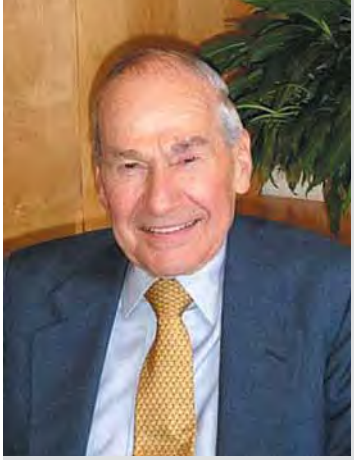
CarnegieScience

The Newsletter of the Carnegie Institution

SPRING 2009

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

On the Inside



With grim economic headlines bombarding us daily, it is heartening to see the good news that science has regained a position of importance in Washington and is considered essential to our long-term health. Of course, we at Carnegie have always known this. Our researchers have consistently strengthened the scientific endeavor not only by conducting science, but also by mentoring the next generation and hosting visiting investigators from all over the world. This outreach has significantly bolstered the scientific enterprise.

Every department has a cadre of postdoctoral fellows, and in some cases predocs, who work side by side with our senior investigators. These young researchers learn the art of exceptional research, and take their experience and Carnegie traditions to other first-rate academic and commercial institutions.

Ben Ohlstein was a postdoctoral researcher in Allan Spradling's lab at the Department of Embryology. These scientists found, for the first time, a type of stem cell that directly determines the fate of its daughter cells—a major contribution to stem cell research. Ohlstein is now on the faculty of the Columbia University Medical Center. A former predoctoral student, Elçin Ünal in the Koshland lab, was instrumental in finding that a key regulator of chromosome segregation works differently than was previously thought. She went on for her postdoctoral work at MIT.

Now a faculty member at the University of California, former Global Ecology postdoctoral fellow Elliot Campbell worked with Chris Field on research that revealed that there are limits to how biomass energy can contribute to global energy needs. Thijs Kaper, a scientist at Genencor, looks at how the major component of plant cell walls, cellulose, can better be used in ethanol applications. He worked in Wolf Frommer's lab at Plant Biology. Both of these research areas are vital for changing our energy system.

Former Vera Rubin Fellow at the Department of Terrestrial Magnetism (DTM) Alceste Bonanos has taken her studies of the most massive stars and the fastest stars to the Space Telescope Science Institute as a Giacconi Fellow. Another former DTM fellow, Fenglin Niu, is now on the faculty of Rice University. He, with DTM's Paul Silver, recently measured interesting changes in the speed of seismic waves that preceded two small earthquakes in California—work that may contribute to eventual earthquake prediction.

Northwestern University's Steven Jacobsen was a fellow at the Geophysical Laboratory (GL). He coauthored a recent study with several GL researchers that identified a driving force of heat movement in the inner Earth—another result that is important for understanding earthquakes and volcanoes.

Straddling North and South America, the Observatories is uniquely positioned to bridge the United States with Latin American educational institutions. That department's extensive roster of visiting investigators includes astronomers from every corner of the globe. But there is a particularly impressive array from the Chilean universities Pontificia Universidad Católica de Chile, Universidad de Chile, Universidad de Concepción, Chile, and Universidad de Valparaiso, Chile. Under our agreement, 10 percent of the viewing time at Las Campanas is dedicated to Chilean astronomers.

Fellows and visiting investigators never forget their time at Carnegie, and we are proud of their accomplishments. It is inspiring to see how far and wide our institution has reached. With science restored to its priority status, I am confident that the future for science is strong and that Carnegie will continue to thrive in its role as a one-of-a-kind proving ground.

Michael E. Gellert, *Chairman*

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TrusteeNews

Tours, Talk, and Dinner Highlight Trustees Meeting

The 129th Carnegie board of trustees meeting began on Thursday, November 20, and continued through the next day at the institution's Washington, D.C., administration building. The Finance, Research, and Development committees convened on Thursday and were followed by the first session of the board. Members of the Nominating Committee met Friday morning, after which the second session met. The meetings concluded with in-depth presentations by the directors about research at their departments.

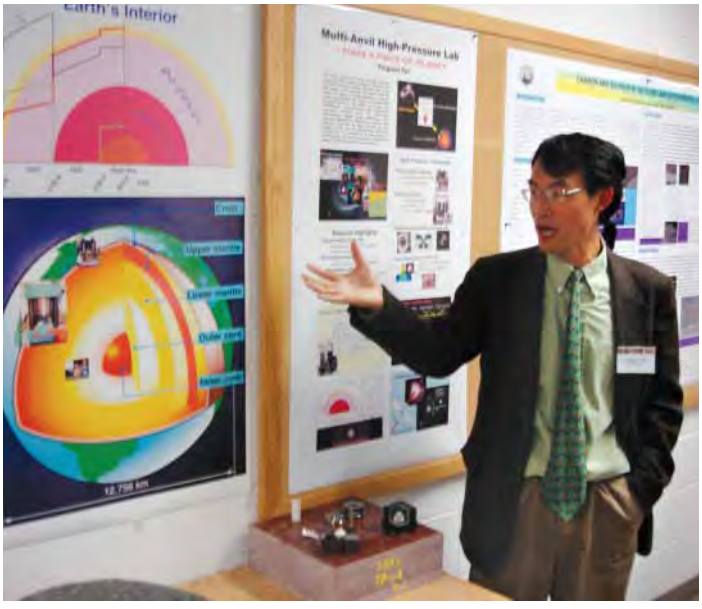
Following the first session of the board Thursday afternoon, the trustees recessed for a tour, talk, and dinner at the Geophysical Laboratory. Investigations at the lab span the physics, chemistry, and biology of the Earth under conditions the planet has undergone since it formed. Tour participants were divided into three groups and visited over a dozen different labs.

The exciting finale of the tour for one group was a visit to the chemical vapor deposition (CVD) diamond lab. A glittering display of diamonds adorned a new diamond-making instrument provided by Secretary of the Board Deborah Rose. The group's unique CVD process produces superfast and superhard crystals with potential applications in high-pressure research, semiconductors, microelectromechanical systems, and more. After the tours, trustees enjoyed a predinner talk by Bob Hazen about a new initiative to study carbon deep inside Earth. □

Board Welcomes MARY LOU ZOBACK!

Mary Lou Zoback

Geophysicist Mary Lou Zoback was elected to the board of trustees at the November meetings. She is vice president of Earthquake Risk Applications, Risk Management Solutions. Before her position there, she was with the USGS, where among other duties she was Chief Scientist of the Earthquake Hazards Team and Northern California Regional Coordinator of the Earthquake Hazard Program. Among her many affiliations, she is a member of the National Academy of Sciences and former president of the Geological Society of America (GSA). In 2007, she received the prestigious Arthur L. Day Medal and the Public Service Award from the GSA. She received her Ph.D. from Stanford University. □



Senior staff scientist Yingwei Fei describes how apparatuses in the multianvil high-pressure lab can mimic conditions in the deep Earth.

New diamond-making instrumentation was generously donated by Secretary of the Board of Trustees Deborah Rose. Rose (second from right) poses in the lab with members of the diamond-making team and tour guests. From left are Chih-Shiue Yan, Susanne Garvey, Rus Hemley, John Janik, Qi Liang, Yufei Meng, Dave Mao, Secretary of the Board Deborah Rose, and Joseph Lai. Image courtesy Amy Lazicki

This artist's rendering shows the Giant Magellan Telescope and support facilities at Las Campanas Observatory, Chile, high in the Andes Mountains.
Artwork by Todd Mason/Mason Productions

NINE HAVE SIGNED THE GMT AGREEMENT!

The Giant Magellan Telescope (GMT) Corporation, with Observatories' Wendy Freedman at the helm, announced February 6 that nine astronomical research organizations from three continents have signed the Founders' Agreement to construct and operate the 25-meter Giant Magellan Telescope. The GMT will be located at Carnegie's Las Campanas Observatory in the Andes Mountains of Chile. Participating institutions in the U.S. are Carnegie, Harvard University, the Smithsonian Institution, Texas A&M University, the University of Arizona, and the University of Texas at Austin. The two Australian members of the Founders group are Australian National University and Astronomy Australia Limited. The South Korean government has more recently approved participation in the GMT project, with the Korea Astronomy and Space Science Institute as the representative of the Korean astronomical community.

Freedman, GMT Corporation board chairperson and Carnegie Observatories director, noted that "the Founders' Agreement establishes the framework for the construction and operation of the telescope. The Founders group represents an extraordinary team of institutions, each of which has made important contributions to the development of the most advanced telescopes and instrumentation over the last 100 years. The GMT continues this remarkable legacy."

"We are very pleased to be joining this project, which will allow us to remain at the forefront of astronomical discovery in the 21st century," added Charles Alcock, director of the Center for Astrophysics, representing Harvard University and the Smithsonian Institution.

With its seven co-mounted 8.4-meter primary segments and adaptive secondary system, the GMT will provide unique capabilities in optical and infrared astronomy. It will open new windows onto the universe and teach us about the nature of dark matter and dark energy, the origin of the first stars and first galaxies, the mysteries of star and planet formation, galaxy evolution, and black hole growth. It will also play a key role in the detection and imaging of planets around nearby stars.

Scheduled for completion around 2019, the GMT will have the resolving power of a single 24.5-meter (80-foot) primary mirror. Each of the primary mirror segments weighs 20 tons, and the telescope enclosure has a height of about 200 feet.

The signing of the Founders' Agreement accompanies two other project milestones. The first of GMT's six "off-axis" honeycomb mirrors, cast in 2005, has just been generated to its almost-final surface at the University of Arizona Mirror Lab. Polishing and testing will be completed in early 2010. "The science opportunities for this telescope are extraordinary," noted Carnegie astronomer and GMT acting director Patrick McCarthy. □

SOUTH KOREA SIGNS UP AS GMT FOUNDER

On behalf of the Republic of Korea, Seok Jae Park, president of the Korea Astronomy and Space Science Institute (KASI), signed the Giant Magellan Telescope (GMT) Founders' Agreement on February 6, 2009, at the Observatories in Pasadena. The event makes KASI a founding member of the Giant Magellan Telescope Corporation. Wendy Freedman, director of the Carnegie Observatories and chair of the Giant Magellan Telescope Corporation board, hosted the event. A reception followed. □

Top: Seok Jae Park of the Korea Astronomy and Space Science Institute signs the GMT Founders' Agreement as Director of the Observatories Wendy Freedman looks on. Center: The deal is sealed with a handshake, making KASI a GMT founder. Bottom: Freedman presents a commemorative plaque to Park.
Images courtesy Barry Madore

"Scrawny" Gene Keeps Stem Cells Healthy

Stem cells are the body's primal cells, retaining the youthful ability to develop into more specialized types of cells over many cycles of cell division. How do they do it? Scientists at Carnegie's Department of Embryology have identified a gene, named *scrawny,* that appears to be a key factor in keeping a variety of stem cells in their undifferentiated state. Understanding how stem cells maintain their potency has implications for our knowledge of basic biology and for medical applications.

"Our tissues and indeed our very lives depend on the continuous functioning of stem cells," explained Embryology director Allan Spradling. "Yet we know little about the genes and molecular pathways that keep stem cells from turning into regular tissue cells—a process known as differentiation."

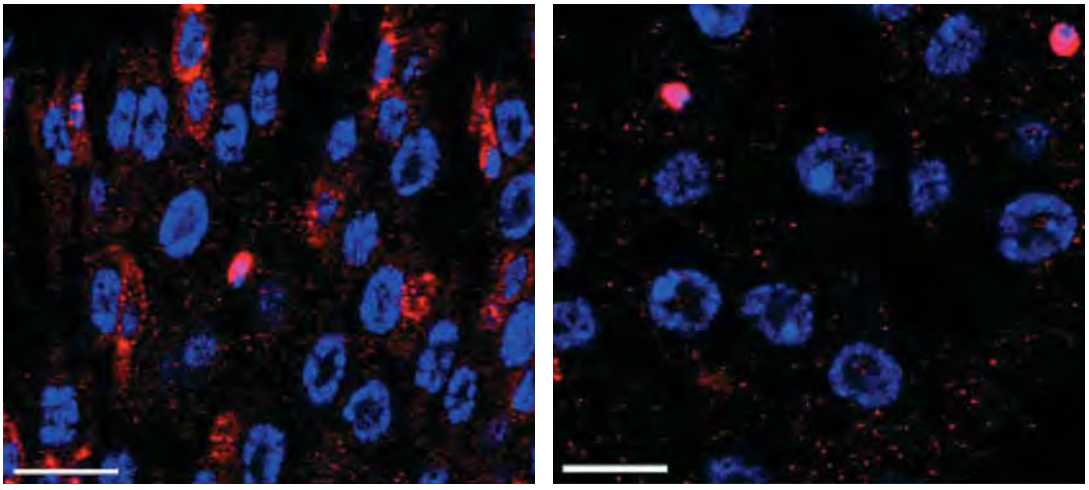
In the study, Spradling, with colleagues Michael Buszczak (now at Southwestern Medical Center in Dallas) and Shelley Paterno, determined that the fruit fly gene *scrawny* (so named because of the appearance of mutant adult flies) modifies a specific chromosomal protein, histone H2B, used by cells to package DNA into chromosomes. By controlling the proteins that wrap the genes, *scrawny* can silence genes that would otherwise cause a generalized cell to differentiate into a specific type of cell, such as a skin or intestinal cell.

The researchers observed the effects of *scrawny* on every major type of stem cell found in fruit flies. In the experiments, mutant flies without functioning copies of the *scrawny* prematurely lost their stem cells in reproductive tissue, skin, and intestinal tissue.

Stem cells function as a repair system for the body. They maintain healthy tissues and organs by producing new cells to replenish dying cells and rebuild damaged tissues. "Losing stem cells represents the cellular equivalent of eating the seed corn," remarked Spradling.

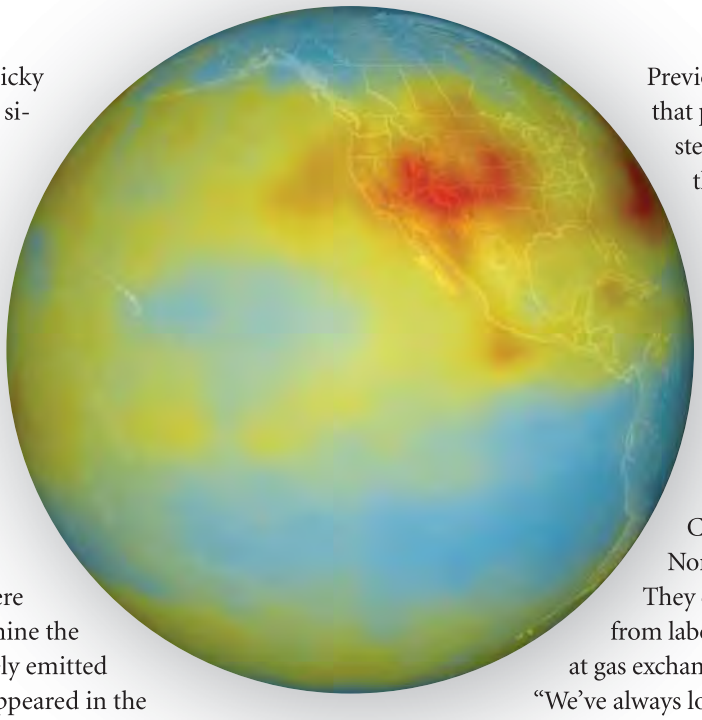
While the *scrawny* gene has so far only been identified in fruit flies, very similar genes that may carry out the same function are known to be present in all multicellular organisms, including humans. The results of this study are an important step forward in stem cell research. "This new understanding of the role played by *scrawny* may make it easier to expand stem cell populations in culture, and to direct stem cell differentiation in desired directions," Spradling said. □

Embryology's Mike Buszczak (now at the University of Texas Southwestern Medical Center in Dallas), Shelley Paterno, and Allan Spradling



Red-stained intestinal stem cells are visible in the tissue of a seven-day-old adult fruit fly with a normal copy of the *scrawny* gene (left), but have been prematurely lost in a mutant fly without a functioning copy of *scrawny* (right). Scale bar is 10 microns.

Corralling the Carbon Cycle



Unsnarling the carbon cycle is a tricky task, particularly since ecosystems simultaneously take up and release CO_2. Now scientists, including Global Ecology's Joe Berry, may have overcome a major hurdle in calculating how much carbon dioxide is absorbed and released by plants. The scientists found that the compound carbonyl sulfide, which plants consume in tandem with CO_2, can be used to quantify gas flow into the plants during photosynthesis. The results could both bolster the understanding of how the biosphere responds to stress and help determine the amount of carbon that can be safely emitted by human activity. The research appeared in the November 14, 2008, issue of *Science*.

"In photosynthesis, plants 'breathe in' carbon dioxide from the atmosphere and, with sunlight energy, convert it and water into food and oxygen, which they then 'exhale,' " explained Berry. "Plants and other organisms also respire producing carbon dioxide. We can measure the net change in CO_2, but we have not had an accurate way to measure how much is going in or out and how this is affected by climate. Understanding this photosynthesis-climate feedback riddle is key to understanding how climate change may affect the natural processes that are a sink for human-made carbon emissions."

Previous laboratory research showed that plants take up carbonyl sulfide in step with photosynthesis. But there there is no emission of carbonyl sulfide from plants.

The researchers compared atmospheric measurements of carbonyl sulfide over North America during the growing season with two simulations of an atmospheric transport model. The airborne observations, from the Intercontinental Chemical Transport Experiment-North America, also measured CO_2. They combined these data with results from laboratory experiments that looked at gas exchange at the leaf level.

"We've always looked at the total change in CO_2, but now we can look for the influence of photosynthesis on this total change," remarked lead author Elliott Campbell, a former Carnegie postdoctoral researcher, currently at UC Merced. "Our approach, based on the relation of carbonyl sulfide to photosynthesis, gives us this unique ability."

With the new inputs, the researchers ran their simulations, which consider plant uptake, soil and ocean absorption, human-made emissions, and how the gases flow through these systems. The simulations showed that the magnitude of the plant uptake was much larger than that of other sources and sinks at a continental scale during the growing season, which is important for using the compound to trace photosynthesis.

"The intriguing outcome of this study is that an inverse analysis of the atmospheric carbonyl sulfide measurements may be used to quantify the carbon released during plant respiration," said Berry. "That key missing piece has inhibited carbon-cycle research for years." □

Above: NASA's Atmospheric Infrared Sounder (AIRS) instrument on the *Aqua* spacecraft can observe carbon dioxide in the atmosphere. This image shows CO_2 over the United States in July 2003. High concentrations of the greenhouse gas are red, low concentrations are blue.
Image courtesy NASA

Left: Carnegie's Joe Berry in the field

DTM's Rick Carlson used minute variations in the isotopic composition of the rare Earth elements neodymium and samarium to date the oldest rocks, called faux amphibolite, which the researchers interpret to be ancient volcanic deposits.
Image courtesy Jonathan O'Neil

OLDEST KNOWN ROCKS DATED AT DTM

Canadian bedrock more than 4 billion years old may be the oldest known section of the Earth's early crust. Terrestrial Magnetism's (DTM) Richard Carlson used geochemical methods to obtain an age of 4.28 billion years for samples of the rock, making it 250 million years more ancient than any previously discovered rocks. The findings, which offer scientists clues to the earliest stages of our planet's evolution, were published in the September 26, 2008, issue of *Science*.

The Nuvvuagittuq greenstone belt is an expanse of bedrock exposed on the eastern shore of Hudson Bay in northern Quebec. Samples of the Nuvvuagittuq rocks collected by geologists from McGill University in Montreal were analyzed by Carlson and Jonathan O'Neil, a Ph.D. student at McGill. By measuring minute variations in the isotopic composition of the rare Earth elements neodymium and samarium in the rocks, O'Neil and Carlson determined that the rock samples range from 3.8 to 4.28 billion years old. The oldest dates came from rocks termed "faux amphibolite," which the researchers interpret to be ancient volcanic deposits.

"There have been older dates from Western Australia for isolated resistant mineral grains called zircons," remarked Carlson, "but these are the oldest whole rocks found so far." The oldest zircon dates are 4.36 billion years. Before this study, the oldest dated rocks were from a body of rock known as the Acasta Gneiss in the Northwest Territories, which are 4.03 billion years old. The Earth is 4.6 billion years old, and remnants of its early crust are extremely rare—most of it has been mashed and recycled into Earth's interior several times over by plate tectonics.

The rocks are significant not only for their great age but also for their chemical composition, which resembles that of volcanic rocks in geologic settings where tectonic plates are crashing together. "This gives us an unprecedented glimpse of the processes that formed the early crust," said Carlson. □

Bedrock in the Nuvvuagittuq region of Quebec may be the world's oldest, dating 250 million years earlier than previously discovered rocks.
Image courtesy Jonathan O'Neil

The research was supported by the National Science and Engineering Research Council of Canada, the U.S. National Science Foundation, and the Carnegie Institution.

"Little Bang" Sparked Solar System

For years, scientists have thought that the Solar System formed when a shock wave from an exploding star—a supernova—triggered the collapse of a dense, dusty gas cloud that then contracted, forming the Sun and the planets. But models of this scenario only worked assuming that temperatures during the violent events remained constant. Now, Alan Boss at the Department of Terrestrial Magnetism (DTM) and colleagues have shown that a supernova could have triggered the Solar System's formation under the more likely conditions of rapid heating and cooling. Their results, published in the October 20, 2008, issue of the *Astrophysical Journal*, finally settle this long-standing debate.

Terrestrial Magnetism's Alan Boss
Image courtesy Alan Boss

"We've had chemical evidence from meteorites that points to a supernova triggering our Solar System's formation since the 1970s," said Boss. "But until this study, scientists have not been able to work out an internally consistent scenario, in which a collapse is triggered at the same time newly created isotopes from the supernova are injected into the collapsing cloud."

Short-lived radioactive isotopes—variants of elements with the same number of protons but a different number of neutrons—found in very old meteorites decay over millions of years and turn into different, so-called daughter elements. When daughter elements are present in primitive meteorites, it indicates that the short-lived parent radioisotopes were created about a million years before.

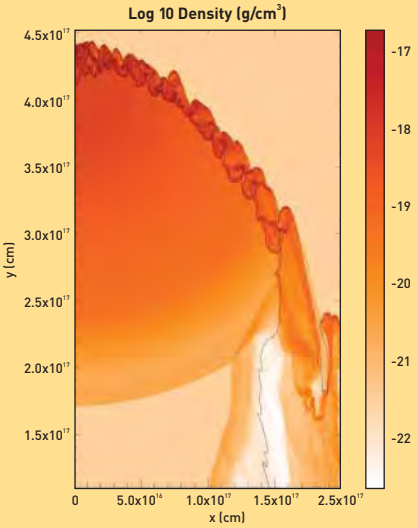
"One of these parent isotopes, iron-60, is made in significant amounts only in the potent nuclear furnaces of massive stars," explained Boss. "Iron-60 decays into nickel-60, and nickel-60 has been found in primitive meteorites. So we've known where and when the parent isotope was made, but not how it got there."

Previous models by Boss and former DTM fellow Prudence Foster showed that the isotopes could be deposited into a presolar cloud if a shock wave from a supernova explosion slowed to 6 to 25 miles per second and the wave and the cloud had a constant temperature of -440°F (10 K). "Those models didn't work if the material was heated by compression and cooled by radiation, and this conundrum has left serious doubts in the community about whether a supernova shock started these events over 4 billion years ago or not," remarked Harri Vanhala, who found the negative result in his Ph.D. thesis at the Harvard-Smithsonian Center for Astrophysics in 1997.

The Carnegie researchers considered several situations using what is known as an adaptive mesh refinement hydrodynamics code, FLASH2.5, designed to handle shock fronts, and an improved cooling law. In all runs, the shock front struck a presolar cloud with the mass of our Sun, consisting of dust, water, carbon monoxide, and molecular hydrogen, reaching temperatures as high as 1340°F (1000 K). Without cooling, the cloud could not collapse. However, with the new cooling law they found that after 100,000 years the presolar cloud was 1,000 times denser than before, and that heat from the shock front was rapidly lost, resulting in only a thin layer with temperatures close to 1340°F (1000 K). After 160,000 years, the cloud center had collapsed to become a million times denser, forming a protosun. The researchers found that isotopes from the shock front were mixed into the protosun, consistent with their origin in a supernova.

"This is the first time a detailed model for a supernova triggering the formation of our Solar System has been shown to work," said Boss. "We started with a Little Bang 9 billion years after the Big Bang." □

This artist's concept illustrates a young solar system, where a dusty disk begins the process of planet formation.
Image courtesy NASA/JPL-Caltech



This cross-sectional view shows one-half of a solar-mass target cloud being struck by a supernova shock front that is traveling downward. The colors represent the target cloud, with redder colors representing denser regions. The solid black contours delineate material that was originally in the supernova shock front, where short-lived radioisotopes are being injected into the collapsing target cloud.
Image courtesy Alan Boss

This research was supported in part by the NASA Origins of Solar Systems and Planetary Geology and Geophysics Programs and the NASA Astrobiology Institute.
The software used in this work was developed in part by the DOE-supported ASC/Alliances Center for Astrophysical Thermonuclear Flashes at the University of Chicago.

BIOLOGISTS ATTACK DATA AVALANCHE

The avalanche of biological information is at the point where the discipline may be unable to reach its full potential without improvements for incorporating data curation into online databases, warns a group of researchers in a feature published in a recent issue of *Nature.* The corresponding author is Plant Biology's Sue Rhee, who is principal investigator of The Arabidopsis Information Resource (TAIR). The commentary offers specific remedies to harness the information overload.

Data curation is very labor intensive. "There is a lack of standardization or consistency in the way scientists report their findings in different journals," remarked Rhee. "In some cases the researchers don't even specify the species of a gene under study. That leaves biocurators, who have advanced degrees in biology and expertise with databases and scripting languages, to read the full text and transfer the essence of the information into specific fields in the database. They spend a lot of time just figuring out the basics. And that leaves a lot of room for error."

Curation is not just a data organization tool. The data have become essential to research. The authors note that 11 different databases had three-quarters of a million visitors, who viewed 20 million pages in just one month. And researchers now tap into related work and use those data in their own experiments, producing a huge advancement in biology. "With this vast universe of information, the whole nature of experimentation is changing," continued Rhee. "But the field is being held back by a curation backlog."

The commentators outlined a series of solutions. First, have authors directly input their data into databases when their papers are accepted by refereed journals. This step has already begun with *Plant Physiology* and TAIR. Second, adopt standard reporting formats that are universally agreed upon. Third, elevate the status of curation in academic institutions and funding agencies. Also, incentives are needed for researchers to curate their own data, such as increases in academic recognition, career advancement, and funding. The commentators additionally suggest that "community annotation" could be modeled after large-scale astronomy projects like the Sloan Digital Sky Survey or the Galaxy Zoo, where 80,000 astronomers and amateurs classified 1 million galaxies in less than three weeks.

"The effort and cost required to curate the data is small compared with the cost of carrying out the research in the first place, yet this additional step adds tremendously to the value of the research results to society," commented Eva Huala, director of TAIR. □

Juna Kollmeier, the newest staff astronomer at the Observatories

Image courtesy Juna Kollmeier

Juna Kollmeier's Universe

Once upon a time, about 300,000 years after the Big Bang, the universe was so hot that electrons and protons could not bond into atoms. The opaque particle soup made photons, those little packets of light, scatter in all directions. When the universe cooled to about 4900°F (3000 K), electrons and protons combined to form hydrogen, and the universe cleared up. The photons that were emitted during this "recombination" are a relic from that era and make up a uniform background radiation that is detected today. Combining cosmological modeling, theory, and observation, the newest staff member at the Observatories, Juna Kollmeier, focuses on how galaxies and black holes in the present universe came from the fluctuations of that early time.

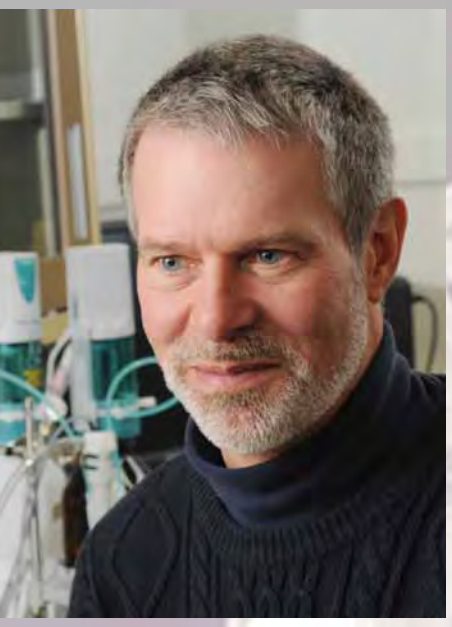
Kollmeier attacks the problem from three angles. First, she studies the intergalactic medium—the material that resides in the vast spaces between galaxies, where most of the baryons in the universe are found. Baryons are the heavy particles, such as protons and neutrons, that are the building blocks of stars and galaxies.

Second, for a closer look at galaxies, Kollmeier uses our own Milky Way. As part of this investigation, she examines how some superfast stars are ejected from the supermassive black hole at our galaxy's center. These stars are propelled at such high speeds they can even escape the galaxy. Kollmeier uses them to probe the properties of the Milky Way's dark matter halo and the galactic center to tell us about how the galaxy formed, and to test structure-formation models.

Finally, Kollmeier looks more directly at other supermassive black holes at galactic centers. These are the most powerful objects in the universe, where matter and even light cannot escape. These black holes are believed to be fundamental to galaxy evolution. She looks at how they grow, the distribution of their fundamental properties, and how they interact with their surrounding environment.

Kollmeier received her B.S. in physics with honors from the California Institute of Technology and her M.S. and Ph.D. in astronomy from Ohio State University. She was a Carnegie-Princeton Hubble Fellow at the Observatories before being appointed a staff member. □

MINERAL EVOLUTION ROCKS WORLD



EVOLUTION ISN'T JUST FOR LIVING ORGANISMS. A group of scientists led by Carnegie's Robert Hazen have determined that the mineral kingdom coevolved with life, and that up to two-thirds of the more than 4,000 known types of minerals on Earth can be directly or indirectly linked to biological activity. The finding not only reframes thinking about the mineral kingdom but also could aid scientists in the search for life on other planets.

The idea for the study arose from a simple question at a Christmas party: Were there clay minerals in the Earth's earliest eons? After a year of pondering the question and consulting colleagues, Hazen drafted a paper, "Mineral Evolution," which was published this fall in the *American Mineralogist*. It immediately attracted attention in the scientific and popular media. Both *Science* and *Nature* published commentaries. *Science News* named it one of 2008's top science stories. Even the venerable *Economist* magazine weighed in on the subject, as did other news publications around the globe.

In the paper, Robert Hazen and Dominic Papineau of Carnegie's Geophysical Laboratory, with six colleagues, reviewed the physical, chemical, and biological processes that began with about a dozen different primordial minerals in ancient interstellar dust grains and that over time have produced the thousands of mineral species on the present-day Earth. (A mineral species, unlike a biological species, is defined by its characteristic chemical makeup and crystal structure.)

"It's a different way of looking at minerals from more traditional approaches," said Hazen. "Mineral evolution is obviously different from Darwinian evolution—minerals don't mutate, reproduce, or compete like living organisms. But we found both the variety and relative abundances of minerals have changed dramatically over more than 4.5 billion years of Earth's history."

All the chemical elements were present from the start in the Solar System's primordial dust, but they formed comparatively few minerals. Only after large bodies such as the Sun and the planets congealed did there exist the extremes of temperature and pressure required to forge a large diversity of mineral species. Many elements were also too dispersed in the original dust clouds to be able to solidify into mineral crystals.

As the Solar System took shape through gravitational clumping of small, undifferentiated bodies—fragments of which are found today in the form of meteorites—about 60 different minerals made their appearance. Larger, planet-sized bodies, especially those with volcanic activity and bearing significant amounts of water, could have given rise to several hundred new mineral species. Mars and Venus, which Hazen and coworkers estimate to have at least 500 different mineral species in their surface rocks, appear to have reached this stage in their mineral evolution.

However, only on Earth—at least in our Solar System—did mineral evolution progress to the next stages. A key factor was the churning of the planet's interior by plate tectonics, the process that drives the slow shifting of continents and ocean basins over geological time. Unique to Earth, plate tectonics created new kinds of physical and chemical environments where minerals could form, and thereby boosted mineral diversity to more than a thousand types.

Above: Geophysical Lab's Bob Hazen Image courtesy Bob Hazen

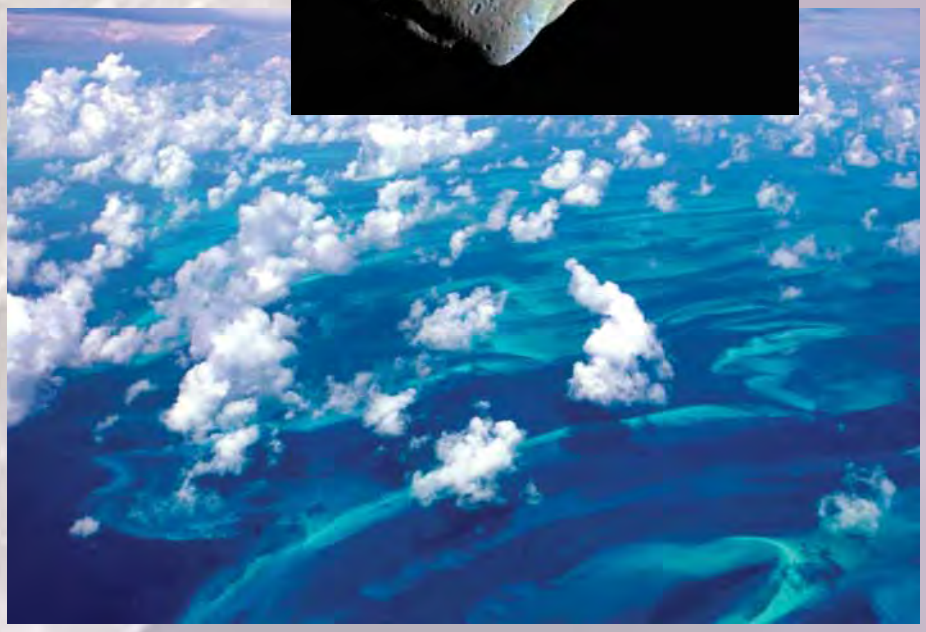
What ultimately had the biggest impact on mineral evolution, however, was the origin of life, approximately 4 billion years ago. "Of the approximately 4,300 known mineral species on Earth, perhaps two-thirds of them are biologically mediated," said Hazen. "This is principally a consequence of our oxygen-rich atmosphere, which is a product of photosynthesis by microscopic algae." Many important minerals are oxidized weathering products, including ores of iron, copper, and many other metals.

Microorganisms and plants also accelerated the production of diverse clay minerals. In the oceans, the evolution of organisms with shells and mineralized skeletons generated thick, layered deposits of minerals such as calcite, which would be rare on a lifeless planet. "For at least 2.5 billion years, and possibly since the emergence of life, Earth's mineralogy has evolved in parallel with biology," continued Hazen. "One implication of this finding is that remote observations of the mineralogy of other moons and planets may provide crucial evidence for biological influences beyond Earth."

Stanford University geologist and Carnegie trustee Gary Ernst called the study "breathtaking," saying that "the unique perspective presented in this paper may revolutionize the way Earth scientists regard minerals." □

Minerals evolve? Mineral species, such as the quartz crystals shown here, are defined by their chemical makeup and crystal structure. Over the history of the Earth and the Solar System, conditions have changed to create an ever-increasing diversity of minerals.
Image courtesy USDA

The Solar System's primordial dust formed just a handful of minerals, but gravitational clumping and melting of small planetary bodies (such as the asteroid 951 Gaspra, shown here) produced rocky mantles and metallic cores—and about 250 different minerals.
Image courtesy NASA/JPL/USGS



The advent of life on Earth had a tremendous impact on mineral evolution. Photosynthesis created an oxygen-rich atmosphere, leading to abundant oxide minerals. In the seas, skeletonized organisms produced abundant carbonate minerals, epitomized by the white sands in the Bahamas shown here.
Image courtesy NOAA/AOML/Hurricane Research Division

Coral Reefs Need Deep CO_2 Cutbacks


Long Cao

How much carbon dioxide is too much? According to the United Nations Framework Convention on Climate Change (UNFCCC), greenhouse gases in the atmosphere need to be stabilized at levels low enough to "prevent dangerous anthropogenic interference with the climate system." But scientists have come to realize that a danger even more acute than climate change is lurking in the world's oceans—one likely to be triggered by CO_2 levels that are modest by climate standards.

Ocean acidification could devastate coral reefs and other marine ecosystems even if atmospheric carbon dioxide stabilizes at 450 parts per million (ppm), a level well below that of many climate change forecasts, report Long Cao and Ken Caldeira of the Department of Global Ecology.

The researchers' conclusions, published in the journal *Geophysical Research Letters*, are based on computer simulations of ocean chemistry stabilized at atmospheric CO_2 levels ranging from 280 ppm (preindustrial levels) to 2000 ppm. Present levels are 380 ppm, but are rapidly rising because of accelerating emissions from human activities, caused primarily by the burning of fossil fuels.

The study was prompted by a question during Caldeira's testimony before the House Subcommittee on Fisheries, Wildlife, and Oceans in April of 2007. Asked what stabilization level would be needed to preserve the marine environment, Caldeira had to answer that no such study had yet addressed that question. Cao and Caldeira's study helps fill the gap.

Atmospheric CO_2 absorbed by the oceans' surface water produces carbonic acid, the same acid that gives soft drinks their fizz. This makes certain carbonate minerals dissolve more readily in seawater, especially aragonite, the mineral used by corals and many other marine organisms to grow their skeletons. For corals to be able to build reefs, which requires rapid growth and strong skeletons, the surrounding water needs to be highly supersaturated with aragonite.

"Before the Industrial Revolution, over 98% of warm-water coral reefs were surrounded by open ocean waters at least 3.5 times supersaturated with aragonite," said Cao. "But even if atmospheric CO_2 stabilizes at the current level of 380 ppm, fewer than half of existing coral reefs will remain surrounded by such an environment. If the levels stabilize at 450 ppm, fewer than 10% of reefs would be in waters with the kind of chemistry that has sustained coral reefs in the past."

For the ecologically productive cold waters near the poles, the prospects are equally grim, Cao said. "At atmospheric CO_2 levels as low as 450 ppm, large parts of the Southern Ocean, the Arctic Ocean, and the North Pacific would experience a rise in acidity that would violate U.S. Environmental Protection Agency water quality standards." Under those conditions the shells of many marine organisms would dissolve, including the shells of those at the base of the food chain.

"If current trends in CO_2 emissions continue unabated, in the next few decades we will produce chemical conditions in the oceans that have not been seen for tens of millions of years," said Caldeira. "We are doing something very profound to our oceans. Ecosystems like coral reefs that have been around for many millions of years just won't be able to cope with the change."

"When you go to the seashore, the oceans seem huge," he added. "It's hard to imagine we could wreck it all. But if we want our children to enjoy a healthy ocean, we need to start cutting carbon emissions now." □

As surface waters become more acidic from atmospheric carbon dioxide, coral reefs such as this one in Micronesia could be devastated. Emissions reductions needed to prevent acidification may be even more than those called for to stabilize climate.
Image courtesy NOAA

Life after Carnegie:

ALUMNUS DAVID KINGSBURY

Although most Carnegie trainees spend their careers in research labs, others take more varied paths. In the late 1960s a young visiting scientist, David Kingsbury, worked in the biophysics section at the Department of Terrestrial Magnetism (DTM), with a group of DTM scientists who pursued highly original genetics work. Under the leadership of section chairman Dean Cowie, Kingsbury worked with the legendary Roy Britten and his team using Cot analysis. Cot analysis is a biochemical method to ferret out repetitive sequences of DNA. It was developed by Britten, who, with his team, discovered that not all DNA codes for genes. The group showed that most DNA in a typical genome is in fact made up of repetitive, noncoding elements.

Carnegie alumnus David Kingsbury recently retired as chief program officer for the science program at the Gordon and Betty Moore Foundation.

Image courtesy David Kingsbury

Kingsbury worked on microbial relationships and genome size estimates based on Cot analysis and looks back on Carnegie as "about as idyllic as any place I have ever worked." After his stint at Carnegie he went to UC San Diego to finish his graduate work, which had been interrupted by three years in the navy, and later joined the faculty at UC Irvine, eventually reaching the rank of professor at UC Berkeley.

But the journey didn't stop there. In the middle 1980s Kingsbury was assistant director of the National Science Foundation and chaired two White House committees on biotechnology policy and regulation. In the 1990s he served on the faculties of George Washington University and the Johns Hopkins University School of Medicine. He then moved to industry as an executive at Chiron Corporation and ValiGene, a French genomics company. Later he became the CEO of a biotechnology consulting firm and finally joined the Gordon and Betty Moore Foundation as chief program officer for the science program, where he has recently retired.

While at Moore, Kingsbury and Carnegie reconnected. As chief program officer for the science program he has been in an important decision-making position for several major grants awarded to the Department of Global Ecology. "David Kingsbury's career, with its unique blend of research, business, and philanthropy, is one that Andrew Carnegie would have truly admired," remarked Carnegie president Richard Meserve. "His decades of service have benefited countless members of the scientific community." □

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

It's Official: Wolf Frommer to Direct Plant Biology

Plant physiologist Wolf B. Frommer has been selected to lead the Carnegie's Department of Plant Biology. He has been acting director of the department since 2007 and a staff member there since 2003.

Before coming to Carnegie, Frommer was a full professor and Chair of Plant Physiology at the Eberhard-Karls-Universität Tübingen in Germany. There he led a group of 80 from 1996 to 2003. From 1997 to 2001 he was also co-founder and director of the Center of Plant Molecular Biology in Tübingen, where he oversaw 150 employees. In the past two years, as Vice President of the Joint Bioenergy Institute in Emeryville, CA, he helped build up the Feedstocks Division.

"Wolf is exceptionally qualified to lead Plant Biology," commented Carnegie president Richard Meserve. "His unique, interdisciplinary approach and vision for plant science, plus his leadership skills, will take the department to a new level. We could not be more pleased."

Frommer is well known for work in which he identified the first sucrose, amino acid and ammonium transporters from plants, as well as the development of FRET metabolite sensors that allow his group to measure sugar and amino acid changes in real time. This work helps to understand how plants distribute energy from leaves, the sites of photosynthesis, to roots and seeds.

Frommer has published 200 papers and has 26 patents and patent applications. He received the highest honor awarded in German research, the Gottfried-Wilhelm-Leibniz Award from Deutsche Forschungsgesellschaft in 1998, and in 2001 he received the Körber Award for European Science. Frommer is a Fellow of the American Association for the Advancement of Science. □

Diamonds like these grown in the laboratory using a chemical vapor deposition process can be treated by a new low-pressure/high-temperature method to improve their color and optical clarity.
Image courtesy Chih-Shiue Yan

New Process Promises Bigger, Better Diamond Crystals

Geophysical Laboratory's Yufei Meng
Image courtesy Yufei Meng

Researchers at Carnegie's Geophysical Laboratory have developed a new technique for improving the properties of diamonds. The process not only adds sparkle to gemstones, but also could simplify the process of making high-quality diamond for scalpel blades, electronic components, and other applications. The results were published in the October 27-31 online edition of the *Proceedings of the National Academies of Sciences USA*.

Yufei Meng, Chih-Shiue Yan, Joseph Lai, Szczesny Krasnicki, Haiyun Shu, Thomas Yu, Qi Liang, Ho-kwang Mao, and Russell Hemley grew diamonds for their experiments using a method called chemical vapor deposition (CVD). Unlike other methods, which mimic the high pressures deep within the Earth where natural diamonds form, the CVD method produces single-crystal diamonds at low pressure. The team then annealed the diamonds at temperatures up to 2000°C using a microwave plasma at pressures below atmospheric pressure. The crystals, which can be yellow-brown if produced at very high growth rates, turned colorless or light pink.

"This low-pressure/high-temperature annealing enhances the optical properties of this rapidly grown CVD single crystal diamond," said Meng. "We see a significant decrease in the amount of light absorbed across the spectrum from ultraviolet to visible and infrared. We were also able to determine that the decrease arises from the changes in defect structure associated with hydrogen atoms incorporated in the crystal lattice during CVD growth."

"The most exciting aspect of this new annealing process is the unlimited size of the crystals that can be treated. The breakthrough will allow us to push to kilocarat diamonds of high optical quality," said coauthor Ho-kwang (Dave) Mao. Because the method does not require a high-pressure press, it promises faster processing of diamonds and more types of diamonds that can be decolored than current high-pressure annealing methods. There is also no restriction on the size of crystals or the number of crystals because the method is not limited by the chamber size of a high-pressure press. The microwave unit is also significantly less expensive than a large high-pressure apparatus.

The high-quality, single-crystal diamond made possible by the new process has a wide variety of applications in science and technology, such as the use of diamond crystals as anvils in high-pressure research and in optical applications that take advantage of diamond's exceptional transparency. Among the more exotic future applications is quantum computing, which could use the diamonds' defect structure for storing quantum information. □

Predoctoral student Joseph Lai has already put CVD diamond technology to good use. He grew a 3-carat diamond with an embedded message for his girlfriend (now his wife) on Valentine's Day 2006. The rosy pink color is a result of high-temperature annealing.
Image courtesy Chih-Shiue Yan

In Brief

❶ Steve Fodor

❷ Sandy Faber

❸ Sharon Bassin

Former Carnegie president and current trustee Maxine Singer met Pope Benedict XVI at the Nov. 2008 meeting of the Pontifical Academy of Sciences, where participants discussed evolution.
Image courtesy the Vatican

Trustees and Administration

❶ Trustee **Stephen Fodor**, founder, chairman, and chief executive officer of Affymetrix Inc., was elected a member of the National Academy of Engineering in Feb., "for pioneering and commercialization of very-high-density DNA arrays, enabling massively parallel genomics."

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❷ Trustee **Sandra Faber** presented a lecture at the Smithsonian on Feb. 26, "The Milky Way: Why We Need Her and How She Was Formed," where she discussed the Milky Way's formation, recent discoveries, and why it is an important "cosmic step" to life. Faber was also chosen to receive the 2009 Bower Award and Prize for Achievement in Science from the Franklin Institute in Philadelphia for "extraordinary advances in our knowledge of the properties of distant galaxies, dark matter, large-scale structure of the universe, and black holes in galactic nuclei; and for innovative leadership in the development of astronomical facilities."

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Carnegie president **Richard A. Meserve** attended the Council and Trust of the American Academy of Arts and Sciences meeting and moderated a Stated Meeting on the nuclear future on Oct. 10-12 in Cambridge, MA. On Oct. 15 he attended a workshop in Chicago on advanced nuclear power sponsored by the National Commission on Energy Policy and gave the opening remarks for the Norwegian Science Week/Transatlantic Forum conference, held at headquarters Oct. 21-22. Meserve chaired a meeting of the IAEA's International Nuclear Safety Group Nov. 4-6 in Vienna, Austria, and provided opening remarks at a seminar on science and technology in the new administration sponsored by the Center for the Study of the Presidency and the Congress on Nov. 18. He chaired a meeting of the National Academies' Nuclear and Radiation Studies Board Dec. 4-5 and attended a board meeting of Carnegie of Canada Dec. 8. Meserve served as moderator of a session on global nuclear safety convened by the Center for Strategic and International Studies on Dec. 9 and then spoke about energy issues at a forum sponsored by the MIT Club of Washington. He participated in the external advisory panel to the MIT Nuclear Fuel Cycle Study on Jan. 14.

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❸ **Sharon Bassin**, former assistant to Carnegie president Richard Meserve, is now assistant to the new president of the Howard Hughes Medical Institute, biochemist Robert Tjian. Bassin worked in the Carnegie administration for nearly 20 years.

Richard Meserve (right) receives the 2008 Philip Hauge Abelson Prize from AAAS CEO Alan Leshner.
Image courtesy AAAS

President Richard Meserve Receives ABELSON PRIZE

The American Association for the Advancement of Science awarded Richard A. Meserve, president of the Carnegie Institution, the 2008 Philip Hauge Abelson Prize at its annual meeting in Chicago for "advancing and promoting the use of science in the service of the public interest and for his exceptional contributions to the scientific community, to policymakers and to the general public, both in the U. S. and abroad."

The prize was established in 1985 and is named for former Carnegie scientist and president the late Philip Abelson. The AAAS noted that, with a background that includes both a law degree from Harvard and a Ph.D. in applied physics from Stanford, Dr. Meserve throughout his career has sought "to bring the practice of law to the aid of the scientific community and the public." Meserve was recognized for decades of service beginning with his role as legal counsel to the President's science adviser (1977-81), and continuing with his legal practice with Covington & Burling (1981-99), his service as Chairman of the Nuclear Regulatory Commission (NRC) (1999-2003), and as president of the Carnegie Institution (2003-present). The AAAS noted that while at the NRC, Meserve "oversaw the revitalization of an agency that had been in decline, working to ensure a sound scientific basis for its actions." At Carnegie, he has been seen as "a tireless advocate for the institution's cutting-edge research and outreach activities."

The AAAS observed that Meserve has "found time to serve on, and in several cases to lead, a truly extraordinary number of panels, committees, and advisory groups," noting that he was awarded a gold medal for service on the Secretary of Energy's Advisory Board, and that he currently serves as Chairman of the International Nuclear Safety Group, chartered by the International Atomic Energy Agency (IAEA).Meserve currently is a member of the Board of Overseers of Harvard University and is a Fellow of the AAAS, the American Academy of Arts and Sciences (where he serves on the Council and Trust), the Phi Beta Kappa Society, and the American Physical Society, and he is a member of the National Academy of Engineering, the American Philosophical Society, and the National Commission on Energy Policy. Past recipients of the Abelson Prize include former Carnegie president and current trustee Maxine Singer and Carnegie senior trustee Frank Press. □

AWASH IN *Awards & Honors*

This fall and winter was a blockbuster season for recognizing Carnegie scientists. In October the Mineralogical Society of America announced that Robert Hazen would receive the 2009 Distinguished Public Service Medal. Hazen researches the possible roles of minerals in the origin of life and is author of more than 300 articles and 19 books on science, history, and music. Carnegie's Chris Field and Doug Koshland were elected AAAS Fellows in December. Field is director of Carnegie's Department of Global Ecology, and Douglas E. Koshland is staff scientist at the Department of Embryology. At the AGU Fall Meeting DTM's Rick Carlson received the Bowen Award, given annually for "outstanding contributions to volcanology, geochemistry, or petrology," and presented the Bowen Lecture.

The new year brought in a new crop of honors. In January, George Preston of the Carnegie Observatories was selected by the American Astronomical Society to be the 2009 recipient of its highest distinction, the Henry Norris Russell Lectureship. Also in January, the International Association for the Advancement of High Pressure Science and Technology awarded Russell Hemley, director of the Geophysical Laboratory, the 2009 Bridgman Award. Plant Biology's Arthur Grossman was awarded the 2009 Gilbert Morgan Smith Medal by the National Academy of Sciences the same month, "in recognition of excellence in published research on marine or freshwater algae." At neighboring Global Ecology, Joe Berry finished up the month by being elected a 2009 Fellow of the American Geophysical Union. Only 0.1% of the members are elected annually.

February continued the trend. Carnegie president Richard Meserve received the AAAS 2008 Philip Hauge Abelson Prize and Doug Koshland at Embryololgy was elected one of 72 Fellows by the American Academy of Microbiology. And the Society for Developmental Biology announced that Don Brown, also at Embryology, would receive their 2009 Lifetime Achievement Award. □

❹ Yixian Zheng

❺ Bjørn Mysen

❻ Marilyn Fogel

Embryology

Allan Spradling attended the Cold Spring Harbor Germ Cell Symposium in Oct. and participated in the 98th International Titisee Conference on Differentiation, Reprogramming, and Regeneration held in Titisee, Germany. He also participated in the colloquium for the inauguration of the new Genetics and Developmental Biology building of the Institut Curie in Paris. He spoke at the Biochemistry and Molecular Biology Stem Cell and Regeneration Symposium at the Mayo Clinic in Rochester, MN.

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Joe Gall presented the Keith R. Porter Lecture at the 2008 American Society for Cell Biology meeting in Dec. This lecture is delivered each year by an eminent cell biologist.

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Donald Brown attended the 12th International *Xenopus* Conference in Leiwen/Trier, Germany, and lectured at the Humboldt and Free U. of Berlin as part of an international seminar series, "Highlights in Molecular Endocrinology."

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Douglas E. Koshland presented a lecture at U. Virginia, Charlottesville.

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Marnie Halpern gave a seminar at U. Texas Southwestern Medical Center and gave the keynote address at the Developmental Biology Symposium at U. North Carolina in Nov.

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❹ **Yixian Zheng** and lab members attended the 2008 ASCB meeting in Dec. and presented posters.

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Steve Farber cochaired a session at the International Zebrafish meeting and spoke at the Molecular Cell Biology Gordon Conference in the "Cell to Tissues" session in June. He presented lectures at the NIH Unit of Vertebrate Organogenesis and at U. Pittsburgh. He also gave a symposium talk at the Chilean Cell Biology Symposium and was an invited speaker at the Argentine Society of Biochemistry and Molecular Biology lipid symposium. In July his BioEYES program was the subject of an article in the *New York Times*.

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In Oct. **Alex Bortvin** and lab members attended the Cold Spring Harbor Germ Cell Symposium, where Bortvin gave a talk. He also spoke at the National Institute of Diabetes and Digestive and Kidney Diseases of the NIH.

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David MacPherson gave talks at U. Toronto and at the Dept. of Cell Biology of The Johns Hopkins Medical Institutions.

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Spradling lab postdoc **Todd Nystul** gave a talk at the 2008 ASCB meeting and postdoc **Don Fox** presented a poster there.

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Bortvin lab member **Godfried Van der Heijden** was named a Hollaender Postdoctoral Fellow.

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Graduate student **Lori Orosco** in the Halpern lab received a three-year fellowship from the Society for Neuroscience in its Neuroscience Scholars Program.

Geophysical Laboratory

GL director **Rus Hemley** gave the invited Kohler Lecture, "Windows on a New Chemistry under Pressure," at UC-Riverside Nov. 5.

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Doug Rumble presented a paper on Hadean triple oxygen isotope fractionation at the 4th International Symposium on Isotopomers in Tokyo in Oct. He then traveled to the Institute for the Study of the Earth's Interior of Okayama U. in Misasa, Japan, to present lectures on oxygen isotopes in cosmochemistry and geochemistry. Rumble hosted a specialists' meeting at GL in Nov. to discuss plans for a new generation of high-resolution mass spectrometers for stable isotope geo- and cosmochemistry. He also gave an invited lecture at Louisiana State U. in Nov. hosted by Huiming Bao, a former GL predoctoral fellow. In Dec. Rumble hosted visiting investigator E. Thomassot of McGill U., who analyzed oxygen isotopes in Earth's oldest rocks, dated at 4.3 billion years old by Rick Carlson and colleagues at DTM. Rumble attended the AGU meeting in San Francisco and presented a talk on measuring triple oxygen isotopes as biomarkers in Archean and Hadean rocks.

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❺ **Bjørn Mysen** gave invited lectures at U. Tokyo on Oct. 24; at Tohoku U., Sendai, Japan, on Oct. 27; "Properties and Structure of Natural Magmatic Liquids: What Do We Know and What Do We Not Know?" and "Crystals, Melts, and Glass: Similarities and Differences," at Seoul National U. on Oct. 29. In Nov. he spoke on "Water in the Deep Earth: Tracing the Recycling Process" and "How Melt Structure Governs Mineral/Melt Element Partitioning" at the Institute for Study of the Earth's Interior, Okayama U., Japan.

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❻ **Marilyn Fogel** visited Memorial U. in St. John's, Newfoundland, to continue working on a Carnegie of Canada-funded project with former postdoctoral fellow Sue Ziegler, who has a Canada Research Chair in Environmental Science. She also visited former postdoctoral fellow Penny Morrill, now an assistant professor in the Earth Sciences.

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❼ Maneeshika Madduri


❽ Wendy Freedman


❾ Steve Shectman


❿ Michael Rauch


⓫ Luis Ho

Themes related to mineral evolution, origins of life, and complex evolving systems were the topics presented by **Bob Hazen** at Case Western Reserve U., George Mason U., Duke U., and the AGU annual meeting in San Francisco.

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Theorist **Ronald Cohen** lectured at the 14th Total Energy Workshop at the International Center for Theoretical Physics in Trieste on Jan. 9; at the Ludwig Maximilians Universität München in Munich on Jan. 12; and at the Bayerisches Geoinstitut in Bayreuth on Jan. 14. He also presented two invited talks at the AGU meeting in San Francisco in Dec.

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Peter Liermann left HPCAT Feb. 1 to become lead beamline scientist for the Extreme Condition Beamline at PETRA III.

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Visiting researchers **Caroline Jonsson**, **Christopher Jonsson**, and **Dimitri Sverjensky**, with **Bob Hazen**, organized a poster session called "Interpretation of Spectroscopic Studies of Organic Species at the Mineral-Water Interface" in which they presented their work at the AGU Dec. meeting in San Francisco. The session was part of the section "Volcanology, Geochemistry, and Petrology," where undergraduate students **Charlene Estrada** and **Ellen Crapster-Pregont** presented posters of their work conducted during the their internships last summer on amino acid adsorption on mineral surfaces.

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Postdoctoral fellow **Jim Cleaves** gave an invited talk, "What Can Mineral/Organic Interactions Tell Us about the Origins of Life?" at the European Science Foundation's COST workshop on systems chemistry held in Acquafredda di Maratea, Italy, Oct. 3-8.

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Postdoctoral fellow **Anat Shahar** presented a talk, "Experimental Evidence for Iron and Silicon Isotope Fractionation during Earth's Core Formation," at the fall AGU meeting in San Francisco.

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❼ Geophysical Laboratory high school summer interns **Maneeshika Madduri** (Thomas Jefferson High School) and **Benjamin Shih** (Montgomery Blair High School) have been named semifinalists in the 2009 Intel Science Talent Search competition. Maneeshika's project was on hydrogen complexation studies in crown ethers, and Benjamin's project was on H_2O and CO_2 compounds. Maneeshika was also a semifinalist in the 2008 Siemens Competition for Math, Science, and Technology.

Global Ecology

Department director **Chris Field** spoke on bioenergy and bioconversion at the 5th annual Global Climate and Energy Project (GCEP) Research Symposium at Stanford U. on Oct. 1-3. He also chaired a session on biofuels and bioenergy conversion, during which **Scott Loarie** spoke on biomass energy.

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Joe Berry spent a week in Sydney, Australia, with a group of colleagues studying stomata in leaves.

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In Nov. **Ken Caldiera** submitted testimony to the British Parliament on global climate and geoengineering.

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Greg Asner spoke about the loss and recovery of tropical forests at a symposium sponsored by the Smithsonian Institution in Washington. **Asner** and **Robin Martin** completed the second Spectranomics field campaign through the Wet Tropics World Heritage Area and Cape York in northern Queensland, Australia. These rain forests have 25- to 45-meter-tall trees representing the greater New Guinea/Oceania ecoregion.

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Field lab's **Luis Fernandez** completed a three-week trip to Peru as technical director of an EPA/Argonne National Laboratory project under partnership with UNEP to study mercury cycling through Amazonian watersheds. **Kimberly Nicholas Cahill**, also of the lab, defended her dissertation and fulfilled her requirements for a doctorate degree in Dec.

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Arrivals: The Caldeira lab welcomed postdocs **Steve Davis** on Oct. 1 and **Kenny Schneider** on Nov. 7. New members of the Asner lab are postdoc **Shaun Levick** from South Africa, who arrived Sept. 24; lab technicians **Mona Houcheime**, hired Oct. 15; **Christina Contreras**, who arrived Nov. 8; and **Jessica Hunt**, who arrived Dec. 12. **Guayana Paez-Acosta** joined as project coordinator Dec. 1.

Observatories

The 62nd General Assembly of the United Nations designated 2009 as the International Year of Astronomy, commemorating the 400th anniversary of Galileo's telescope and Kepler's publication of *Astronomia Nova*.

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Former director of the Observatories **Maarten Schmidt** (1978-80), now at Caltech, shares the 2008 Kavli Prize for Astrophysics for work that "underpins our understanding of quasars."

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Carnegie-Princeton/Hubble Fellow **Jenny E. Greene** received the 2008 Annie Jump Cannon Prize awarded by the American Astronomical Society. She gave her prize lecture, "Building Black Holes and Bulges," at the 213th AAS meeting in Long Beach, CA.

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❽ Director **Wendy Freedman** was invited to give the inaugural Brinson Lecture at the Dept. of Astronomy and Astrophysics at U. Chicago. Her lecture, "Astronomy in the New Millennium: New Windows on the Cosmos," was presented on Oct. 2. On Oct. 20-21 she participated in the KICP External Advisory Board Meeting at U. Chicago. She was invited to visit the Institute of Space Sciences in Barcelona Oct. 25-Nov. 1, where she gave talks on dark energy, the Hubble constant, and the Giant Magellan Telescope. She was also invited to the Harvard symposium to honor the 100th anniversary of Henrietta Leavitt's Cepheid Period Luminosity Relation. On Nov. 10 she hosted a dinner to celebrate the premiere of Todd and Robin Mason's film "The Journey to Palomar," and on Nov. 12 she was an invited keynote speaker at the 60-inch Centennial Event at Mt. Wilson Observatory.

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Director Emeritus **George Preston** delivered a lecture, "A Few Binary Puzzles for Roberto on the Occasion of His Birthday," at a workshop Sept. 25-28 in Turin, Italy, to honor Italian astrophysicist Roberto Gallino.

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❾ In Oct. **Stephen Shectman** traveled to Beijing, where he was an honoree at the conference "New Vision 400: Engaging Big Questions in Astronomy and Cosmology Four Hundred Years after the Invention of the Telescope." He then attended the dedication of the LAMOST telescope at Xinglong Station, near Beijing, and presented a talk on the Giant Magellan Telescope at the Nanjing Institute for Astronomical Optics and Technology.

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❿ **Michael Rauch** gave a talk on ultradeep galaxy surveys at the workshop "Understanding Lyman Alpha Emitters" held Oct. 6-10 at the Max Planck Institute for Astronomy in Heidelberg.

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⓫ **Luis Ho** gave invited lectures at the 3rd Workshop on Cosmology and Structure Formation at the Korean Institute of Advance Studies in Oct. and at the Workshop on Accretion Disks at the Kavli Institute for Astronomy and Astrophysics at Peking U. He also gave presentations on the Giant Magellan Telescope for the Chinese Academy of Sciences and the National Astronomical Observatories in Beijing.

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The newest staff member, **Juna Kollmeier**, gave a colloquium at Columbia U. and coorganized a three-month KITP program titled "Building the Milky Way." Over 60 astronomers gathered to discuss the formation and evolution of the Milky Way. Part of this program was a conference, "Back to the Galaxy II," that had over 100 participants.

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This years' participants in the annual visit to the Las Campanas Observatories include (left to right) Robert Shelton, Adrian Shelton, Miguel Roth, Wendy Freedman, Mark Phillips, Warrick Couch, Richard Meserve, Martin Cole, Jeremy Bloxham, Charles Munnerlyn, Judy Munnerlyn, Juan Sanchez, and Arnie Phifer. Image courtesy Martin Cole

MORE THAN 400 PEOPLE ATTENDED THE OBSERVATORIES' 7TH ANNUAL OPEN HOUSE on Nov. 16 and enjoyed exhibits, films, and fun activities. A highlight was the selection of three local elementary students from over 100 entrants as the winners of Carnegie's first astronomy essay and drawing contest. The USPS was also on hand with a special display commemorating the recently issued Edwin Hubble stamp. □

The above photo is a bird's-eye view of the Observatories' open house in Pasadena. The post office's Hubble stamp was on exhibit.

Images courtesy Arnie Phifer

Postdoctoral research associate **Jeff Crane** attended the "Back to the Galaxy II" conference in Santa Barbara in Sept.

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Hubble Fellow **Joshua Simon** gave a public lecture at Keck Observatory on Nov. 6, "The Dark Side of Galaxies," and a seminar at Princeton U. on Dec. 1, "Dark Matter in Dwarf Galaxies."

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UCLA graduate student **Chun Ly** worked at the Observatories this past summer with Hubble Fellow **Janice Lee**. He won an AAS Chambliss Astronomy Achievement Student Award for their work on "H-alpha Luminosity Functions and Star Formation Rate Volume Densities at z=0.8" that was a poster at the AAS Long Beach meeting in Jan.

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In Nov. NSF Fellow **Karín Menéndez-Delmestre** attended a conference titled "When the Universe Formed Stars" in Martinique and spoke on "The Luminous, the Massive, and the Dusty: Integral Field Spectroscopy of Submm Galaxies with OSIRIS."

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Carnegie Fellow **Masami Ouchi** gave an invited talk at the conference "Understanding Lyman-alpha Emitters" at the Max Planck Institute for Astronomy in Heidelberg Oct. 6-10. He was invited to Princeton and U. Chile for seminar talks on Oct. 13 and Dec. 3, respectively. He visited Keck, Subaru, and Las Campanas observatories for his observing runs.

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Spitzer Fellow **Jane Rigby** gave scientific talks at Princeton and U. Maryland on lensed galaxies and obscured active galactic nuclei. She also served on the review panel for plans to close out the cryogenic Spitzer Space Telescope mission.

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On Oct. 10 staff and postdocs from the Observatories toured Mt. Wilson's 150-foot solar tower and 100-inch Hooker telescope, and Georgia State U.'s CHARA Array. They also began observing on the 60-inch telescope and saw several interesting objects before the clouds arrived. On Oct. 14 the department hosted a surprise 90th birthday party for Don Nicholson, son of longtime Carnegie astronomer Seth Nicholson. Don has volunteered at Mt. Wilson for years, maintaining and refurbishing the telescopes and giving educational tours.

Plant Biology

Director of the department **Wolf Frommer** taught a Plant Biology seminar in Oct., "Limits to Growth: The Molecular Machinery for Carbon Allocation in Plants," and in Nov. presented "The Role of Oligomerization for the Regulation of Ammonium Transport" at Purdue U. He also chaired and organized the techonology/bioimaging session at the XX International Congress of Genetics in July in Berlin and presented a lecture at that meeting. Frommer also lectured at the Cold Spring Harbor Banbury Conference and attended the Gordon Conference: Membrane Transport Proteins in Il Ciocco, Italy, where he presented a lecture. He also presented a lecture at the DOE Radiochemistry and Imaging Workshop in Bethesda, MD.

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Winslow Briggs gave the keynote talk at the Protein Modification in Plant Development meeting held in Nov. in Lijiang, China, and presented a lecture, "Phototropin LOV Domains—Light Sensors from Bacteria to Higher Plants," at UC-Davis in Nov. He presented the same lecture at U. Maryland-College Park in Dec.

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⓬ **Matthew Evans** spoke at the Frontiers in Sexual Plant Reproduction III meeting held in Tucson in Oct. **Allison Phillips**, a postdoctoral fellow in the Evans lab, attended that meeting and presented a poster.

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David Ehrhardt presented a talk at Purdue U. in Oct. titled "A Dynamic Template: Cytoskeletal Organization of Cell Wall Deposition and Plant Cell Shape." He presented a lecture at the Castilleja School in Palo Alto, CA, and attended the American Society for Cell Biology meeting in San Francisco in Dec.

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Zhiyong Wang presented a talk at the 1st Symposium on Signal Transduction during Plant Organogenesis in Beijing. In Aug. he spoke at the 25th Mid-Atlantic Plant Molecular Biology Society Conference in Savage, MD. At Michigan State U. he gave a lecture, "Fill the Gaps in the Brassinosteroid Signaling Pathway by Proteomics." In Oct. Wang presented a talk at the Donald Danforth Plant Science Center in St. Louis and a seminar at the Monsanto Biotech Co., also in St. Louis. He spoke at The Frontiers of Plant Biology: Protein Modifications in Plant Signaling and Development Meeting held in Lijiang, China, and gave a lecture in Dec. at the Purdue U. Life Science Interdisciplinary Graduate Program.

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Eva Huala attended the iPlant Workshop: Impacts of Climate Change on Plant Productivity World-Wide held at Biosphere 2, Tucson, and presented a talk, "Tools Developed for the Model Plant: Arabidopsis and TAIR."

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Kathryn Barton attended "The Geometry and Mechanics of Growth in Biological Systems" course in Cargese, Corsica, in July and taught a two-week course on advanced plant development. She presented a lecture in Japan in Oct. at the Nara Institute of Science and Technology and presented the same lecture in Dec. at Purdue U. In Oct. she attended the 9th International Congress on Cell biology in Seoul and presented a talk, "The Regulatory Network Controlling Leaf Polarity and Meristem Formation in *Arabidopsis*."

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Wirulda Pootakham, a student in Arthur Grossman's lab, received the FEMS Young Scientist Meeting Grant (YSMG), which allowed her to attend the EMBO-FEMS Workshop on Microbial Sulfur Metabolism in Tomar, Portugal.

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Arrivals: In Oct. Wolf Frommer's lab welcomed postdoctoral research associate **Woei-Jiun Guo** (Academia Sinica, Taiwan) and laboratory technician **Saman Asgharzadeh Parsa** (UC-Davis). Postdoctoral research associate **Claudia Calanotti** (U. Siena) joined Arthur Grossman's lab in Oct. Kathy Barton's lab welcomed lab technician **Nicole Newell** in Sept. and postdoctoral research associate **Tie Liu** (Stanford U.) in Dec. In Sept. two Chinese predoctoral research associates joined Zhiyong Wang's lab: **Peng Xu** (Hebei Normal U.) and **Li Tian** (Lanzhou U.), followed in Oct. by **Yaqi Hao** (Northwest A&F U.) and **Min Yuan** (Hebei Normal U.). Two visiting professors from China joined the lab in Nov.: **Tonglin Mao** (China Agricultural U., Beijing) and **Zhiguang Zhao** (Lanzhou U.). Sue Rhee and Eva Huala's TAIR group welcomed new scientific curator **Rajkumar Sasidharan** from Yale in Nov. Lab technician **Clayton Coker** joined Matt Evans's lab in Oct.

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Departures: In June the Somerville labs completed their moves to UC-Berkeley with the departure of postdoctoral research associate **Shaolin Chen**, lab technician **Natalia Khitrov**, lab assistant **Nadejda Kleimenova**, postdoctoral research associate **Wensheng Qin**, and visiting fellow **Christian Voigt**. Chris Somerville's graduate student **Michelle Facette** graduated from Stanford and left to pursue her career in Canada. In Sept. lab technician **Antoinette Sero** left

⓬ Matt Evans

MICHAEL ACIERNO, IT/ISManager/ Systems Engineer at the Dept. of Terrestrial Magnetism, is the latest recipient of Carnegie's Service to Science Award. The award was created to recognize outstanding and/or unique contributions to science by employees who work in administrative, support, and technical positions. Acierno is recognized for his support of scientific activities over 24 years. He has developed astronomy data-processing software and programmed innovative electronic hardware that supports research in seismology, geology, and volcanology, earning him the accolade of "scientific colleague." Carnegie plans to make Service to Science awards on a semiannual basis. Any individual employed by or officially affiliated with Carnegie may nominate an eligible employee for this award. □

Above: Michael Acierno

the Frommer lab to join a biotech firm, and postdoctoral research associate **Bhavna Chaudhuri** left to start a family. Visiting researchers **Ben Backer** and **Alex Pauck** returned to Germany in Nov. **Melissa Adams**, a postdoctoral research associate in the Grossman lab, left in Sept. for a position in Boston. In Oct. postdoctoral research associate **Florence Mus** left the Grossman lab for a job at Metabolic Explorer Laboratories in France. In Aug. postdoctoral research associate **Meghan Sharp** left the Barton lab for an internship at Venture Capital Group before returning to Michigan for a business management degree. Laboratory technician **Khar-Wai Lye** left the lab for Malaysia to get married and pursue her career. **Liping Ji**, a postdoctoral research associate in the Rhee lab, left in May to return to China.

Terrestrial Magnetism

Sean Solomon chaired meetings of the MESSENGER science team in Nov. in Boulder, CO, and the NASA Advisory Council's Planetary Science Subcommittee in Jan. in Washington, DC. He delivered an invited presentation on MESSENGER's second Mercury flyby at the American Astronomical Society's Division for Planetary Sciences meeting held in Ithaca, NY, in Oct., and he organized three special sessions on MESSENGER flyby results at the Fall Meeting of the AGU held in San Francisco in Dec.

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In Sept. **Alan Boss** talked about the Solar System's origin at the Muséum National d'Histoire Naturelle in Paris. In Oct. he gave the summary talk at a Galactic Habitability Workshop at the Royal Observatory, Edinburgh. He also spoke on giant planet formation at the Royal Observatory, St. Andrews U., UK, and at U. Central Florida. Also in Oct. Boss delivered a keynote lecture on disk instability and gave a public lecture at the Star Formation Workshop at Embry-Riddle Aeronautical U., and gave a colloquium on supernovae and the solar nebula at SUNY-Stony Brook. In Nov. Boss talked about recent advances in exoplanet research at the Kepler Mission science team meeting at the NASA Ames Research Center in Moffett Field, CA.

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In Nov. **Rick Carlson** gave a series of lectures as the Hamilton Visiting Scholar in Geophysics at the Dept. of Earth Sciences of Southern Methodist U.

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John Chambers gave a talk at NASA Goddard Space Flight Center in Jan.

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Larry Nittler gave a colloquium on supernova dust at UC-Berkeley in Nov.

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⓭ In Nov. **Vera Rubin** attended a meeting on "Scientific Insights into the Evolution of the Universe and of Life" hosted by the Pontifical Academy of Sciences in Vatican City, Rome.

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Scott Sheppard gave colloquia on small Neptune Trojans at the 213th American Astronomical Society Meeting in Long Beach, CA, and at a New Horizons spacecraft science team meeting held in Boulder, CO, in Jan.

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In Sept. and Oct. **Paul Silver**, field seismologist **Steven Golden**, and colleagues carried out fieldwork in Parkfield, CA, testing a controlled "shaker source" for imaging changes in fault-zone structure and reinstalling a seismometer as part of the San Andreas Fault Observatory at Depth project. In Nov. Silver gave a talk at a meeting of the Sino-U.S. Earthquake Studies Protocol in Boulder, CO.

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Alycia Weinberger presented a poster at the first American-French Kavli Frontiers of Science Symposium in Roscoff, France, in Nov. In Jan. she gave a colloquium at the second Giant Magellan Telescope High-Resolution Spectroscopy Workshop at U. Texas-Austin.

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Postdoctoral associate **Maureen Long** gave a talk on subduction and the mantle flow field at UNC-Chapel Hill in Nov.

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Hubble Fellow **Mercedes López-Morales** gave an invited talk about planets around M dwarfs at a Society for the Advancement of Chicanos and Native Americans in Science conference in Salt Lake City in Oct. She gave an invited talk on the physical properties of hot exoplanet atmospheres at the Consejo Superior de Investigaciones Científicas in Madrid in Jan. From Nov. 2008 to Feb. 2009, López-Morales served as a visiting scientist at the Astrophysics Institute of the Canary Islands, Spain, and at U. Complutense de Madrid.

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In Jan. postdoctoral fellow **Evgenya Shkolnik** gave a video-conference talk on long-term spectroscopic monitoring of stars for the Star-Planet Interaction Workshop 2009 in Marseille, France.

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The 40th annual meeting of the Division for Planetary Sciences of the American Astronomical Society was held in Ithaca, NY, in Oct. Several DTM staff gave papers, including **Sean Solomon**, **John Chambers**, **Larry Nittler**, and **Scott Sheppard**.

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Several staff and postdoctoral fellows presented at the 2008 AGU Fall Meeting in San Francisco in Dec., including **Sean Solomon**, **Rick Carlson**, **David James**, **Alan Linde**, **Selwyn Sacks**, **Steve Shirey**, **Paul Silver**, postdoctoral fellows **Julie O'Leary**, **Liping Qin**, **Jessica Warren**, and **Wen-che Yu**, and postdoctoral associate **Maureen Long**.

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The second Years of Service recognition reception was held at DTM in Dec. Several staff members were recognized with Years of Service pins. The 10-year recipients included **Larry Nittler**, **Brian Schleigh**, and **Richard Bartholomew**; the 15-year recipients were **Sandy Keiser** and **Maceo Bacote**; the 25-year recipient was **Bill Key**; the 35-year recipient was **Terry Stahl**; and a 40-year pin went to **David James**.

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Departures: In Oct. postdoctoral fellow **Isamu Matsuyama** began a Miller Research Fellowship at UC-Berkeley, and postdoctoral fellow **Cathy Slesnick** started work as a staff member at Draper Laboratories in Boston. In Nov. postdoctoral fellow **Ann Nguyen** began working on-site as a NanoSIMS Specialist for Jacobs Engineering at the NASA Johnson Space Center in Houston. Postdoctoral associate **Maureen Long** began work as an assistant professor at Yale U. in Jan.

⓭ Vera Rubin shakes hands with Pope Benedict XVI at the Pontifical Academy of Sciences meeting in Nov.
Image courtesy the Vatican

DTM/GL

Librarian **Shaun Hardy** participated in the Geological Society of America Annual meeting held in Houston in Oct. Hardy was awarded a $9,400 grant from the Center for the History of Physics of the American Institute of Physics to preserve and enhance access to DTM's historic photographs. □

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Global Ecology's Congressional "Hat Trick"

One of the rationales behind basic research is to provide the scientific foundations for good public policy. Carnegie scientists have always done their share, but the Department of Global Ecology recently pulled off a public policy "hat trick" that is impressive even by Carnegie standards, with three scientists testifying to three separate Congressional hearings in one day.

Chris Field appeared before the Senate Committee on Environment and Public Works on updates on the latest climate-warming science.
Image courtesy Senate Committee on Environment and Public Works

On February 25, 2009, department director Chris Field appeared before the Senate Committee on Environment and Public Works to provide an update on the latest climate change science. Field, a leading member of the Nobel Prize–winning Intergovernmental Panel on Climate Change, briefed the committee on scientific findings since the panel's last report in 2007. He warned that carbon emissions are accelerating faster that any of the models anticipated, and that dangerous feedbacks in the climate system may be triggered if action is not taken soon.

That same day, Ken Caldeira testified before the House Subcommittee on Insular Affairs, Oceans, and Wildlife of the Committee on Natural Resources, in a hearing on HR860, the Coral Reef Conservation Act. This act is intended to expand protection for coral reefs. Caldeira briefed the committee on threats to reefs from global warming and ocean acidification (p. 12).

Finally, Greg Asner submitted a written statement to a congressional briefing for House representatives and staff on tropical deforestation. Asner emphasized the importance of monitoring and measuring rates of deforestation, which accounts for about 20% of global greenhouse gases released and noted that technologies for such monitoring already exist and can be implemented now.

The fact that these scientists have the ear of the nation's lawmakers concerning some of society's most urgent issues underscores not only the importance of their work, but the growing impact of Carnegie's newest department. □