdam Institute for Climate Impact Research.

OBSERVATORIES

⓰ Director **Wendy Freedman**, Carnegie president **Richard Meserve**, and trustee **Mike Long** hosted a visiting group to Las Campanas Observatory Jan. 8-11. Freedman hosted a second group Mar. 9-13. Freedman received an honorary doctorate from the U. of Chicago, June 14. She was invited to participate in the 12th Kavli Futures Symposium on "Future U.S. Ground-Based Astronomy in the Global Context," along with 30 other representatives of the U.S. astronomy community on Jan. 16-17 in Santa Monica, CA; the group addressed the future of ground-based astronomy in the U.S. From Jan. 31-Feb. 2 Freedman participated in the Origins Project Fifth Anniversary Meeting and workshop "Is Our Universe Necessary?" at Arizona State U.

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Staff astronomer **Luis Ho** gave an invited lecture at the annual meeting of Yunnan Observatory in Pu'er, China. He gave colloquia at National Taiwan U., Tsinghua U., and the National Astronomical Observatories of the Chinese Academy of Sciences.

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⓱ Staff astronomer **Juna Kollmeier** gave a talk "The Near-Field Deep-Field Connection" at the Southern California Center for Galaxy Evolution meeting at UC-Irvine. She attended the first Cognitive Astrophysics workshop Jan. 23-25. This is a joint workshop project with **Andrew Benson**, **Wendy Freedman**, and **Barry Madore**. She co-organized with Andrew Benson the first Simons Symposium "Galactic Super Winds: Beyond Phenomenology" at the St. Regis, Bahia Beach, Puerto Rico, Mar. 23-29.

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Staff astronomer **Joshua Simon** attended the meeting "The Near-Field Deep-Field Connection" at UC-Irvine Feb. 12-14 and gave a talk titled "Are the Ultra-Faint Dwarf Galaxies Fossils from Reionization?"

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Hale Scholar **Andrew Benson** gave the talk "Quantitative Predictions for Galaxy Formation" at Caltech on Mar. 14 as part of the TAPIR seminar series. With Juna Kollmeier, he co-organized the Simons Symposium "Galactic Super Winds: Beyond Phenomenology" in Puerto Rico, Mar. 23-29.

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Einstein Lyman Spitzer Fellow **Selma de Mink** gave an invited seminar at the MacGillavry Fellowship Symposium, Amsterdam, on Jan. 14. She gave an invited review at the Gamma-Ray Burst-Magnetar Meeting in Bormio, Italy, Jan. 20-24. On Jan. 29 she gave an invited colloquium at Caltech and an invited colloquium at UCLA on Feb. 5.

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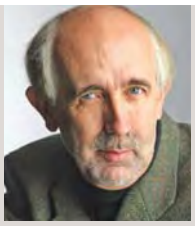
Preparing to Experiment

In Apr. intern **Yana Nebuchin** and postdoctoral research associate **Lester Kwiatkowki** (from left to right, foreground) of the Caldeira lab helped prepare for an upcoming experiment on ocean acidification and tidal pools to take place at Bodega Marine Laboratory (UC-Davis) in the coming months. □

⓰ Wendy Freedman ⓱ Juna Kollmeier



⓱ Barry Madore

⓲ Wolf Frommer

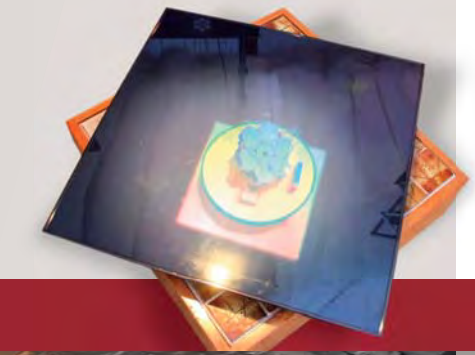
Image courtesy Robin Kempster

⓳ Zhiyong Wang

⓴ José Dinneny

㉑ Sue Rhee

㉒ Devaki Bhaya



Postdoctoral research associate **Rik Williams** gave a colloquium titled "Galaxy Evolution in the Thermal Era" at Ohio U. on Jan. 22. Feb. 2-7 he attended the conference "Unveiling the Formation of Massive Galaxies-Theoretical and Observational Challenges" in Aspen, CO. On Mar. 18 he gave a seminar titled "Hot Intermedia: WHIM, WHCGM, Both, or Neither?" for the Interstellar and Galactic Medium Program of Studies (IMPS) group at UC-Santa Cruz.

PLANT BIOLOGY

⓲ **Wolf Frommer** was an invited speaker at the Plant Molecular Biology Consortium meeting held at the North Carolina Biotechnology Center Mar. 2-5, giving a talk on "In Vivo Biochemistry—Fluorescent Biosensors for Measuring Metabolite Dynamics and Transporter Activity." He gave a talk at the John Innes Center, Norwich, U.K., on Mar. 6-8 on a similar topic and a related seminar on Mar. 9-12 at the IS ISV-CNRS French National Center for Scientific Research in Paris.

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⓳ **Zhiyong Wang** attended the Keystone Symposia "Plant Signaling: Dynamic Properties," Feb. 5-10 in Breckenridge, CO.

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⓴ **José Dinneny** presented a poster "Water Acts as a Positional Signal to Pattern Root Architecture in Maize" at the Maize Genetics Conference Mar. 13-16 in Beijing.

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㉑ **Sue Rhee** gave a talk "Towards Rational Assessment of Changes in Small Molecules by Leveraging Genomics and Metabolic Network Modeling" at the Genetic Basis of Unintended Effects in Modified Plants. This international conference, organized by ILSI Health and Environmental Sciences Institute (HESI) on Jan. 14-15 in Ottawa, Canada, brought together government, academic, and industry stakeholders regarding genetically modified organisms. Rhee's talk is at https://www.youtube.com/watch?v=fYUapPGewoU&feature=youtube.

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Matt Evans presented the poster "Mutant Analysis of Maize Antipodal Cells and Auxin Signaling" at the Maize Genetics Conference Mar. 13-16 in Beijing.

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Martin Jonikas was a speaker at the annual Food & Fuel for the 21st Century Symposium "Pushing the Genetic Boundaries of Photosynthetic Biomanufacturing," Mar. 14-15 at UC-San Diego. He gave the talk "A New Dawn for Photosynthesis Research: High-Throughput Genetics in Algae."

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㉒ **Devaki Bhaya** was the organizer of the NSF-Biotechnology and Biological Sciences Research Council (NSF-BBSRC) joint kickoff meeting "Nitrogen: Improving on Nature (NITROGEN)," held in San Francisco Feb. 27-Mar. 1. Bhaya presented a seminar titled "Nitroplast: A Light-Driven, Synthetic Nitrogen-Fixing Organelle." On Mar. 10 she gave a seminar about metagenomics and the metabolism of interacting microbial communities at the Indian Institute of Technology, Mumbai, India. On Apr. 29 she was the inaugural invited seminar speaker at Matrix Genetics in Seattle; she spoke on cyanobacteria. She also gave a special lecture at the Stanford Environmental Microbial Genomics on Feb. 6.

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Frommer lab's postdoctoral research associate **Davide Sosso** spoke about SWEET transporters at the Maize Genetics Conference Mar. 13-16 in Beijing.

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Dinneny lab members attended the Plant and Animal Genome XXII Conference held Jan. 11-15 in San Diego. Postdoctoral research associate **Ruben Rellan Alvarez** gave a talk titled "Growth and Luminescence Observatory of Roots." Research associates **José Sebastian** and **Muh-ching Yee** presented posters titled "*Setaria vitidis*: A Monocot Root Model System" and "Developing Tools for Studying Roots in *Setaria*," respectively. Postdoctoral research associate **Shahram Emami** attended the annual DOE Joint Genome Institute User Meeting and Genomics Technologies Workshop Mar. 18-20 in Walnut Creek, CA.

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Hulya Aksoy, the accounts payable manager, was promoted to assistant business manager for Plant Biology and Global Ecology on Feb.1.

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Arrivals: The Frommer lab welcomed former visiting scholar **Cindy Ast** from U. Potsdam, Germany, to the lab on Jan. 3 as a postdoctoral researcher. **Xiaoqing Qu** from China Agricultural U., another former visiting scholar, joined the Frommer lab as a postdoctoral researcher Mar. 17. Visiting researcher **Mira Reger** joined the lab Mar. 17 from the Friedrich-Alexander-U. Erlanger-Nuremberg, Germany. **Michael Banf** joined the Rhee lab as a postdoctoral researcher Jan. 6 from U. Siegen, Germany. **Inseob Han**, a professor at U. Ulsan, Korea, started his sabbatical in the lab on Jan. 23. Visiting researcher **Pierre-Luc Pradier** joined the Dinneny lab on Jan. 31 from U. Bordeaux, France. **Shimantika Sharma** joined the Huala TAIR group on Mar. 10 as a programmer from Georgia Institute of Technology. Postdoctoral researcher **Haojie Jin** arrived from Aarhus U., Copenhagen, Denmark, to join the Bhaya lab on Jan. 3. **Maria Slade** joined the administration for Plant Biology/Global Ecology on Mar. 3 as accounts payable specialist.

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Departures: Sam Parsa, a lab technician in the Frommer and Jonikas labs, departed for a new position as a production coordinator in Santa Rosa, CA, on Jan. 24. **Bernie Hauser**, a professor at U. Florida-Gainesville, left the Rhee lab in Mar. after his sabbatical. Visiting investigator **Pietro Fontana** of the Grossman lab returned to his university in Italy on Feb. 28. **David Huang**, senior software developer in the TAIR group, left on Mar. 31 to take his new position with Phoenix, a start-up company in Palo Alto.

TERRESTRIAL MAGNETISM

㉓ **Linda Elkins-Tanton**, director of the Department of Terrestrial Magnetism, resigned her position at Carnegie, effective May 9, 2014. She accepted a position as the director of the School of Earth and Space Exploration at Arizona State U., starting July 1, 2014. **Rick Carlson** is serving as acting director.

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In Feb. **Alan Boss** gave an invited talk on "The Crowded Universe" at the National Council of Space Grant Directors Spring Meeting in Arlington, VA. In Mar. he spoke about the first 3-D calculations of shock interactions with rotating presolar clouds at the LPSC in Houston.

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Rick Carlson presented invited public lectures on the history of Earth formation at Oregon State U. in Mar. and U. Alberta (ATLAS Lecture) in Apr. In late Mar. he was an invited speaker at the second annual meeting of the Earth-Life Science Institute in Tokyo.

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Chilean Astroday 2014

Roberto Bermúdez and colleagues helped organize an event in Mar. with other scientific organizations and observatories in Chile, to bring the stars to the people. One exhibit was a Giant Magellan Telescope hologram (upper left), which caused quite a stir. There were talks in addition to exhibitions. **Abdo Campillay, Consuelo Gonzalez, Mark Phillips,** and Bermúdez manned the stand. Campillay gave a talk to 40 people about constellations. **Gabriel Prieto** showed a PowerPoint presentation about the Las Campanas Observatory, and **Eduardo Carvajal** helped prepare the stand Saturday morning. This was the second time that Las Campanas joined the event. □

Seed Sorting Party!

The department obtained a genome-wide collection of tagged mutants from the *Arabidopsis* stock center in Feb. **Jianjun Guo** in the Rhee lab and **Franklin Talavera-Rauh** in the Barton lab organized a seed-sorting party. About 40 plant scientists at Carnegie and Stanford participated. Over 24,000 tubes of seeds were sorted and boxed in three days. ☐

㉓ (Left) Linda Elkins-Tanton. (Right) Rick Carlson was appointed acting director of DTM.

㉔ Alycia Weinberger (left) introduces the Apr. postdoctoral workshop panelists: former DTM postdoctoral fellows Sonia Esperança (NSF Program Director) and Winston Chan (CEO Corvusys, Inc.), former visiting investigator David Applegate (USGS Associate Director, Natural Hazards), and former GL postdoctoral fellow Michelle Weinberger.

In Apr. **John Chambers** published an article in *Nature* titled "Planetary Science: A Chronometer for Earth's Age" and was interviewed by the Australian Broadcasting Corporation's morning radio show.

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In Jan. **Larry Nittler** gave a scientific colloquium at Goddard Space Flight Center.

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Diana Roman conducted fieldwork at Popocatépetl Volcano, Mexico, in Mar. and presented seminars at National Autonomous U. Mexico and Mexico's National Polytechnic Institute.

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In Mar. **Scott Sheppard** and Chad Trujillo (Gemini Observatory) published the discovery of a new outermost object in our Solar System, the dwarf planet 2012 VP113, which resulted in an avalanche of press coverage and interviews. Sheppard also gave a presentation at NASA's Astrobiology Institute's executive council meeting in Mar. and in Apr. in Canada at the Herzberg Institute for Astrophysics weekly colloquium.

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㉔ **Alycia Weinberger** gave talks at the Stratospheric Observatory for Infrared Astronomy (SOFIA) Science Center at NASA-Ames in Feb. and the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA, in Mar. She built spectrographs and discussed astrobiology at Carnegie's booth at the USA Science and Engineering Festival in Washington, DC, in Apr.

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In Mar. postdoctoral fellow **Jacqueline Faherty** was on the science organizing committee and then attended the meeting "Gaia and the Unseen: The Brown Dwarf Question" in Turino, Italy.

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In Feb. DCO fellow **Marion Le Voyer** gave talks about global cycle of volatiles on Earth at Rutgers and U. Chicago. She spoke at the Geological Society of Washington on carbon content from submarine volcanic glasses.

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Postdoctoral fellow **Christelle Wauthier** presented an invited talk "Rifting Processes at Kilauea Volcano Inferred from a Joint Analysis of Geodetic and Seismic Data" at Lamont-Doherty Earth Observatory (LDEO), Columbia U.

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㉕ In Mar**. Linda Elkins-Tanton**, **Conel Alexander**, **Larry Nittler**, **Alan Boss**, **Paul Byrne**, **Aki Takigawa**, **Jemma Davidson**, **Shoshana Weider**, and **Christian Klimczak** attended the 45th LPSC in Houston. Outreach coordinator **Robin Dienel** provided science coverage.

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Arrivals: Postdoctoral fellow **Brad Foley** arrived in late Jan. In Feb. visiting investigators **Caroline Beghein** and **Jeremy Boyce** arrived for one month and **Jiuxing Xia** returned to work with Rick Carlson and Conel Alexander. In Mar. intern **Laura Flagg** returned for four months to work with Alycia **Weinberger,** and visiting investigator **Kiyoshi Suyehiro** arrived to collaborate with Selwyn Sacks and Alan Linde.

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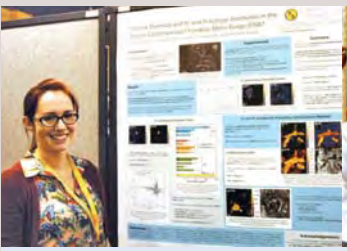
Departures: In Mar. facility manager **Roy Dingus** departed after 29 years of service. Visiting investigator **Satoshi Inaba** returned to Japan following his sabbatical from Waseda U. At DTM he developed new *ab initio* quantum mechanical models of chemical reactions related to astrobiology. Postdoctoral fellows **Christelle Wauthier** (Penn State) and **Christian Klimczak** (U. Georgia) departed for university positions. In Apr. senior fellow **Vera Rubin** left Washington, DC, for Princeton following 49 years at DTM. Visiting investigator **Aki Takigawa** left for Japan following collaboration with Larry Nittler and Rhonda Stroud.

DTM/GL

㉖ In Apr. DTM and GL celebrated the 100th anniversary of the Broad Branch Road campus. A commemorative website (http://bbr100.carnegiescience.edu) tells the story of the historic Abelson Building and the growth of the campus. Also in Apr. **Shaun Hardy** hosted a visit by participants in the American Institute of Physics International Conference for Early-Career Historians of the Physical Sciences. The Abelson Collaboration Center, a meeting facility with state-of-the-art presentation technology, opened in the DTM/GL library in Feb. ☐



㉕ Postdoctoral fellow Jemma Davidson presents her poster at the 45th LPSC meeting in Houston.

The MESSENGER group (from left) Paul Byrne (now at the Lunar and Planetary Institute), Larry Nittler, Sean Solomon (now at LDEO), Christian Klimczak, and Shoshana Weider gathered at the LPSC meeting.

㉖ Abelson centennial planning committee members are (first row from left) Casey Leffue, Michelle Scholtes, Robin Dienal and (back row from left) Janice Dunlap and Danielle Appleby.

Image courtesy Jan Dunlap

Good-bye Vera Rubin!

Astronomer and National Medal of Science recipient Vera Rubin moved to Princeton, NJ. Rubin arrived at Carnegie's Department of Terrestrial Magnetism in 1965. A Washington, DC, native, Rubin was the first woman allowed to observe at Palomar Observatory.

In the 1960s, Rubin's interest in how stars orbit their galactic centers led her and colleague Kent Ford to study the Andromeda galaxy, a nearby spiral. The two scientists wanted to determine the distribution of its mass by looking at the orbital speeds of stars and gas at varying distances from the galactic center. They expected the speeds to conform to Newtonian gravitational theory, where an object farther from its central mass orbits slower than those closer in. To their surprise, the scientists found that stars far from the center traveled as fast as those near the center.

After observing dozens more galaxies by the 1970s, Rubin and colleagues found that something other than the visible mass was responsible for the stars' motions: Each spiral galaxy is embedded in a "halo" of dark matter—material that does not emit light extending beyond the optical galaxy. The first inkling that dark matter existed came in 1933 when Swiss astrophysicist Franz Zwicky of CalTech proposed it. But it was Rubin's work that confirmed dark matter's existence.

In 1993 Vera Rubin received the National Medal of Science—the nation's highest scientific award for this work. She was elected to the National Academy of Sciences in 1981, and in 1996 became the first woman to receive the Royal Astronomical Society's Gold Medal since Caroline Hershel, who was awarded the prize in 1828. ☐

(Above) Vera Rubin at her good-bye celebration. She has moved to New Jersey to be closer to family.

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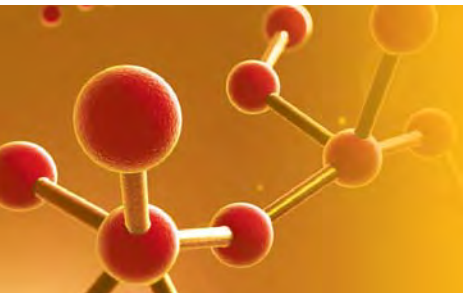

Annual Dinner

Is There a Right to Health Care?

Harvey Fineberg was this year's Annual Dinner speaker. Fineberg is the president of the Institute of Medicine, which, like the National Academies of Engineering and Sciences, provides unbiased and authoritative advice to government and public decision makers.

Fineberg began his talk "Is there a Right to Health Care?" by explaining that, although the United Nations universally recognized the right to health in 1948, national compliance of health rights as expressed in constitutions is lagging.

The rights spelled out in the U.S. constitution, for instance, are civil and political; there are no social or economic rights such as pensions, health care, or jobs. Fineberg recalled that Franklin Delano Roosevelt proposed a second Bill of Rights securing social and economic rights, but it failed. However, eventually—through choice—states started offering free elementary education, and by 1940 over half of U.S. youngsters graduated from high school. Fineberg believes that health care might follow a similar path, and he cited how the health care landscape is changing dramatically. He foresees that health care coverage will evolve similarly to retirement planning, which evolved from employer-provided pensions to 401(k) plans. Fineberg predicts the face of health care in the U.S. will be radically different in five to 10 years. □

Images courtesy Ben Barbin

Musical Tribute Concludes Evening

Twelve-year-old pianist Avery Lin Gaglian (shown above) wowed the audience to conclude this year's program. She started playing piano at age five and has since won first prize in numerous competitions, including the most recent Grand Prix award at the Chopin International Piano Competition in Hartford, CT. She transfixed the audience with her animated renditions of Chopin's "Nocturne op. 15, no. 2" and the prelude from Debussy's "Pour le Piano."

(Left) President of the Institute of Medicine Harvey Fineberg (left) was this year's Annual Dinner speaker. He answers questions after the talk, with Carnegie president Richard Meserve at his side.