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2011-2012 YEAR BOOK

Carnegie Institution
FOR SCIENCE

2011-2012







YEAR BOOK

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2011-2012 YEAR BOOK

The President's Report

July 1, 2011 - June 30, 2012

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About Carnegie

". . . to encourage, in the broadest and most liberal manner, investigation, research, and discovery, and the application of knowledge to the improvement of mankind . . ."

The Carnegie Institution was incorporated with these words in 1902 by its founder, Andrew Carnegie. Since then, the institution has remained true to its mission. At six research departments across the country, the scientific staff and a constantly changing roster of students, postdoctoral fellows, and visiting investigators tackle fundamental questions on the frontiers of biology, earth sciences, and astronomy.

Carnegie Institution

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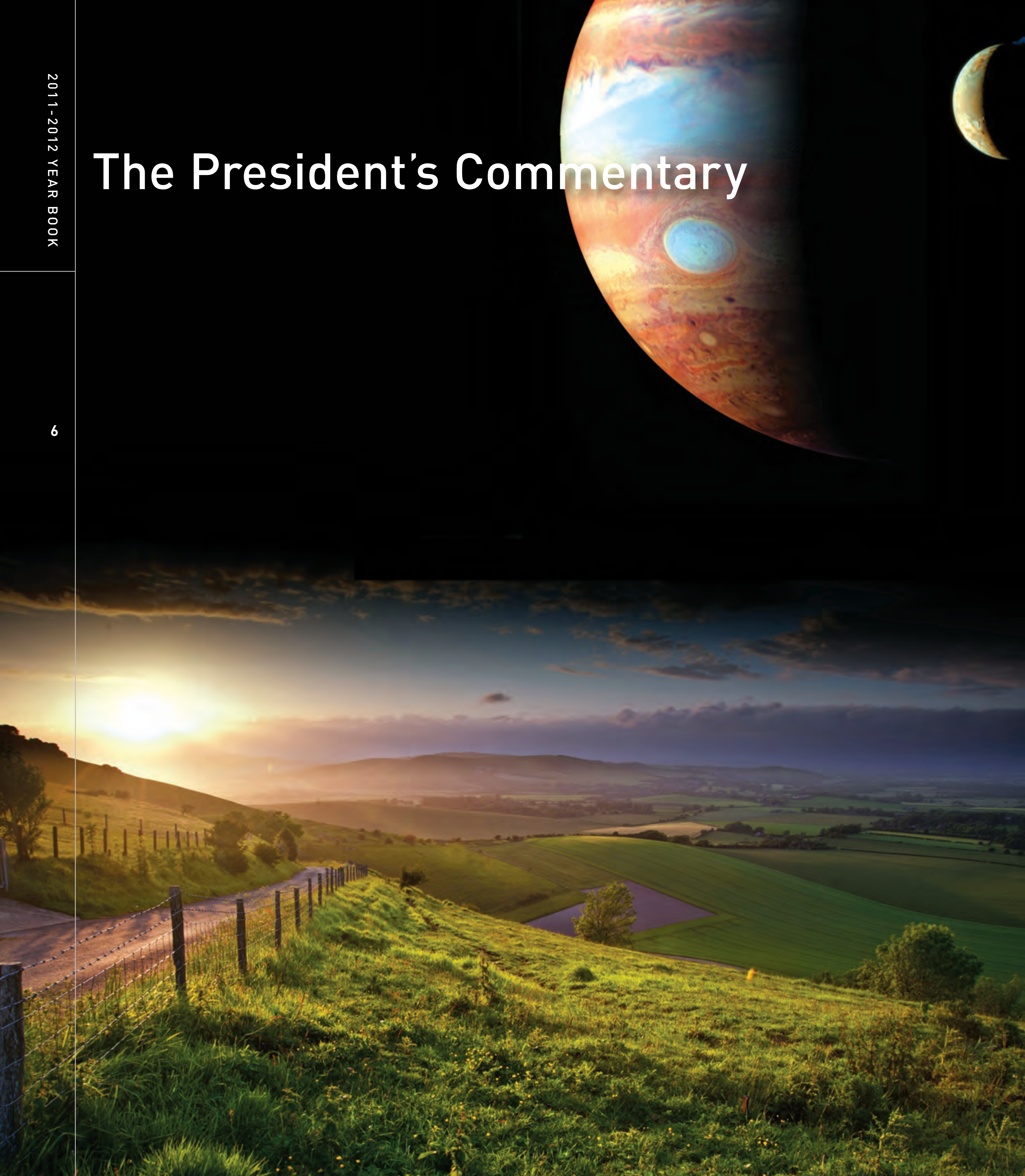
The President's Commentary



Carnegie president
Richard A. Meserve
Image courtesy Jim Johnson

We live in turbulent economic times. As I compose this text, Congress has temporarily avoided the fiscal cliff that loomed in early January but has signaled that further and even more difficult conflicts must be resolved in the coming months. Against this backdrop, we should be worried about the future trajectory of our economy. But even if these problems are successfully resolved, there is one troubling certainty: significant downward adjustments in federal funding for the discretionary part of the federal budget is inevitable for many years. Even with growing tax revenues, there is simply no way that our country's debt obligations can be met and that our entitlement programs, even with adjustments, can be funded without significant budget reductions elsewhere. Although both political parties support scientific research, powerful advocates support other parts of the federal budget. We must worry about how support for science will fare in the inevitable radical restructuring of federal spending.

A strong case can be made for the sustenance of basic science even in these troubling economic times. Numerous studies over the years have consistently shown that investments in scientific research pay off in significant ways. The groundbreaking work of Robert Solow—work that garnered him a Nobel Prize—showed that more than half of the productivity growth in the first half of the 20th century could be attributed to technological change. Subsequent studies by others have confirmed the fundamental importance of research and development (R&D) as an engine for economic advance.[1]

The fact that R&D provides a healthy return on investment does not, of course, by itself justify federal investment. A significant share of total U.S. R&D expenditures is (and should be) undertaken by the business sector—about 71% in 2009.[2] But the business sector invests far less in basic research than is socially optimal because the returns from such research are very uncertain and cannot necessarily be captured by the entity that makes the investment. Indeed, the pressure for short-term returns has meant that business-sector investment in basic research has declined over recent decades, and once vital industrial research centers, such as Bell Labs and RCA Labs, no longer focus on basic research. Industry predominantly directs its support to applied or developmental activities, which promise near-term returns that can be captured by the funder.

In light of these facts, the government has a critical role in the support of basic research for the benefit of all. In 1945 Carnegie President Vannevar Bush made exactly this argument to President Truman in the report *Science—The Endless Frontier.* This report ultimately resulted in the establishment of the National Science Foundation, launched the dramatic rise in federal support for basic

[1]See, e.g., President's Council of Advisors on Science and Technology, *Report to the President, Transformation and Opportunity: The Future of the U.S. Research Enterprise,* 3 (Washington, D.C.: Executive Office of the President, 2012), pp. 19-21; Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (Washington, D.C.: National Academies Press, 2007), pp. 41-67.

[2]National Science Board, *Science and Engineering Indicators 2012* (Washington, D.C.: National Science Foundation, 2012), Table 4-1.

research over the past 68 years, and is largely responsible for the university research enterprise that has proven to be an important source of new discoveries.

Of course, by its very nature, the returns from any specific project in basic research are difficult to predict. The whole point of basic research is the exploration of the unknown, driven by an individual scientist's curiosity and quest for knowledge. What is remarkable is that this type of "unfocused" work can open entirely new vistas for advance that could not be contemplated previously and of which even the scientist was unaware. Basic research in quantum mechanics provided the understanding on which today's microelectronics, communications, and computer businesses were built. Basic work in mathematics and computer science laid the foundations for the Internet, spawning some of the world's largest companies. And even less earth-shattering work can provide for the steady advance of products and services. Because it is sometimes impossible to determine before the fact what research will contribute in this way, the aim should be to support a wide portfolio in anticipation that astonishing and often unanticipated gains will result. For this reason alone, significant federal support for basic research should be maintained. We will regret the consequences if we starve the goose that lays the golden eggs.

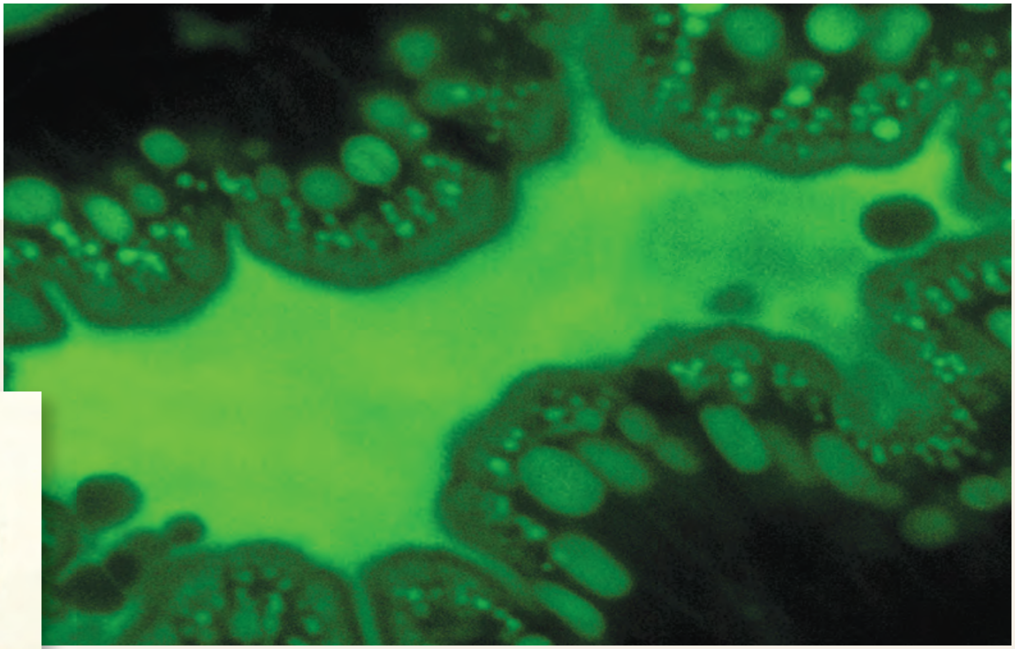


Image courtesy Steve Farber

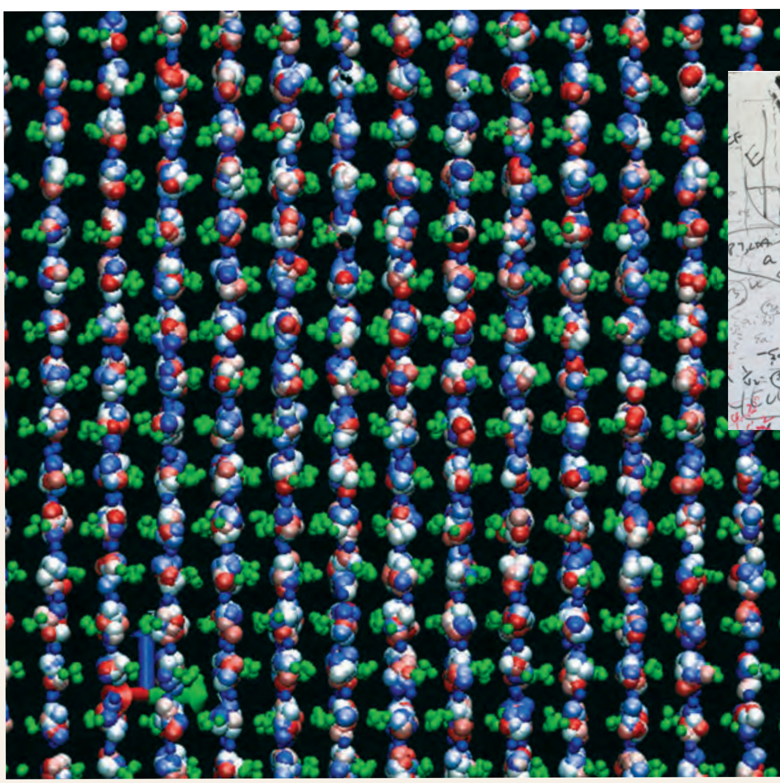
Steve Farber's lab uses young zebrafish to learn how fats and cholesterol are metabolized. Juvenile fish are entirely transparent, and the researchers can watch digestive metabolism in real time. Farber fed egg yoke to young zebrafish. The green image shows inside the fish gut; the bright green areas are the lipids.

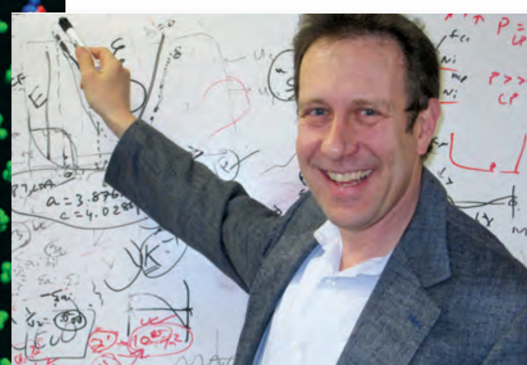
Of course, many of the benefits derived from basic science extend beyond the economic effects. Basic science is the underpinning for advances in healthcare, contributing to both the length and quality of life. It underlies our national security, providing deterrence and a capacity to respond to both conventional warfare and the difficult threats of terrorism, cyberwarfare, and biological attacks. It provides the capacity to respond to climate change and to the challenges of providing adequate energy supply, feeding the growing world's population, achieving sustainable economies, protecting the environment, and meeting the emerging challenge of providing sufficient potable water. Perhaps, most fundamentally, basic science satisfies a deep-seated human desire to *know*—to understand the universe and our place in it.

As revealed in the subsequent pages of this Year Book, the work of Carnegie scientists exemplifies the promise of basic research. Consider the following examples:

Steve Farber of our Department of Embryology is undertaking path-breaking work on the metabolism of fats and cholesterol. Using fluorescently tagged lipids, he is able to observe absorption in the small intestine and subsequent metabolism in live zebrafish, a remarkable model animal for such work because

Images courtesy Ronald Cohen





Ronald Cohen (above) and former intern Maimon Rose discovered a new and efficient way to pump heat at miniscule scales using crystals. The image at left shows a molecular dynamics simulation of lithium niobate under a time-varying electric field. The electric field changes the sign of the polarization—the critical component to the discovery. Niobium is red, oxygen is green, and lithium shows a range of colors for different time steps. The niobium and oxygen are shown for one time step only, for clarity.

zebrafish are transparent in their early stages of development. The work has important implications for our understanding of a variety of ailments, including diabetes, obesity, and cardiovascular disease.

Ron Cohen of our Geophysical Laboratory and Maimon Rose, a former high-school Carnegie intern, have conducted work on ferroelectric crystals—materials that have electrical polarization in the absence of an electric field. Applying an external electric field reverses the polarization and causes a temperature change in the material. They found a very dramatic temperature change in their studies of ferroelectric lithium niobate. The work holds the prospect that such crystals could be used to pump or extract heat. The crystals might find application on computer chips to prevent overheating, which currently limits higher computing speeds.

David Ehrhardt of the Department of Plant Biology and Ryan Gutierrez have been studying cellulose, the crucial component of plant cell walls. Normally the individual chains that make up cellulose bond to each other to make a semi-crystalline fiber, which provides a plant with rigidity and strength. This fiber is also responsible for cellulose's resistance to digestion. In collaboration with Seth DeBolt

Image courtesy Diana Roman

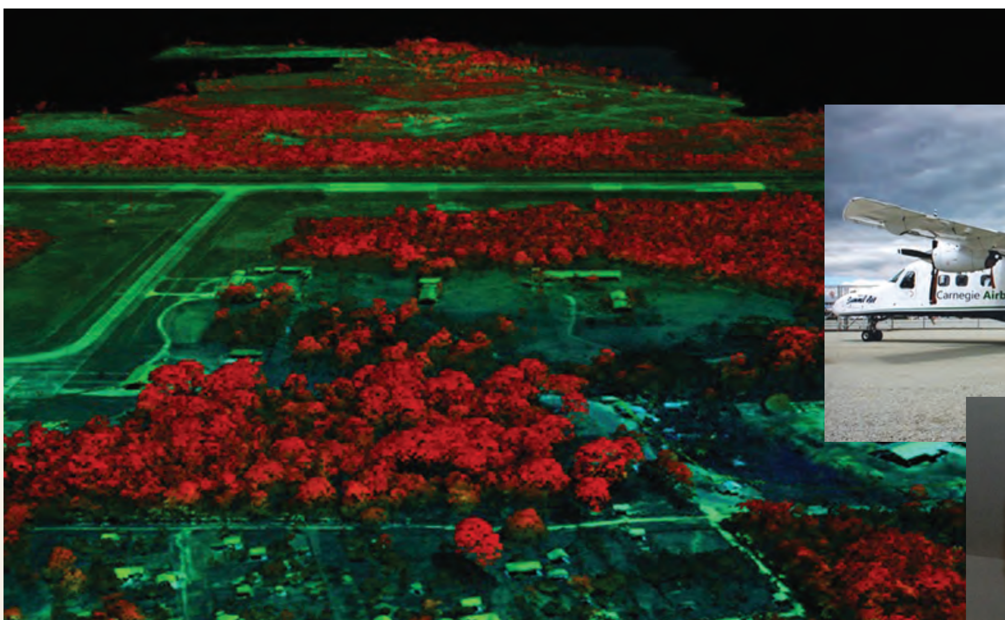
Diana Roman studies how magma travels through the Earth's crust and in volcanic conduit systems to understand seismicity and stress changes as magma moves. She is deploying a broadband seismometer at the Crater Lake volcano in Oregon.

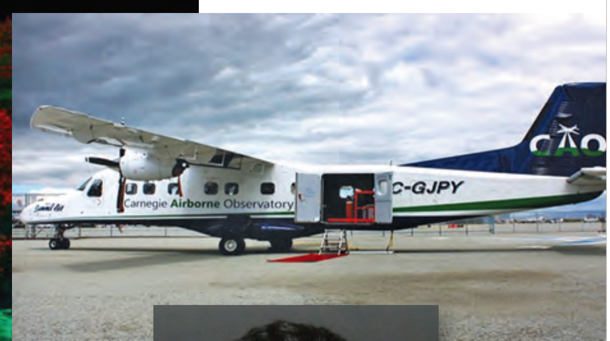
at the University of Kentucky, a former Carnegie postdoctoral fellow, the researchers have discovered mutations in the genes that encode the cellulose-making proteins, resulting in plants with cell walls with structural defects. This results in the production of cellulose that is less recalcitrant to digestion. The work may provide a pathway to liberate sugars from cellulose, a crucial step in the production of biofuels.

Diana Roman of the Department of Terrestrial Magnetism is studying the formation, structure, evolution, and dynamics of the conduit systems for the transport of magma in volcanoes, and the relationship of these systems to the microearthquake swarms that occur in the vicinity of active volcanoes. The work will allow greater understanding of volcanoes, with the promise of eventually enabling prediction of the timing and scale of eruptions.

Global Ecology's Greg Asner and his team are using the Carnegie Airborne Observatory (CAO) to revolutionize wide-scale ecological studies. The researchers combine laser and spectral imaging technology onboard a twin-engine aircraft to derive simultaneous measurements of an ecosystem's chemistry, structure, biomass, and biodiversity. In just one year, the system has mapped tens of millions of acres

Images courtesy Greg Asner



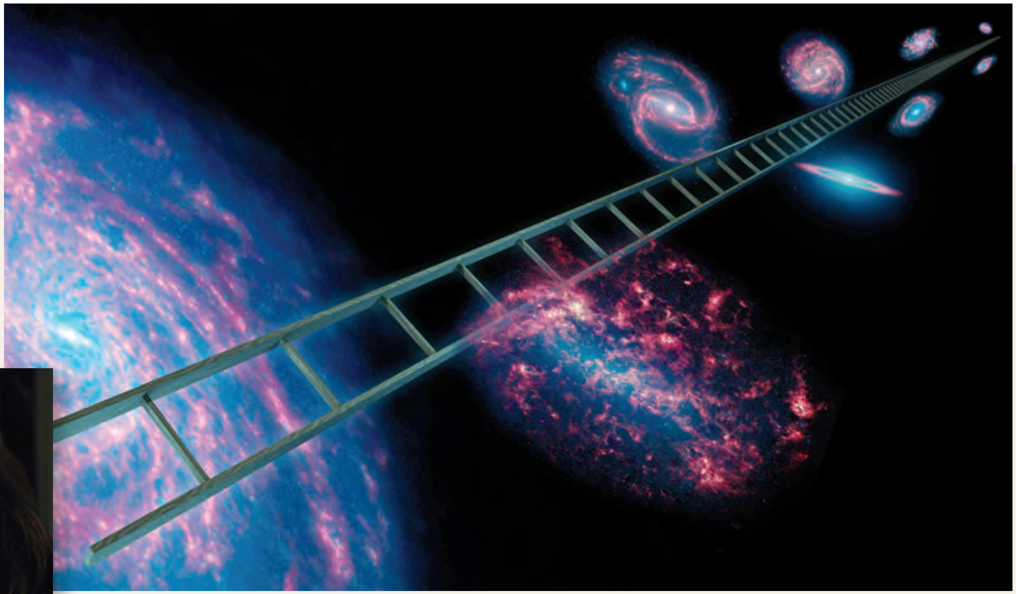


Greg Asner's team recently rolled out results from the new Airborne Taxonomic Mapping System (AToMS) mounted on the Carnegie Airborne Observatory (CAO), a fixed-wing aircraft (top right). The groundbreaking technology and its scientific observations are uncovering a previously invisible ecological world. The CAO landscape shows the height of vegetation, with red areas tallest.

of ecosystems in California, Panama, Colombia, Costa Rica, and the Peruvian Amazon basin. In addition to enhancing the understanding of ecosystems, the technology has applications for mitigating climate change, forest conservation, and ecosystem management. Indeed, the CAO could be a crucial element in the implementation of the United Nations initiative Reducing Emissions from Deforestation and forest Degradation (REDD) by enabling the swift and accurate measurement of carbon stocks in protected forests.

A team of astronomers lead by **Wendy Freedman, the director of the Observatories**, has used NASA's Spitzer Space Telescope to make one of the most accurate measurements of the Hubble constant yet achieved. The Hubble constant is a measure of the universe's expansion rate, and it underlies our understanding of the universe's age and size. By establishing a precise measure of the rate at which the universe is expanding at the current time, the research provides insights into the observed acceleration of the expansion rate over time—perhaps the most fundamental scientific mystery of our age.

Finally, as an adjunct to our research activities, our educational activities reflect the same innovation we bring to our scientific research. The staff of the Carnegie Academy for Science Education (Julie Edmonds, Toby Horn, and Marlena Jones)



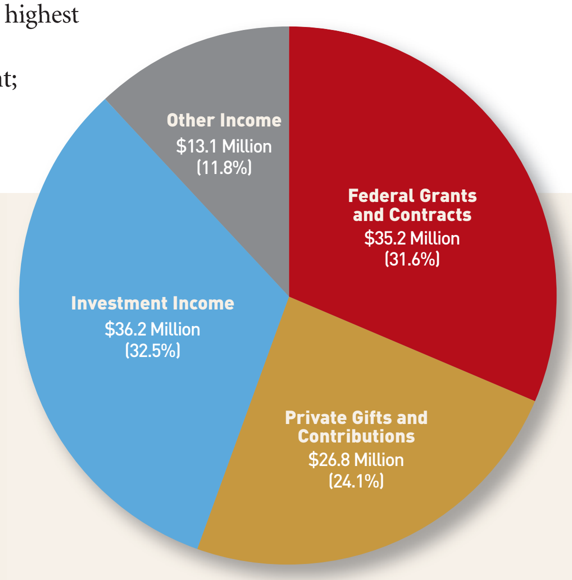
Artwork courtesy NASA/JPL-Caltech

Since the dawn of consciousness, people have wondered about our place in the cosmos. **Wendy Freedman** and her team recently refined the measure of the expansion rate of the universe, improving its accuracy by a factor of 3. Pinning this value down is important for understanding the age and size of the cosmos.

has worked closely with Friendship Collegiate Academy to develop a new teaching approach that integrates instruction in science, technology, engineering, and math with English and social studies. The Washington, D.C., branch of Math for America, which was launched by Carnegie and American University—with careful shepherding by my predecessor Maxine Singer, continues to develop master teachers in mathematics for Washington, D.C., schools.

As these examples reveal, Carnegie remains an oasis of exciting activities in an uncertain time. Indeed, although the threat of reduced federal support looms for all of science, Carnegie has fared through the recent turmoil rather successfully. Our federal grants and contracts have been sustained in a period when many have endured cutbacks—a tribute to the capability of the Carnegie scientists. And unlike many institutions and universities, we have the benefit of balanced support for research from additional sources—our endowment, gifts from foundations and individuals, and other income (e.g., from rentals of our P Street headquarters). Thanks to the careful stewardship by our Finance Committee, our endowment had a gain of 5.4% over the 2011-12 fiscal year, which is well above the State Street median for endowments and foundations for the period. (Indeed, the Carnegie endowment has outpaced the State Street median over the two-, three-, and five-year periods as well.) And our efforts to strengthen our outreach to the broader community have served many purposes, including a growing flow of support for Carnegie science. At the same time, our frugality and care in operations has gained us the highest rating available from Charity Navigator, the nation's largest evaluator of non-profits and charities for fiscal management; we are one of only five non-profit organizations of the 5,500 that are monitored to have achieved this ranking for twelve years running. In short, although I observe the overall financial climate with concern, Carnegie has shown that it has the capacity to thrive. With your continuing help and support, we will do so.

Richard A. Meserve, *President*



2012 Revenue
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Friends, Honors & Transitions

Carnegie Friends

Annual Giving

Gifts were received between July 1, 2011, and June 30, 2012.

The Barbara McClintock Society

An icon of Carnegie science, Barbara McClintock was a Carnegie plant biologist from 1943 until her retirement. She was a giant in the field of maize genetics and received the 1983 Nobel Prize in Physiology/Medicine for her work on patterns of genetic inheritance. She was the first woman to win an unshared Nobel Prize in this category. To sustain researchers like McClintock, annual contributions to the Carnegie Institution are essential. The McClintock Society thus recognizes generous individuals who contribute $10,000 or more in a fiscal year, making it possible to pursue the highly original research for which Carnegie is known.

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Frederick N. Webber
Johannes Weertman
James A. Weinman
Paul J. Werner
Maxwell Westman
Richard Weston
Edward White, V
Herman B. White, Jr.
William M. White
James E. Williams
James W. Williams
James Willingham
Evelyn M. Witkin
Laquita Wood
Lee D. Woolever
Julianne Worrell
Sara Wriston
Frank K. Wyatt III
Robert J. Yamartino
Charles Yanofsky
Richard Young and Bonnie Beamer
Robert A. Young
Timothy A. Zimmerlin
Matthew S. Zipfel
Janet M. Zydney

★ *Robert and Margaret Hazen*

Robert and Margaret Hazen

Over the years, Geophysical Laboratory (GL) scientist Bob Hazen and his wife, Margee, have become among the most ardent supporters of Carnegie science. Bob came to Carnegie as a postdoctoral fellow in 1976 and has been a staff researcher since 1978. His work is expansive—from the origins of life and the emergence of prebiotic chemistry to mineral evolution. In addition to his Carnegie research, Bob is the Clarence Robinson Professor of Earth Science at George Mason University. He lectures around the world and is dedicated to public education and outreach on numerous scientific topics. Bob has authored more than 350 scientific articles and 20 books on science, history, and music, many in collaboration with Margee.

The Hazens' contributions to Carnegie go well beyond Bob's extraordinary science. In 1989 they began donating annually to support scientific research and instrumentation at GL. They started an instrument fund in honor of the late GL scientist Thomas Hoering. In 2001 the Hazens made significant contributions to the Carnegie Campaign for Science. Since then they have made annual donations to support GL fellowships, interdisciplinary studies, renovations to the Broad Branch Road campus, and more. They are members of the Edwin Hubble and Second Century Legacy Societies.

Margee's support for Carnegie science also exceeds the norm. She was pivotal in the institution's centennial celebrations in 2002. An accomplished author and historian, she curated the centennial exhibition *Our Expanding Universe* and co-authored the book *Good Seeing*; both highlighted the first century of Carnegie's remarkable scientific discoveries, and neither would have succeeded without her long hours and unwavering dedication.

More recently, Bob has been forging a new, interdisciplinary field involving researchers worldwide: the study of the Earth's deep carbon cycle. It began in 2007 when Bob gave a lecture in New York about understanding life's geochemical origins and attracted the attention of Jesse Ausubel, a science advisor at the Alfred P. Sloan Foundation. Today Bob serves as executive director of the Deep Carbon Observatory, which has important Sloan funding, among his numerous other duties and research projects. Carnegie is extraordinarily fortunate that Bob and Margee have chosen to support the institution in so many different ways. We are deeply indebted to them for their enduring commitment.

Burton and Deedee McMurtry

With an electrical engineering background and a passion for astronomy, Burton McMurtry was a natural fit for Carnegie. Trustee William Hearst introduced Burton to the institution, by way of their mutual interest in astronomy. Burton's first-hand exposure to Carnegie came through a trip that he took with his wife, Deedee, to the Las Campanas Observatory in early 1995. He was captivated by the experience and was elected to Carnegie's board in December 1996.

Burton received two bachelor's degrees from Rice University and master's and doctoral degrees in electrical engineering from Stanford University. He then worked for GTE Sylvania in engineering and management until 1969, when he changed course and went into the venture capital business. Burton founded several venture firms, including Technology Venture Investors (TVI), with a focus on start-up electronic companies. Among the many successful companies that his firms backed were ROLM Corporation, KLA-Tencor, Intuit, Microsoft, Sun Microsystems, and VeriFone. In 1995 Burton began retiring from TVI, and in 2004 he became the chairman of the Stanford University board.

Initially, Burton served on Carnegie's Research committee. In 1999 he became a member of the Finance committee, where he provided invaluable guidance on Carnegie's investments.

Burton generously supported Carnegie even before he joined its board. His first gift, in 1996, was for the wide-field camera for the Magellan Telescope Project. Later Burton served on the Visiting committee for the Observatories. His interests expanded to include Global Ecology, where he served on the committee that selected the architectural firm for the department's innovative "green" building. Burton and Deedee have generously donated every year to the Annual Fund. They have additionally supported the Carnegie Campaign for Science, Science for the City, and the Department of Embryology's Singer Building. They are members of the Hubble Society.

Among his many other contributions, Burton initiated a flourishing relationship with the Gordon and Betty Moore Foundation. In 2001 he met with Gordon Moore and discussed the then-new Department of Global Ecology. Since 2002, the Moore Foundation has made some $13 million in grants to support work at Global Ecology. Carnegie is deeply grateful for Burton McMurtry's leadership and guidance over the years and for the couple's generous, steadfast support of many facets of Carnegie science.

★ *Burton and Deedee McMurtry*

Foundations and Corporations

$1,000,000 or more
The John D. and Catherine T. MacArthur Foundation
The Cynthia and George Mitchell Foundation
Gordon and Betty Moore Foundation
Alfred P. Sloan Foundation

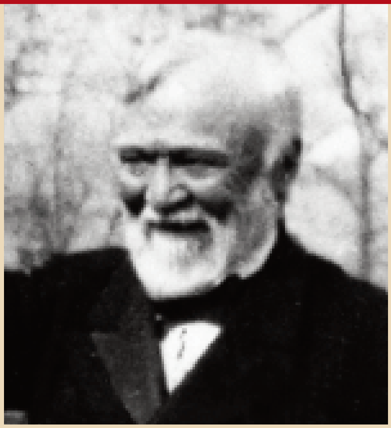
$100,000 to $999,999
The Ahmanson Foundation
Blue Moon Fund, Inc.
The Margaret A. Cargill Foundation
The Gayden Family Foundation
Michael E. Gellert Trust
The Grantham Foundation for the Protection of the Environment
Richard Lounsbery Foundation, Inc.
The Andrew W. Mellon Foundation
Ambrose Monell Foundation
The G. Unger Vetlesen Foundation

$10,000 to $99,999
Anonymous
The Abell Foundation, Inc.
Air Liquide Foundation
Association of American Medical Colleges
The Bodman Foundation
The Brinson Foundation
Dana and Albert R. Broccoli Charitable Foundation
Carnegie Institution of Canada/Institution Carnegie du Canada
The Crystal Family Foundation
Dow AgroSciences LLC
Durland & Co., Inc.
The O.P. and W.E. Edwards Foundation
Fondation de France
Herman Frasch Foundation for Chemical Research
Golden Family Foundation
Robert and Margaret Hazen Foundation
Richard W. Higgins Charitable Foundation
Laurel Foundation
The McMurtry Family Foundation
MGW & CJW 2007 Trust
The Robert & Bethany Millard Charitable Foundation
Monsanto Company
The Kenneth T. and Eileen L. Norris Foundation
Northrop Grumman Corporation
The Pfizer Foundation Matching Gifts Program
The Rose Hills Foundation
Shippy Foundation
Skoll Global Threats Fund
Society for Developmental Biology
Syngenta Biotechnology, Inc.
The Sidney J. Weinberg, Jr. Foundation

$500 to $9,999
Anonymous
American Academy of Arts and Sciences
Arnhold Foundation, Inc.
Bank of America Matching Gifts
The Boeing Gift Matching Program
The Bristol-Myers Squibb Foundation, Inc.
Carl Zeiss Microscopy, LLC
Cavalieri-Look Fund
Coulombe Family Trust
Damel Investors LLC
The Nick Dewolf Foundation
Earth Force, Inc.
Ernst Charities
Arthur and Linda Gelb Charitable Foundation
Google Matching Gifts Program
Hicks Family Charitable Foundation
The Johns Hopkins University
The Johns Hopkins University - Department of Biology
The Marion I. & Henry J. Knott Foundation, Inc.
Laubach Family Fund
Linden Trust for Conservation
Longfield Family Charitable Foundation
Lutron Foundation
Robert W. and Gladys S. Meserve Charitable Trust
Mulago Foundation
Omenn-Darling Family Advised Fund
Honey Perkins Family Foundation, Inc.
Rathmann Family Foundation
Roxiticus Foundation
T. Rowe Price Foundation, Inc.
Harvey and Leslie Wagner Foundation
Whittier Trust Company
Xerox Corporation
ZGF Architects LLP
The Zoback Trust

Lifetime Giving Societies

The Carnegie Founders Society



Andrew Carnegie, the founder of the Carnegie Institution, established it with a gift of $10 million. Although he ultimately gave a total of $22 million to the institution, his initial $10 million gift represents a special level of giving. In acknowledgment of the significance of this initial contribution, individuals who support Carnegie's scientific mission with lifetime contributions of $10 million or more are recognized as members of the Carnegie Founders Society.

Caryl P. Haskins*
William R. Hewlett*
George P. Mitchell

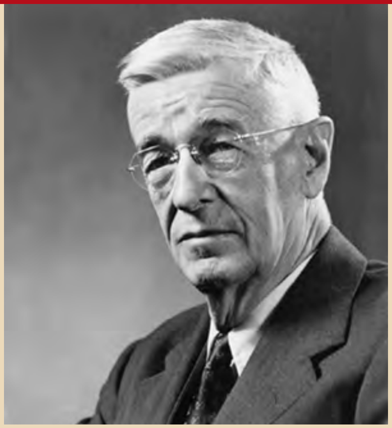
The Edwin Hubble Society

The most famous astronomer of the 20th century, Edwin Hubble, joined the Carnegie Institution in 1919. Hubble's observations shattered our old concept of the universe. He proved that the universe is made of collections of galaxies and is not just limited to our own Milky Way—and that it is expanding. This work redefined the science of cosmology. Science typically requires years of work before major discoveries like these can be made. The Edwin Hubble Society honors those whose lifetime support has enabled the institution to continue fostering such long-term, paradigm-changing research by recognizing those who have contributed between $1,000,000 and $9,999,999.

D. Euan and Angelica Baird
William and Cynthia Gayden
Michael and Mary Gellert
Robert G. and Alexandra C. Goelet
William T. Golden*
Crawford H. Greenewalt*
David Greenewalt*
Margaretta Greenewalt*
Robert and Margaret Hazen
William R. Hearst III
Richard E. Heckert*
Kazuo and Asako Inamori
Michael T. Long
Burton and Deedee McMurtry
Jaylee* and Gilbert* Mead
Cary Queen
Deborah Rose, Ph.D.
William J. Rutter
Thomas and Mary Urban
Sidney J. Weinberg Jr.*

Second Century Legacy Society

The Vannevar Bush Society



Vannevar Bush, the renowned leader of American scientific research of his time, served as Carnegie's president from 1939 to 1955. Bush believed in the power of private organizations and wrote in 1950, "It was Andrew Carnegie's conviction that an institution which sought out the unusual scientist, and rendered it possible for him to create to the utmost, would be worthwhile . . ." He further said that "the scientists of the institution . . . seek to extend the horizons of man's knowledge of his environment and of himself, in the conviction that it is good for man to know." The Vannevar Bush Society recognizes individuals who have made lifetime contributions of between $100,000 and $999,999.

Anonymous (3)
Philip H. Abelson*
Bruce and Betty Alberts
Daniel Belin and Kate Ganz
Bradley F. Bennett*
Didier and Brigitte Berthelemot
Gary P. and Suzann A. Brinson
Donald and Linda Brown
Richard Buynitzky*
A. James Clark
Tom and Anne Cori
John Diebold*
Jean and Leslie Douglas*
James Ebert*
Bruce W. Ferguson and Heather R. Sandiford
Stephen and Janelle Fodor
Henrietta W. Hollaender*
Antonia Ax:son Johnson and Goran Ennerfelt
Paul and Carolyn Kokulis
Gerald D. and Doris* Laubach
Lawrence H. Linden
John D. Macomber
Steven L. McKnight
Richard A. and Martha R. Meserve
J. Irwin Miller*
Al and Honey Nashman
Evelyn Stefansson Nef*
Alexander Pogo*
Elizabeth M. Ramsey*
Vera and Robert* Rubin
Allan R. Sandage*
Leonard Searle*
Frank Stanton*
Christopher and Margaret Stone
William and Nancy Turner

The Carnegie Institution is now in its second century of supporting scientific research and discovery. The Second Century Legacy Society recognizes individuals who have remembered, or intend to remember, the Carnegie Institution in their estate plans and those who have supported the institution through other forms of planned giving.

Anonymous (2)
Paul A. Armond, Jr.
Lore E. Brown
Eleanora K. Dalton
Nina V. Fedoroff
Kirsten H. Gildersleeve
Gary K. Hart and Cary S. Hart
Robert and Margaret Hazen
Paul A. Johnson*
Paul and Carolyn Kokulis
Gilbert and Karen Levin
Chester B. and Barbara C. Martin
Robert Metcalf
Al and Honey Nashman
Holly M. Ruess
Leonard Searle*
Maxine and Daniel Singer
Thomas H. B. Symons, C.C.
John R. Thomas, Ph.D.
Hatim A. Tyabji

* **Deceased:** *Members were qualified with records we believe to be accurate. If there are any questions, please call Irene Stirling at 202.939.1122.*

Honors & Transitions

Honors

Trustees/Administration

Carnegie trustee **Sandra Faber** was awarded the 2012 Catherine Wolfe Bruce Gold Medal for lifetime achievement in astronomical research.

Carnegie president **Richard Meserve** was elected a foreign member of the Russian Academy of Sciences. He was also elected president of the Harvard Board of Overseers. Meserve was awarded the William S. Lee Award for Leadership by the Nuclear Energy Institute and the binaugural 2011 Richard L. Garwin Award from the Federation of American Scientists.

Retired director of administration and finance **Gary Kowalczyk** received Carnegie's 2011 Service to Science award.

Embryology

Steve Farber's BioEYES program received the 2012 Viktor Hamburger Outstanding Educator Prize from the Society for Developmental Biology.

Staff associate **Christoph Lepper** received a National Institute of Health Director's Early Independence Award.

Geophysical Laboratory

Robert Hazen received the 2012 Virginia Outstanding Faculty Award from the State Council of Higher Education for Virginia.

New staff member **Timothy Strobel** was awarded the 2011 Jamieson Award by the International Association for the Advancement of High Pressure Science and Technology.

Global Ecology

Greg Asner was named a Senior Energy and Climate Partnership of the Americas Fellow by the U.S. Department of State.

Plant Biology

Director **Wolf Frommer** was awarded the Lawrence Bogorad Award for Excellence in Plant Biology Research by the American Society of Plant Biologists.

Terrestrial Magnetism

Richard Carlson was elected to the National Academy of Sciences.

Librarian **Shaun Hardy** received Carnegie's 2011 Service to Science award.

Transitions

Trustees/Administration

The Carnegie board of trustees welcomed **Michael Long** and **Cristián Samper** as new board members.

Former senior board member **Michael Duffy** rejoined the board as a full member.

Director of administration and finance **Gary Kowalczyk** retired in 2011.

Cynthia Allen became the new director of administration and finance.

Embryology

Christoph Lepper was appointed a staff associate July 1, 2011.

Terrestrial Magnetism

Former department director **Sean Solomon** is taking a leave of absence to serve as the new director of Columbia University's Lamont-Doherty Earth Observatory.

Linda Elkins-Tanton became the new department director on September 26, 2011.

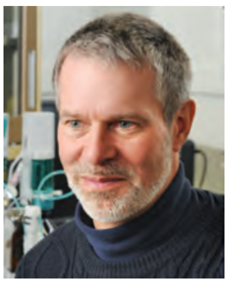

★ *Sandra Faber*


★ *Richard Meserve*


★ *Gary Kowalczyk*


★ *Steve Farber*


★ *Christoph Lepper*


★ *Robert Hazen*


★ *Timothy Strobel*


★ *Greg Asner*


★ *Wolf Frommer*


★ *Richard Carlson*


★ *Shaun Hardy*


★ *Michael Long*


★ *Cristián Samper*


★ *Michael Duffy*


★ *Cynthia Allen*


★ *Sean Solomon*


★ *Linda Elkins-Tanton*

Research Highlights

Embryology

Deciphering the Complexity of Cellular, Developmental, and Genetic Biology

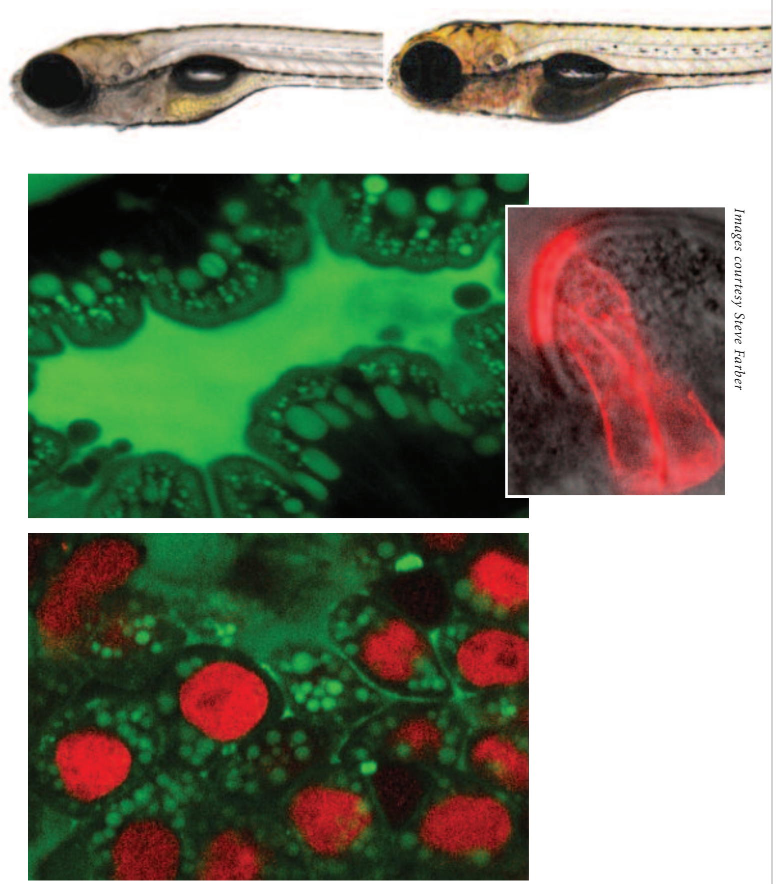
Fish, Fat, and Cholesterol

Balanced cholesterol levels are essential for heart health, but many aspects of cholesterol's transport remain poorly understood. Carnegie's Steven Farber, James Walters, and Jennifer Anderson have developed a strategy that allows scientists to watch lipid metabolism in live zebrafish. They made the first visual observations of cholesterol absorption in a living vertebrate system, enabling studies to better understand diabetes, obesity, and cardiovascular disease.

Fatty acids, cholesterol, and most other lipids are absorbed by the small intestine in vertebrates. The complexity of cells, fluids, microorganisms, and bile make it very difficult to study lipid metabolism outside of the context of the living body.

When we consume fat (triacyglycerides), our digestive organs release enzymes that break it down into fatty acids. Despite years of study, the cellular processes that mediate dietary fatty acid uptake into absorptive cells (called enterocytes) are unclear. Once absorbed, these fatty acids are prepared for transport out of the cell, transformed into droplets of stored fat, or burned by the cell for energy. Many of the steps that regulate the formation of these intracellular fat droplets are unknown. In addition, scientists have yet to explain a long-standing observation that dietary fat increases dietary cholesterol absorption.

Researchers know that after cholesterol is absorbed by enterocytes it combines with proteins to form lipoproteins, which distribute lipids throughout the body. A protein called NPC1L1 plays an important, albeit poorly under-



Images courtesy Steve Farber

Clear, living zebrafish gorge on fluorescently tagged chicken egg yoke (top right). In panel two, inside the intestines, the bright green areas are the lipids. Two cholesterol transporter cells are shown in red on right. The bottom panel shows glowing red nuclei that provide a landmark for the scientists, while cholesterol glows green.

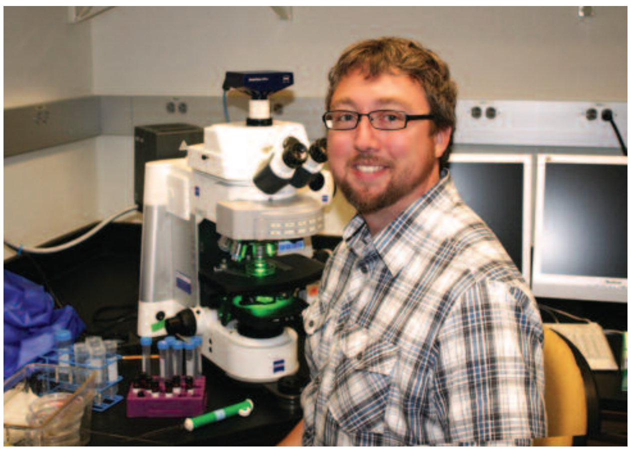


Image courtesy Steve Farber

Farber lab's James Walters is part of the team that studies lipid metabolism using zebrafish.

stood, role in cholesterol absorption by the enterocytes.

To address these unanswered questions, the Farber lab turned to the optically clear zebrafish larvae. Using fluorescent forms of lipids to observe fat and cholesterol absorption in the small intestines of live zebrafish, they made a number of breakthroughs. They confirmed that the physiological processes regulating fatty acid and cholesterol absorption are linked, which was first suggested in the 1960s. They also found that a long-chain fatty acid (oleic acid) could increase dietary cholesterol uptake by modulating the subcellular location of NPC1L1. Their research further revealed that—following a meal rich in fat and cholesterol—fatty acids were rapidly stored as lipid droplets while cholesterol was initially stored in special structures called endosomes. These results and this novel research strategy will help us to better understand the cell biology of lipids, with important implications for human health.

Map Reading: Using Proteins to Understand Genes

The ability to sequence genomes has outstripped the research methods for deciphering the information they encode. Carnegie's Nick Ingolia has been working to develop and refine new techniques for mapping protein synthesis, which can be used to decode these genomes. His work is revealing a previously little-known level at which gene expression is controlled and, in the process, helping to home in on potential cancer treatment targets.

The genome of a cell is made up of many thousands of genes. Each gene is an instruction for making one protein. But different genes are activated at different times and in different types of cells. When a gene is turned on, it is *transcribed* into bits of specialized RNA, called mRNA. This mRNA leaves the nucleus and is *translated* into a sequence of amino acids that, when complete, forms a protein. Ingolia's methods reveal many examples where mRNAs are transcribed but where their translation into protein is specially regulated, or occurs in ways that were not previously appreciated.

Only some portions of the genome are used to generate mRNAs. Other portions regulate mRNA translation or serve purposes that aren't yet understood. Ingolia and his colleagues focused on mapping the regions of the mammalian genome that are actually translated into protein. This is different from earlier techniques that used computational modeling to predict the parts of the genome that are turned into protein; Ingolia's team showed those models are incomplete. For example, sometimes the region of a gene that is translated into protein is longer or shorter than expected and the difference between these expectations and actual protein synthesis could change the way the protein functions. Also, sometimes a cell will translate a "decoy"

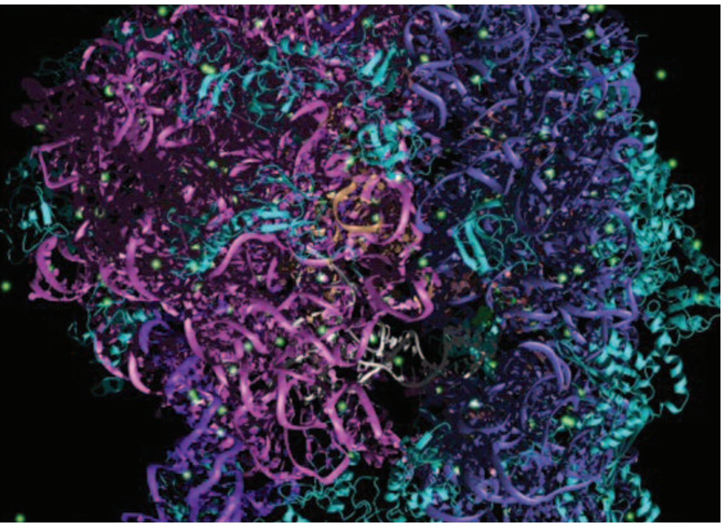


Image courtesy Los Alamos National Laboratory

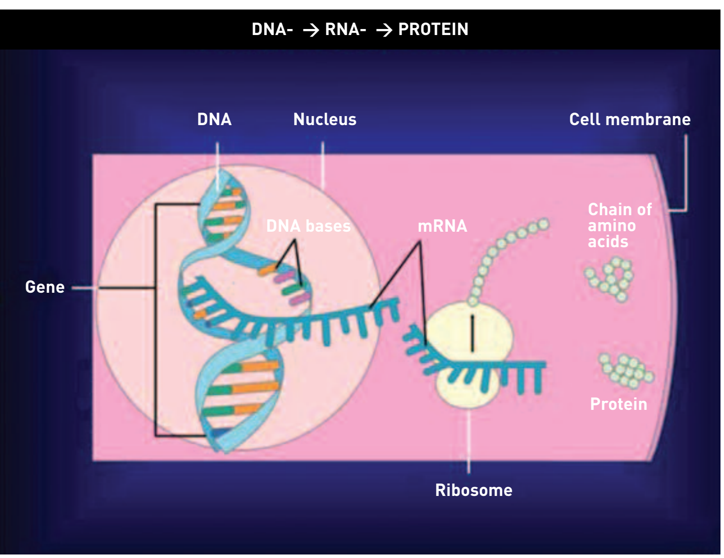


Image courtesy National Cancer Institute

segment of the genome, which resembles the code for a particular protein, but is different. It serves to distract the translation of the real gene into a protein, thus controlling the amount of protein produced.

Ingolia's team also measured the speed of protein production to gain a better understanding of places where translation stalls or slows down. Lastly, they focused on changes in protein synthesis that take place as mouse embryonic stem cells differentiate into specialized cells that serve specific functions. Stem cells initially divide rapidly into more stem cells. Eventually they differentiate into different types of cells. Ingolia found that translation of suites of genes in the mouse genome changed when the cells went through this process. Interestingly, these same genes were found to be activated in cancer cells and were inhibited by a cancer-fighting drug. □

Top left: Ribosomes attach to mRNA and, based on mRNA instructions, manufacture proteins.

Bottom left: Genes make proteins. First, the information from the bases are copied from a DNA strand into a strand of messenger RNA (mRNA). The mRNA leaves the cell nucleus for an organelle called the ribosome, where it directs the production of amino acids that form the protein.

Image courtesy National Cancer Institute

Embryology's Nick Ingolia

Geophysical Laboratory

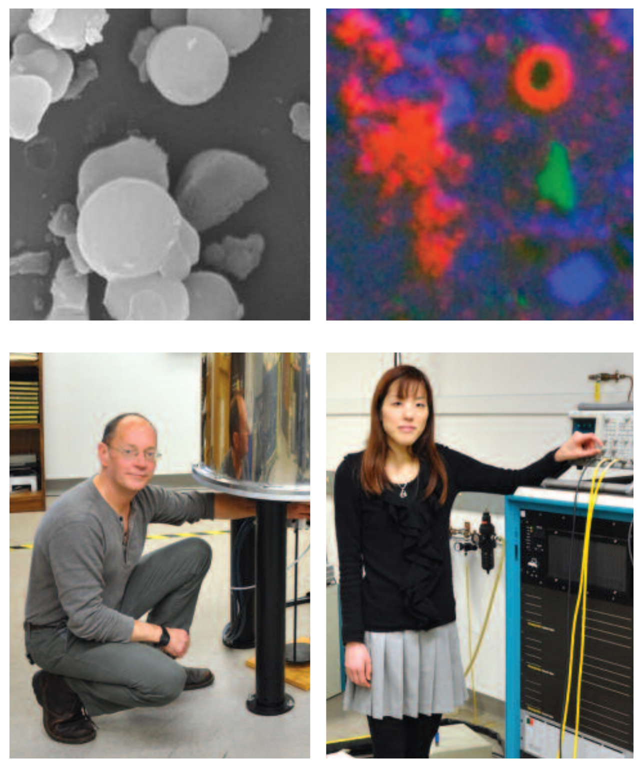
Probing Planetary Interiors, Origins, and Extreme States of Matter

Life's Poisonous Start

Carbon, the basis for life, either came from comets and asteroids during the formation of the early Solar System or was trapped within the Earth during planetary accretion. How the Earth was able to hold onto this carbon during its energetic origin is not known. Staff scientist George Cody, postdoctoral fellow Yoko Kebukawa, and their colleagues have been studying organic carbon in comets and meteorites. They find that formaldehyde, a poisonous compound, may be the origin of the complex carbon molecules in these bodies and, by extension, may be the source of the existence of life.

It has long been a challenge to determine how early carbon-containing materials were formed, because their chemistry is extremely complex. Cody and team succeeded in determining their origin by applying advanced molecular spectroscopic techniques both at the Geophysical Laboratory—using solid-state 13 C nuclear magnetic resonance spectroscopy—and at the Advanced Light Source (an X-ray synchrotron radiation source)—using X-ray absorption spectroscopy. Using these techniques, they studied the chemistry and structures of actual particles of carbon-containing material from comet Wild-2, retrieved by the NASA Stardust mission; of interplanetary dust particles, obtained by high-flying aircraft; and of ancient meteorites called chondrites found on Earth. All contain a polymer (a large molecule) formed by formaldehyde.

Formaldehyde (CH_2O) is a common molecule in the galaxy; radio astronomers observe it in the interstellar medium, in protoplanetary disks, and in cometary



Images courtesy Proc. Natl. Acad. Sci. USA 108 (no. 48), 19171-19176, 2011

Top: The image at left shows a scanning electron microscope of tiny carbon-containing spheroids made during the synthesis of formaldehyde. The image at right shows material from a typical, ancient meteorite called a chondrite. The matter in red is carbon, blue is iron, and green is calcium.

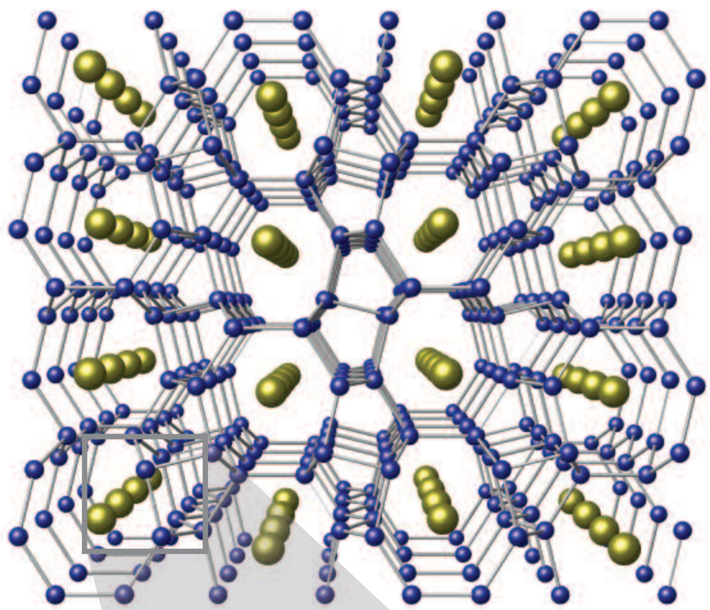
Bottom: George Cody (left) and Yoko Kebukawa are in their lab.

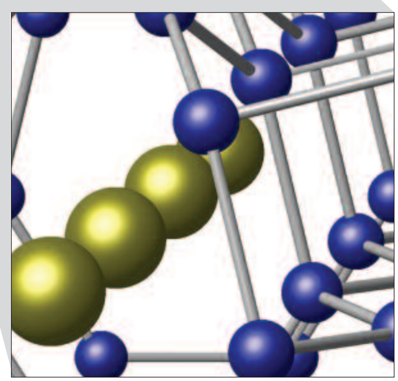
volatiles. Under certain circumstances, formaldehyde will spontaneously grow into a polymer through a complex series of reactions. Cody and team are now tackling the details of the formaldehyde reaction in the lab. Interestingly, along with the polymerization of formaldehyde, simple sugars are formed—including ribose, a component of ribonucleic acid (RNA), which is essential to life. The polymerization of formaldehyde also yields extremely small spheroidal particles that are similar in size and shape to the nanoglobules in primitive meteorites.

Currently the team is focused on the effect of synthesis temperature on molecular structure and the role of ammonia in the reaction. Ammonia is also abundant in the galaxy and is expected to play an important role in the complex formaldehyde polymerization chemistry. Their results support a new theory that the carbon components in chondrites and comets were formed through the polymerization of interstellar formaldehyde after the accretion of small planetesimals in the presence of water during the early Solar System.

Tiny Cages Hold Big Promise

Understanding the chemical reactions that can create tiny molecular cages that hold other “guest” molecules—structures called clathrates—is key to creating a new generation of electronic devices and possible energy materials. Timothy Strobel and team are the first to use high-pressure synthesis to create a stable clathrate of sodium (Na) and silicon (Si)—the least understood system of the so-called group 14 clathrates. Strobel also created a new clathrate of hydrogen sulfide (H_2S) and molecular hydrogen (H_2). Both findings open the door for major advances in materials science.



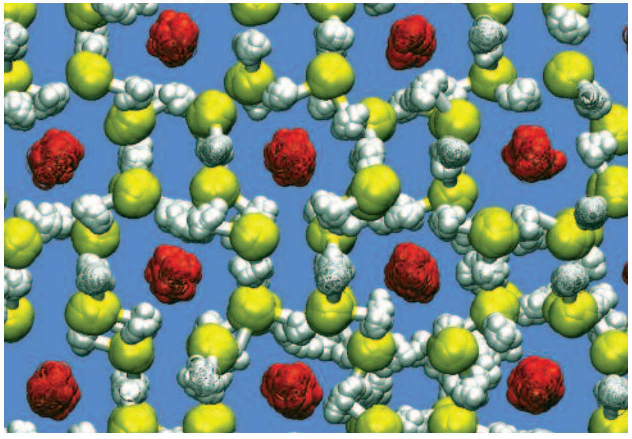


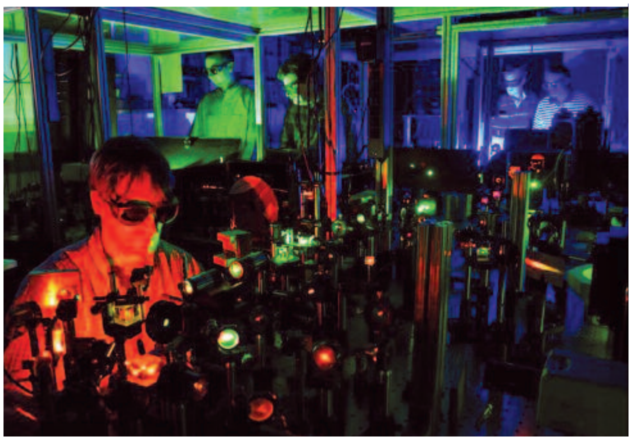
Images courtesy Timothy Strobel

The sodium silicon structure $NaSi_6$ shows what is called sp^3 bonded silicon atoms (blue)—which form tunnels along the a-axis of the crystal, trapping sodium atoms (yellow).

Geophysical Laboratory, *Continued*

Images courtesy Timothy Strobel





Top: This image is a composite of time-lapse snapshots overlaid for the cage-like H_2S+H_2 clathrate structure at 20,000 times atmospheric pressure (2 GPa). It shows ordered hydrogen bonds for H_2S molecules (yellow), hydrogen atoms (white), and disordered H_2 molecules (red).

Bottom: Timothy Strobel (foreground) works with a supercontinuum light source.

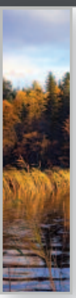
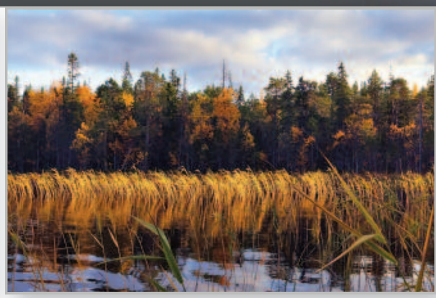
Until now, scientists created most silicon clathrates by heating a chemical precursor in a vacuum. This process, however, is not ideal for controlling growing conditions and keeping the cages stable. Synthesis under high pressure provides a reliable means to control growth of certain other materials (e.g., diamond and cubic boron nitride), so the Strobel team decided to pursue that approach for clathrates. They subjected mixtures of Na-Si to various pressures and temperature regimes and found a type of clathrate, Na_8Si_{46}, that formed at pressures ranging from 20,000 to 60,000 times atmospheric pressure (2 to 6 gigapascals, GPa) and temperatures of 1160 to 1520°F (900 to 1100 K). When the pressure was increased to 79,000 atmospheres (8 GPa), a new clathrate structure $NaSi_6$ formed. The latter material behaves like a metal and has never been seen before.

In addition to these experiments, the researchers performed calculations to predict how the materials would behave. Calculations and experiments revealed that sodium clathrates are thermodynamically stable at high pressure. The consistency suggests that scientists can use theoretical calculations to predict new synthesis routes for other compounds.

Strobel and colleagues also discovered that a clathrate formed from hydrogen sulfide and molecular hydrogen ($H_2S + H_2$) exhibited different behaviors under different pressure conditions. At pressures of 35,000 atmospheres (3.5 GPa), the compound crystallized into a stable "guest /host" structure held together by weak attractive forces (van der Waals forces). At 170,000 atmospheres (17 GPa), the hydrogen bonding increased between neighboring H_2S molecules. This type of bonding alone, however, was not sufficient for stability; when the hydrogen molecules were removed from the cage, the H_2S molecule framework collapsed. The research showed that novel cooperative interactions arising from molecular packing are necessary to hold such structures together. □

Global Ecology

Linking Ecosystem Processes with Large-scale Impacts

Deciphering Dead Zones

There are some 400 coastal "dead zones" around the world where the concentration of dissolved oxygen is so low that water cannot support healthy aquatic life. Researchers know that nutrients from agricultural runoff play an important role in the formation of dead zones, but their impact relative to other factors—such as the degree of stratification or layering in the water body—is difficult to identify. This makes it challenging to assess how the incidence and size of dead zones can be reduced through agricultural and runoff management.

Dan Obenour, a Ph.D. student working with Anna Michalak and a colleague at the University of Michigan, conducted the first study to isolate the impact of nutrients from that of stratification on dead zone variability in the Gulf of Mexico. They developed a statistical model that can pinpoint the impact of stratification; they found that stratification and nutrient concentrations contribute approximately equally to reductions in dissolved oxygen concentration. This result means that reducing nutrient runoff into the Gulf would have a substantial beneficial effect—a boon to coastal management practices.

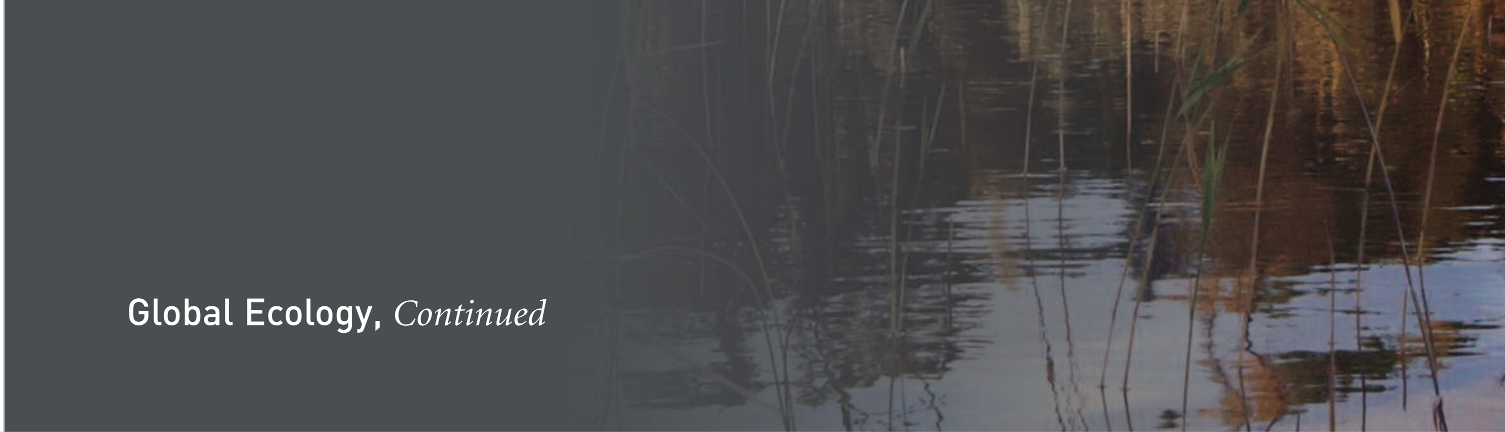
Strong stratification, measured by looking at the temperature or salinity as a function of depth, shuts off the resupply of oxygen to the bottom. Nutrients stimulate algal growth, and algae consume oxygen as they sink to the bottom and decompose. The net impact of both factors is a reduction in oxygen levels and the formation of dead zones.

Obenour and team used a data analysis tool called geostatistical regression to isolate the impact of stratification by looking at its spatial relationship to dissolved oxygen at the bottom of the water column. They modeled 10 years of monitoring data from 1998-2007 along the Louisiana-Texas coast. They examined yearly variability in dissolved oxygen that could not be explained by the relationship with stratification against a variety of other factors; they found that nitrogen, in the form of nitrate and nitrite concentrations, explained the remaining signal.

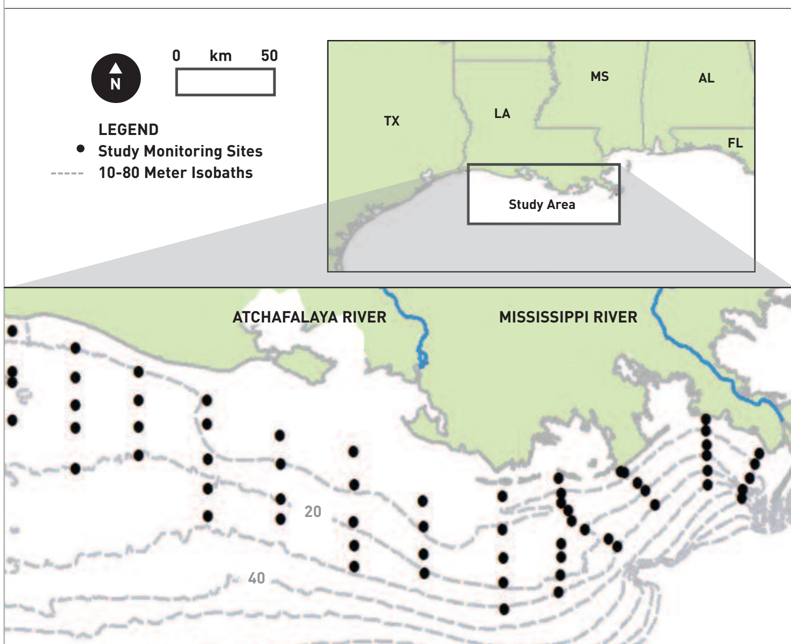
The team then explored the impact of hypothetical nutrient reduction scenarios over the 10 years. They found that shrinking the size of the low-oxygen zone to 1,930

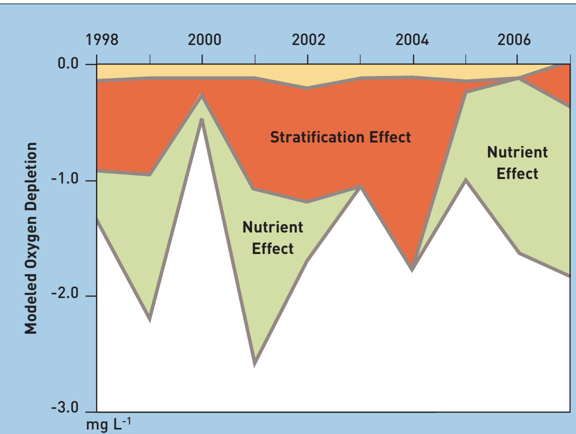
Image courtesy Dan Obenour

Ph.D. student Dan Obenour is on a research vessel in the Gulf of Mexico study area.



Global Ecology, *Continued*





Left: This map shows the study area, including depth and monitoring sites (black dots).

Above: This chart shows the relative importance of the different factors that the model found contributed to bottom water dissolved oxygen depletion in "dead zones" over the study period.

Images used with permission Environmental Science and Technology

square miles (5000 km^2), a goal set for the Gulf of Mexico by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, would require about a 30% to 60% reduction in nitrate and nitrite concentrations.

Uncovering Canopy Chemistry

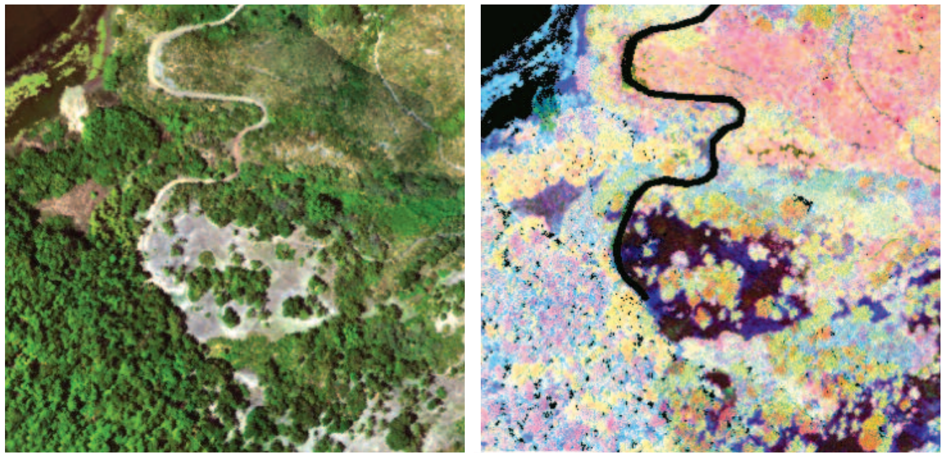
In seeking to understand the chemistry of the plant canopy, scientists try to determine the different effects of environmental regulators—such as terrain and soil—and of different plant species. The failure to understand these effects limits our ability to predict the effects of climate change and to unravel how nitrogen and carbon cycle through a system. A study by doctoral student Kyla Dahlin has revealed some new insights about whether the stronger predictors of canopy chemistry are environmental regulators or species within plant communities.

To study the diversity and distribution of plants, researchers can look at how different plant traits, like plant height or leaf shape and size, among different species in a community vary under different environmental conditions. Dahlin took a broader approach. For her Ph.D. thesis, she measured four chemical traits of California plant communities using the new Carnegie Airborne Observatory Airborne Taxonomic Mapping System (AToMS), coupled with on-ground sampling, to produce maps of these four traits across the landscape.

Dahlin measured leaf nitrogen per unit mass, leaf carbon per unit mass, leaf water concentration, and canopy water content across the ecologically diverse Jasper Ridge Biological Preserve in Northern California. The plant communities included savanna/grasslands, evergreen oaks and chaparral, riverbank ecosystems, and more. AToMS allowed Dahlin to detect the chemistry at extremely high resolution.

Dahlin combined her airborne data with known environmental regulators, such as terrain, soil, and land-use history, to model whether environmental regulators or species within plant communities were more indicative of the chemical variation of the canopy. She found that environmental regulators played a role but that plant communities were a stronger predictor.

For instance, Dahlin found that leaf shedding (deciduousness) willow-dominated communities, areas dominated by deciduous shrubs, and tracts with deciduous oaks were stronger predictors of leaf nitrogen levels than environmental regulators, making plant characteristics more important than environmental ones. Since nitrogen and carbon variations in the canopy are more closely tied to the vegetation community than to environmental regulators, individual species could become critical for understanding nitrogen and carbon cycling. The results not only are intriguing, they also represent a major step in integrating remote-sensing science with community ecology and spatial statistics. □



Images courtesy Kyla Dahlin

Top: The left image shows a true color image of part of Jasper Ridge Biological Preserve. The right image shows the same area but colored by canopy chemistry measured by the Carnegie Airborne Observatory Airborne Taxonomic Mapping System. Leaf carbon is red, leaf nitrogen is green, and leaf water is blue.

Bottom: Kyla Dahlin assesses the health of a young California bay laurel *(Umbellularia californica)*.

Image courtesy Nona Chiariello

Observatories

Investigating the Birth, Structure, and Fate of the Universe

Birthing Stars

The birth of a star is a violent business. It begins in giant clouds of molecular gas and dust that gravitationally collapse. Pressure and temperature increase, causing these clumps to coalesce into spinning spheres of very hot gas known as protostars. Over millions of years the protostars grow and ultimately stabilize into different star types, depending on their mass. Miguel Roth and team are studying whether young stars of different masses are made by the same mechanisms.

Low-mass stars can eject energetic jets of gas in an early stage, exciting the surrounding medium. The excitation induces chemical changes and forms spectacular knots of molecular hydrogen and sulfur called Herbig-Haro objects in the neighborhood of the newborn star. These knots are short-lived, compact nebula with specific chemical signatures. Roth and team believe that such knots could be associated with the formation of more massive stars as well.

Other processes can excite hydrogen, too. In a recent study, the team looked at star clusters of intermediate mass stars—stars about 7 to 9 times the mass of the Sun—in the Carina Nebula. The group consisted of at least 72 young stars in a cloud of ionized hydrogen called an H II region.

The astronomers found a photodissociation region caused by ultraviolet (UV) photons from other, more massive stars in the area, plus stellar winds that provide the heat that affects the gas chemistry. They found the 72-

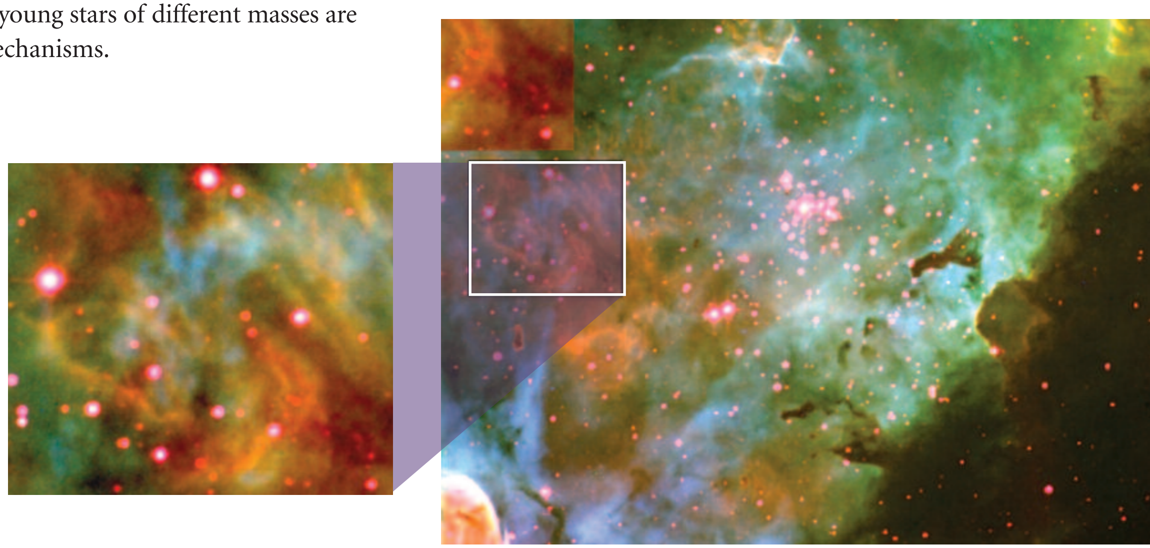


Image courtesy Miguel Roth

The inset of this image shows the area (in red) where Miguel Roth and colleagues discovered the 72-member group of young stars in the Carina Nebula. They are embedded in filaments of a hydrogen cloud, a typical birthplace for newborn stars.

member cluster of young stars embedded at the top of a pillar-like structure made of dust just behind this region.

The scientists discovered that their young star group shares many features of recent star formation with stars of different masses formed elsewhere in the Carina Nebula. Scientists believe that the heating mechanism of star formation for those other stars was the interaction of UV radiation from a previous generation of stars and winds with the interstellar medium. They think that the original molecular cloud interacts with this radiation and forms photodissociation areas, which appear as dust structures that resemble pillars and "elephant trunks." Stars form toward their tops. Roth and team believe that the same formation scenario is likely for their new group of 72 stars. The astronomers hope to unravel the different formation processes with a new infrared spectrograph on the Magellan telescope called FIRE, an instrument built by investigators at MIT.

Image courtesy Paolo Persi

Miguel Roth (back) and his colleagues Paolo Persi (middle) and Mauricio Tapia are on a three-night observation run.

Behold Galacticus!

Galacticus is not a super hero. Galacticus is a super model used to determine the formation and evolution of the galaxies. Developed by Andrew Benson, the George Ellery Hale Distinguished Scholar in Theoretical Astrophysics, it is one of the most advanced models of galaxy formation available.

Rather than building his model around observational data, Benson's Galacticus relies on known laws of physics and the so-called N-body problem, which predicts the motions of celestial bodies that interact gravitationally in groups. Galacticus' results are stunning 3-D videos.

Some 80% of the matter in the universe cannot be seen. This unseen matter is believed to be cold, dark matter, and it forms a halo around galaxies like our Milky Way. Dark matter affects how galaxies form. Galacticus solves the physics of galaxy formation inside a hierarchy of dark matter halos, which are linked in tree-like structures called merger trees. Galacticus is "fed" merger trees and then populates them with galaxies.

Benson and colleagues have run numerous simulations, including a simulation of the reionization period—an epoch between about 200 million and one billion years after the Big Bang—when neutral hydrogen began to form quasars, stars, and the first galaxies. Benson examined the growth of ionization fronts—clouds of hydrogen in the intergalactic medium that has been stripped of electrons. He modeled a star-forming protogalaxy with an energetic, dense, bright area near its center called an Active Galactic Nucleus (AGN). The stars and AGN yielded ultraviolet and X-ray photons that produced an ionization front. The results will guide future surveys of this epoch.

Benson, with colleague Arif Babul, is also modeling the growth of black holes with highly energetic jets at their

Observatories, *Continued*

center within a hierarchically growing population of galaxies. Researchers believe the spin of the black hole drives the jets; the model computes this spin rate and the power of the jets.

Benson has ambitious plans for Galacticus, including simulating a very early and hidden part of the universe dubbed the submillimeter universe when light was obscured by dust. Thus far, theorists have not been able to model it successfully. □

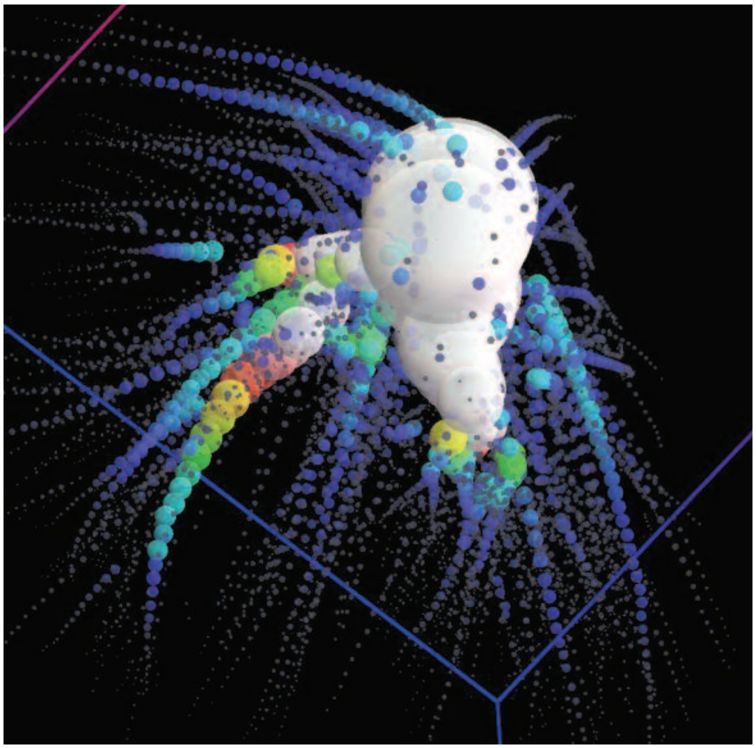


Image courtesy Andrew Benson

Left top: This still image shows a representation of a merger tree from one of Galacticus' calculations. Each colored sphere represents a dark matter halo that grows with time and eventually merges with other dark matter halos.

Below: Andrew Benson at the Griffith Observatory

Right: This image shows a simulated patch of sky containing many thousands of galaxies. Benson's model produced this image; it represents what the Hubble Space Telescope would see if it were able to "observe" Benson's model universe. It was made with collaborators Rick White and Mike Fall.

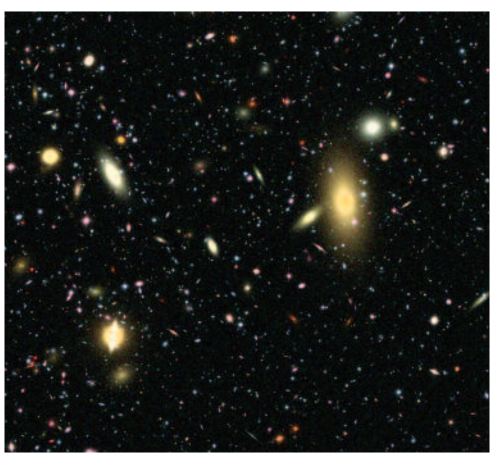
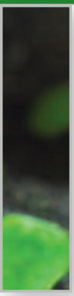


Image courtesy Andrew Benson, Rick White, and Mike Fall

Image courtesy Andrew Benson

Plant Biology

Characterizing the Genes of Plant Growth and Development




Pumped Up Plants

Steroids are important hormones in both animals and plants. Steroids bulk up plants just as they do human athletes, but the pathway of molecular signals that tell the genes to boost growth and development is more complex in plant cells than in human and animal cells. Unlike animals, plants do not have glands to produce and secrete hormones. Rather, each plant cell has the ability to generate hormones. Another difference is that animal cells typically have receptor molecules that respond to select steroids located within a cell's nucleus. In plants, steroid receptors are anchored to the outside surface of a cell's outer membrane—the membrane that delineates a cell as a single unit thus requiring relay systems to trigger changes in gene regulation in the nucleus.

In a tour de force, Carnegie's Zhiyong Wang has been homing in on the chemical signaling pathways of one major class of plant hormones called brassinosteroids, making it one of the best-studied aspects of cellular physiology. As it turns out, brassinosteroids are not only involved in pumping up the plant, they conduct in an incredibly wide array of functions, including response to environmental stresses, cell elongation, and resistance to pathogens.

Mutant plants that are deficient in brassinosteroids show many defects at various phases of the plant life cycle, including reduced seed germination, irregular growth in the dark, altered pattern of organ formation, dwarfism, and sterility. Brassinosteroids also control the leaf angle, which is critical for optimal energy capture and thus yield. As such, understanding the brassinosteroid pathway could help researchers improve plant growth and hardiness, which could increase crop yields and help fight world hunger.

The Wang lab has become the leader in uncovering this exciting signaling pathway. In 2012, Wang and his lab again expanded our understanding of many important aspects of the pathway. They made new breakthroughs in

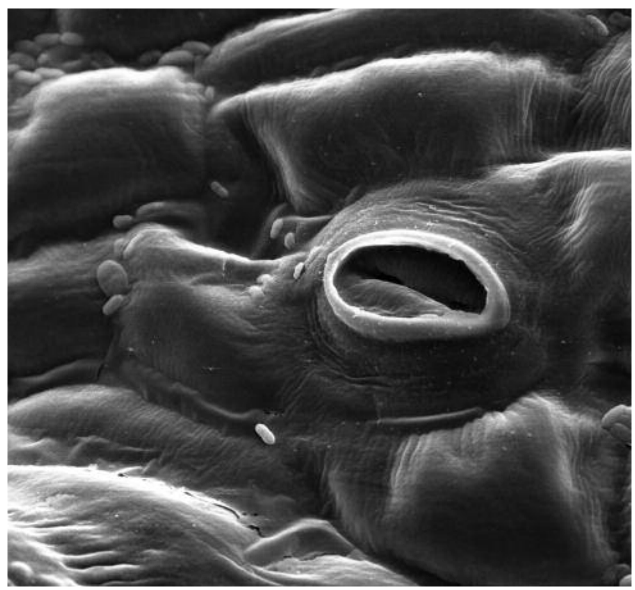


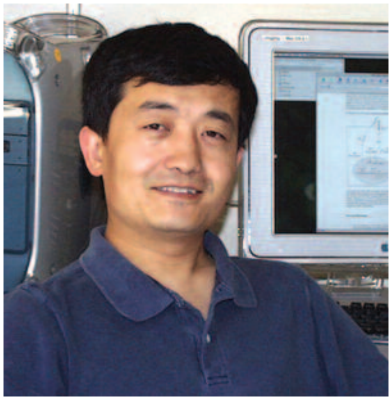
Image courtesy Dartmouth College Electron Microscope Facility

A plant's leaves are sealed with a gastight wax layer to prevent water loss. A plant breathes through microscopic pores called stomata (Greek, for mouths) on the surfaces of its leaves, shown here. Zhiyong Wang and team found that brassinosteroids are involved in regulating the developmental process for these crucial plant organs.

Image courtesy www.public-domain-image.com

When a seed germinates underground, it rapidly elongates its stem to reach the soil's surface. If its neighbor shades the plant, it elongates its stem to out compete its neighbors for sunlight. Under full sunlight, the plant's priority is leaf expansion. Management of these responses to environmental signals is, at least in part, controlled by a "command center" that involves brassinosteroids and another major class of plant hormones called gibberellins.

Image courtesy Department of Plant Biology



Zhiyong Wang

how brassinosteroids are involved in the distribution of a plant's gas-exchange system, as well as breakthroughs in how a plant responds to changes in light and temperature. Moreover, they discovered a system of "cross-talk," by which brassinosteroids interact with a chemical signaling system controlled by another major class of plant hormones called gibberellins. Together, brassinosteroids and gibberellins form a "command center" controlling plant growth and environmental responses. Wang believes this network will be a major target for genetically engineering high-yielding crops.

A Paradigm Shift in Plant Disease Resistance

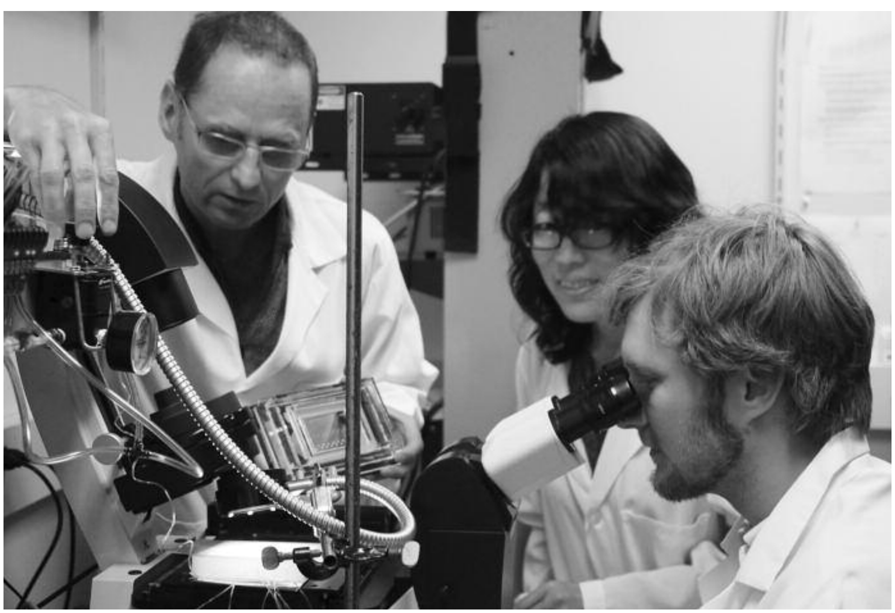
Feeding a growing population, resisting plant disease, and overcoming the human problems of obesity and diabetes have one thing in common: they involve sugar transport by SWEET proteins. Plants and humans use sugars as key compounds to distribute carbon, energy, and a common set of transport proteins (SWEETs) that Wolf Frommer's lab discovered. SWEETs hold the key to increasing crop yields. They open a completely new way to prevent plant diseases. Excitingly and unexpectedly, they also may help researchers understand how sugars are transported in human cells, with implications for our understanding of diabetes and obesity.

Plants capture light energy and convert atmospheric carbon dioxide and water to create the sugar sucrose. Sucrose biosynthesis occurs inside green leaf cells, which are connected to all other plant organs via a network of veins, the phloem. Unlike animals, plants do not have a mechanical pump for distributing sugars and other nutrients; they use a molecular pump instead. Over the course of 20 years, Wolf Frommer and his lab have identified the core components of this pump—starting with identifying the active pore proteins that load sucrose into the plant's veins. But the mechanism that gets the sugar out of the cells that produced it in the first place remained elusive.

Frommer's team tracked down these missing links, named SWEETs, with novel tools: fluorescent Förster resonance energy transfer biosensors. These sensors report sugar levels in subcompartments of individual cells and quantify them by a color change. The technology has myriad research uses, including the study of brain chemistry, cancer, and biofuel development.

Over the past two years, the team discovered that bacteria and fungi hijack the SWEET sugar transport pores to access the plant sugar. The pathogens enter the spaces between the cells, camp out, pick the lock to the pantry, dine, reproduce, and dash. The pathogens inject activator proteins into the cell that directly turn on sugar efflux transporters—the floodgate mechanism at the plasma membrane that pumps sugars out of the cell for the pathogen to steal. This is the first time scientists have a direct handle on controlling the food supply to pathogens, which opens a new avenue for preventing a wide range of crop diseases. Additionally, fine-tuning the SWEETs may help produce higher crop yields. And because humans also use SWEETs to transport glucose, understanding the sugar-transporting mechanism could lead to breakthroughs in medicine. □

Images courtesy Wolf Frommer



Plant Biology director Wolf Frommer (left) discusses the new microfluidic chip for live imaging of plant roots with Li-Qing Chen (center), lead author of the *Science* and *Nature* articles describing the identification of the SWEET transporters, and Guido Grossmann (right), lead author of the *Plant Cell* and *JoVE* articles describing the development and use of the novel RootChip technology.

Terrestrial Magnetism

Understanding Earth, Other Planets, and Their Place in the Cosmos

Moon Awash with Water

The Moon has much more water than previously thought, according to a team of scientists led by geochemist Erik Hauri. Their research shows that droplets of magma trapped within crystals collected during the Apollo 17 mission contain 100 times more water than earlier measurements recorded. The lunar magmas are just as wet as Earth's mid-ocean-ridge basalts—a common volcanic rock—which means that the Earth's mantle and the Moon's mantle could have similar amounts of water. The finding could overturn the prevailing theory about the Moon's origin.

The team used Carnegie's state-of-the-art NanoSIMS 50L ion probe. This instrument shoots a beam of charged particles at tiny samples to determine their trace element composition with unparalleled precision; the team's unique techniques can detect extremely minute quantities of water in glasses and minerals. The researchers measured seven bits of magma trapped within lunar crystals. Because these bits, called inclusions, are encased in crystals, water and other easily evaporative (i.e., volatile) materials could not escape during the eruptions that brought them to the Moon's surface eons ago.

The Earth and the other inner planets contain relatively low amounts of water and volatile elements, which were

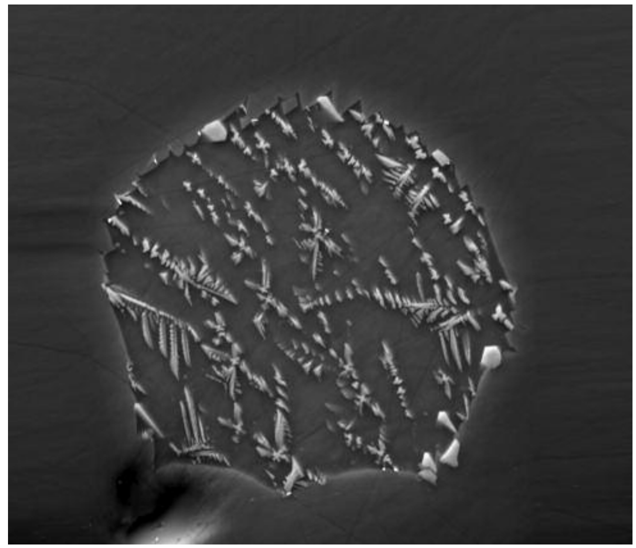


Image used with permission, © AAAS, Science Express

not abundant in the inner Solar System during planet formation. The Moon has even lower quantites of these volatile elements, which has long been claimed as evidence that the Moon must have formed from material ejected from the Earth as a result of a catastrophic giant impact. But this new research shows that aspects of this theory must be reevaluated, because such an impact would have been expected to cause the escape of these volatiles.

The study also puts a new twist on the origin of water ice detected in craters at the lunar poles by several recent NASA missions. The ice has been attributed to comet and meteoroid impacts, but it is possible that some of this ice could have come from the water released by past eruptions of lunar magmas.

Researchers should take these findings into account when analyzing samples from other planetary bodies in our Solar System. Hauri's team believes that their unique method of analysis provides an accurate and direct way to determine the water content of a planet's interior.

Image courtesy Erik Hauri

Left top: This is an optical photograph of a droplet of solidified melt within an olivine crystal from the Apollo 17 mission. It is about 40 microns in diameter. Analysis of the Apollo 17 samples indicates that the Moon has 100 times more water than found in previous measurements.

Left bottom: Carnegie's Erik Hauri (left) sits with coauthor Alberto Saal in the lab.

Particles to Planets

Comets and asteroids represent the building blocks of our Solar System and thus record the physics and chemistry of how planets formed. But there are puzzles: How did icy comets obtain particles made by high-temperature conditions? How did the particles acquire different compositional layers ("rims"), and when did they form? Collaboration between theoretical astrophysicist Alan Boss and cosmochemist Conel Alexander, with colleague Morris Podolak, is answering these riddles and illuminating the earliest stages of Solar System formation.

The protosun in the early solar nebula is thought to have experienced a series of outbursts propelling particles of many sizes through the nebula to distances ranging from one astronomical unit (the Earth/Sun distance, AU) to 10 AUs. Boss and Alexander are the first to model the particles' trajectories. They modeled 200 2-centimeter spherical particles (representing calcium-aluminum-rich inclusions (CAIs) from primitive meteorites) over 200 years and predicted their thermal and chemical processing.

The model assumed a solar nebula with a mass about 5% of today's Sun, with temperatures ranging from a frigid -351°F (60 K) in the outer regions to a scorching 2240°F (1500 K) near the center. The calculations allowed the CAIs—dominated by the mineral melilite—to orbit, interact with the disk gas and pressure, and gravitationally interact with the protosun.

The 2-centimeter particles started orbiting in unison, but after about 20 model years their trajectories started to diverge significantly. Some particles reached the hot, central disk, while others headed for the cold, outer disk; some did both.

The researchers modeled a number of different evaporation and condensation scenarios for melilite. The model

Terrestrial Magnetism, *Continued*

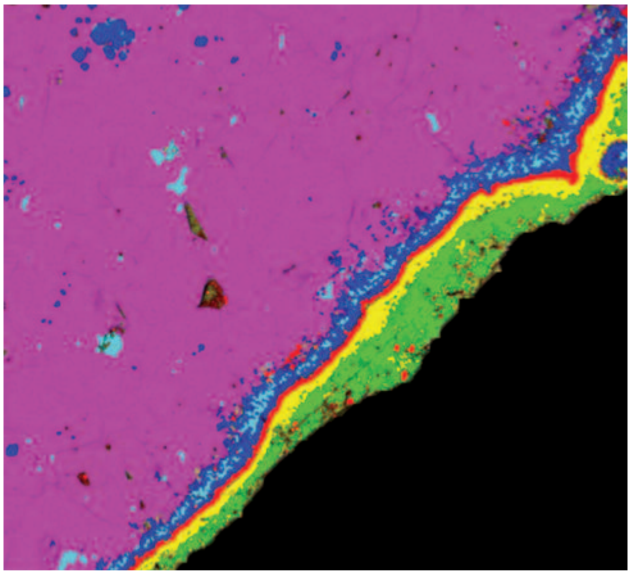
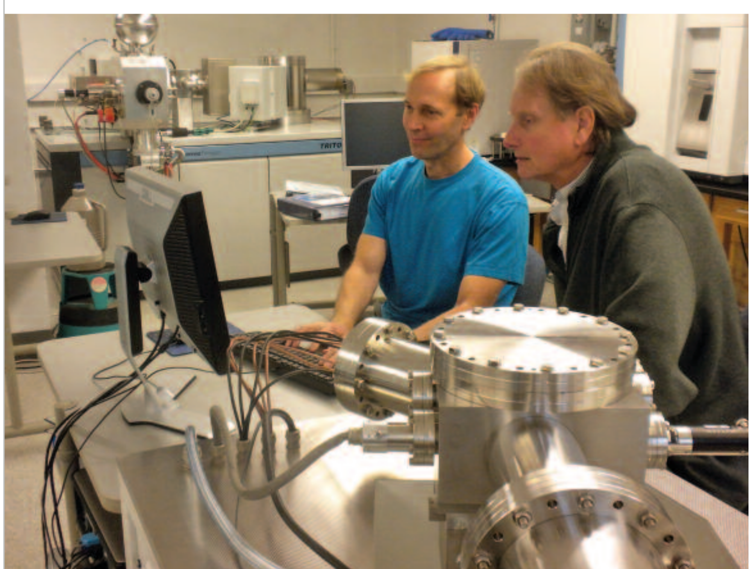


Image courtesy Justin Simon



mage courtesy Kasey Cunningham

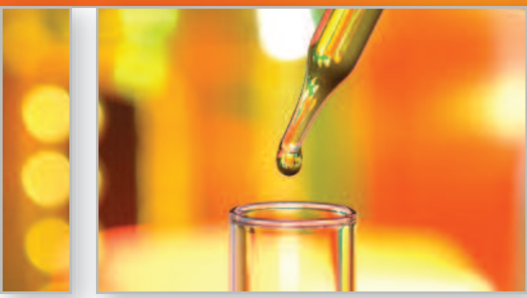
indicated that the particles could have undergone processing in the hot inner disk and then moved to the frigid outer regions, explaining how particles with compositions indicating high temperatures of formation could have ended up in icy comets. The results also showed some strange trips back and forth, which could explain the layers with different oxygen isotopes found in some particles. (Isotopes are varieties of oxygen with different numbers of neutrons.) The varying isotope compositions reflect different processing conditions: some isotopes are associated with processing near the protosun, while others are associated with the planet-formation areas. The fact that particles survived the mayhem suggests that they were processed during a late outburst, which counters current assumptions that they formed during earlier stages of Solar System formation. □

Top left: This X-ray image shows the compositional differences along the rim of a typical Type A calcium-aluminum-rich particle. This particle was found within the Allende meteorite.

Bottom left: Cosmochemist Conel Alexander (left) and theoretical astrophysicist Alan Boss (right) collaborated on modeling the trajectories of tiny particles in the early Solar System to decipher what happened during the earliest stages of Solar System formation.

First Light & The Carnegie Academy for Science Education

Teaching the Art of Teaching Science and Math



Retooling Teaching With Friendship

This past year, Carnegie Academy for Science Education (CASE) staff (Julie Edmonds, Toby Horn, and Marlena Jones) teamed with Friendship Collegiate Academy, a public charter school in northeast Washington, D.C., to help develop a new teaching approach in the school's Allied Health and PolyTech Career Academies. Friendship's objective is to emphasize interdisciplinary Science, Technology, Engineering, and Math (STEM) instruction integrated with English and social studies across its academies.

Seventeen 11th and 12th grade teachers participated in the CASE Summer Institute to learn how to teach using project-based learning. In this approach, the teacher becomes an academic coach and guides students to take control of a topic within a theme and explore it independently.

CASE encouraged the interdisciplinary teams from each academy to choose an interesting, challenging, and rich question to drive instruction across the disciplines. In the Allied Health project, "What is Healthy Living?," a social studies segment examines historical farming practices in the United States, including foods and recipes. The science unit investigates the physics behind Olympic gymnastics, while the microbiology unit explores the role of microbes in food and disease. Other courses contribute similarly relevant topics. The academy's effort will culminate in a community health fair and walk, with student projects on display.

The PolyTech Academy chose to examine the Washington, D.C., subway system, Metro. Facets of this project, "Is Metro Safe, Reliable, and Effective?," are exploring the history of transportation in the city, how to redesign cars to hold more passengers without them feeling crowded, and the physics behind the Metro accident that killed nine people near the Fort Totten station in 2009. At the end of this project, the students will present their recommendations for improvements to the Metro Board.

Some of the teachers were also blended into a six-week student research project in astrobiology, "Life in Extreme Environments," led by Julie Edmonds. Since most of the students in the program attend Friendship, the teachers could see firsthand how their own students became engaged when given the chance to learn independently.

Math for America Spreads its Wings

This past academic year 14 Math for America (M*f*A) fellows taught mathematics to some 1,200 high-need students in Washington, D.C., public schools. Six more fellows began teaching in the current school year, and four more began this year's 15-month training program. Carnegie and American University run the Washington, D.C., M*f*A (M*f*A DC) program.

All M*f*A fellows attend professional development sessions and are guided by mentors to sharpen their skills.

First Light & The Carnegie Academy for Science Education, *Continued*

Images courtesy Toby Horn

Top: PolyTech Academy teachers explore the engineering, physics, and math connections of a proposed student activity before making their decision to pursue the Metro project. From left to right: Jaclyn Claiborne, engineering, math, and statistics; Christian Schaefer, engineering; Aaron Morton, digital graphics and software applications.

Bottom: John Neral, guest speaker from the District of Columbia's Office of the State Superintendent for Education, spoke about the new Common Core State Standards for Mathematics. Seated from left to right: Julie Edmonds, CASE co-director (in yellow); Sarah Bax, CASE Mentor Teacher and M*f*A DC Master Teacher (in pink); Carlyle Chalmers, Friendship PolyTech Academy video production teacher (in purple); and Francis Ayissi, 10th grade chemistry teacher (in blue).

In addition to a background in mathematics, teachers must be able to connect with high-need youngsters, have a sense of humor, be flexible, and be resilient. Perhaps most importantly, they need to convey the joy of learning math with a contagious enthusiasm for the subject.

The staff at M*f*A has made a number of enhancements since 2009, including improved professional development and the inauguration of a Master Teacher Fellowship. James Tanton, who now leads professional development for M*f*A DC, mesmerizes students and teachers with his animated teaching approach. Tanton deconstructs problems so others understand the reasons why, for instance, multiplying two negative numbers creates a positive one. (See Tanton's style and approach to mathematics at www.jamestanton.com.)

The year 2012 marks the second year for the Master Teacher Fellowship. The goal is to establish five master teachers to encourage math teachers to continue in their field and to help develop leadership skills for high-needs instruction. Master teachers have degrees in mathematics and have taught for at least four years. These fellows receive stipends and professional development support. The first M*f*A DC Master Teacher, Sarah Bax, received the 2011 Presidential Award for Excellence in Mathematics and Science Teaching. □

Image courtesy James Tanton

Image courtesy NSF

Top: Mathematician James Tanton directs professional development for the Washington, D.C., Math for America chapter. Tanton has a Ph.D. in mathematics from Princeton University.

Bottom left: Sarah Bax, the first M*f*A Master Teacher from the Washington, D.C., chapter, received the 2011 Presidential Award for Excellence in Mathematics and Science Teaching. She has been teaching in Washington, D.C., public schools for 18 years; she currently teaches at Hardy Middle School.

Financial Profile

for the year ending June 30, 2012 (unaudited)

Reader's Note: *In this section, we present summary financial information that is unaudited. Each year the Carnegie Institution, through the Audit committee of its Board of Trustees, engages an independent auditor to express an opinion about the financial statements and the financial position of the institution. The complete audited financial statements are made available on the institution's website at www.CarnegieScience.edu.*

The Carnegie Institution of Washington completed fiscal year 2012 in sound financial condition due to the positive returns (+5.30%) of the diversified investments within its endowment; a disciplined spending policy that balances today's needs with the long-term requirements of the institution and the interests of future scientists; and the continued support of organizations and individuals who recognize the value of nurturing basic science.

The single primary source of support for the institution's activities continues to be its endowment. This reliance on institutional funding provides an important degree of independence in the research activities of the institution's scientists.

As of June 30, 2012, the endowment was valued at $795 million. Over the period 2001-2012, average annual increases in endowment contributions to the budget were 5.5%. Carnegie closely controls expenses in order to ensure the continuation of a healthy scientific enterprise.

For a number of years, under the direction of the Finance committee of the board, Carnegie's endowment has been allocated among a broad spectrum of asset classes including: fixed-income instruments (bonds), equities (stocks), absolute return investments, real estate partnerships, private equity, and natural resources partnerships. The goal of this diversified approach is to generate attractive overall performance and minimize the volatility that would exist in a less diversified portfolio.

The Finance committee of the board regularly examines the asset allocation of the endowment and readjusts the allocation, as appropriate. The institution relies upon external managers and partnerships to conduct the investment activities, and it employs a commercial bank to maintain custody. The following chart shows the allocation of the institution's endowment among asset classes as of June 30, 2012.

Asset Class	Target	Actual
Common Stock	37.5%	40.5%
Alternative Assets	55.0%	54.0%
Fixed Income and Cash	7.5%	5.5%

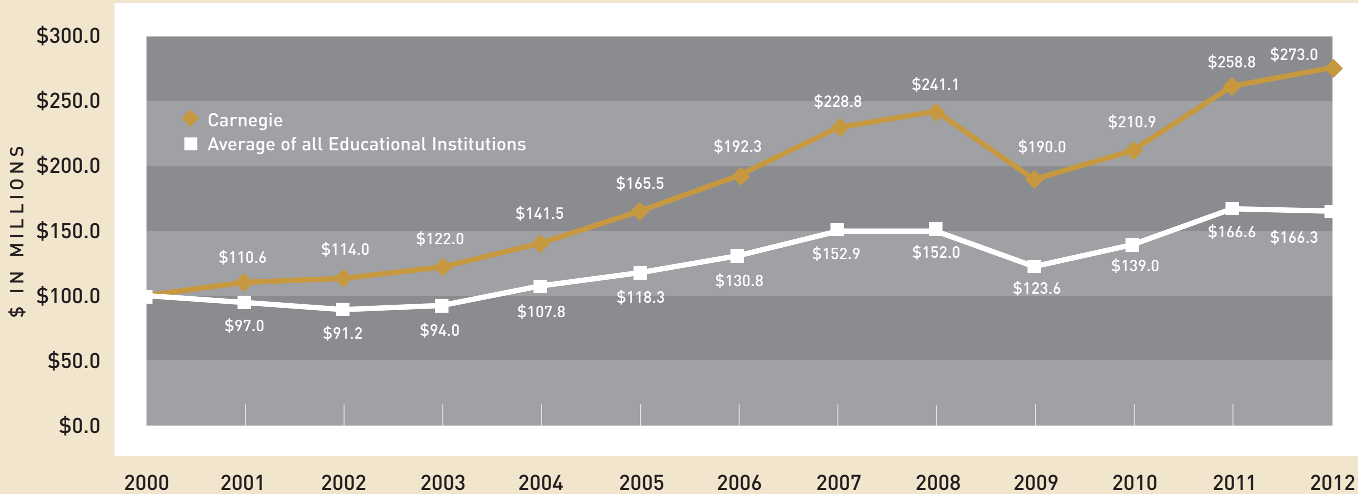
Carnegie's investment goals are to provide high levels of current support to the institution and to maintain the long-term spending power of its endowment. The success of Carnegie's investment strategy is illustrated in the following figure that compares, for a hypothetical investment of $100 million, Carnegie's investment returns with the average returns for all educational institutions for the last twelve years.

Carnegie has pursued a long-term policy of controlling its spending rate, bringing the budgeted rate down in a gradual fashion from 6+ % in 1992 to 5.00% today. Carnegie employs what is known as a 70/30 hybrid spending rule. That is, the amount available from the endowment in any year is made up of 70% of the previous year's budget, adjusted for inflation, and 30% of the most recently completed year-end endowment value, multiplied by the spending rate of 5.0% and adjusted for inflation and for debt. This method reduces volatility from year-to-year. The following figure depicts actual spending as a percentage of ending market value for the last 20 years.

In fiscal year 2012, Carnegie benefitted from continuing federal support. Carnegie's federal support has grown from $24.5 million in 2006 to more than $34.5 million in new grants in 2012. This is a testament to the high quality of Carnegie scientists and their ability to compete successfully for federal funds in this period of fiscal restraint.

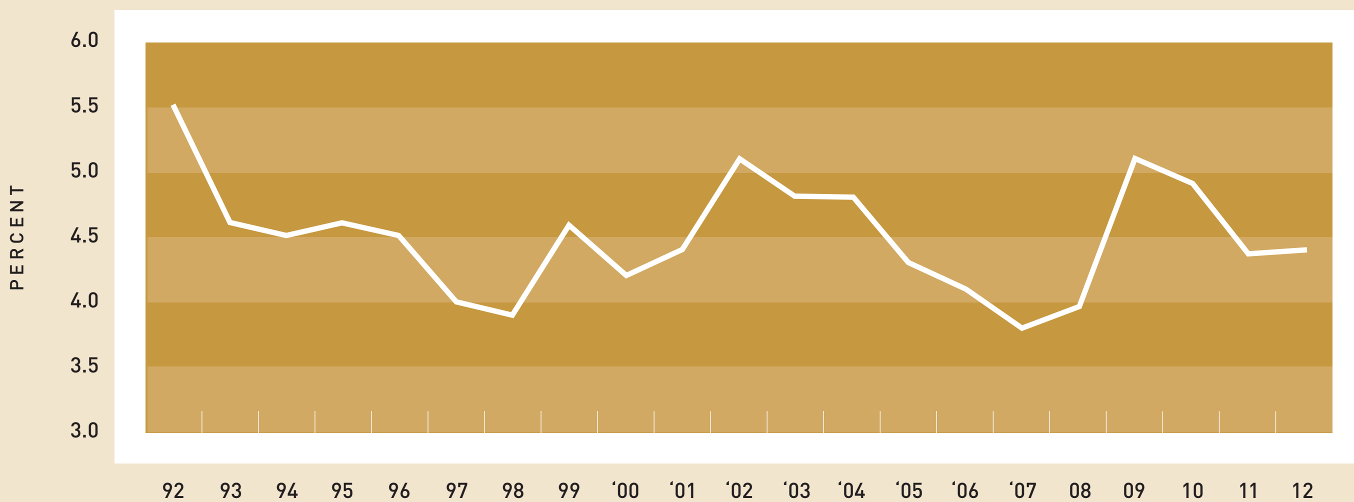
Carnegie also benefits from generous support from foundations and individuals. Funding from foundations has grown from an average of about $3 million/year in the period from 2000 to 2004 to $7.4 million in 2012. Within Carnegie's endowment, there are a number of "funds" that provide support either in a general way or targeted to a specific purpose. The largest of these is the Andrew Carnegie Fund, begun with the original gift of $10 million. Mr. Carnegie later made additional gifts totaling another $12 million during his lifetime. This tradition of generous support for Carnegie's scientific mission has continued throughout our history and a list of donors in fiscal year 2012 appears in an earlier section of this year book. In addition, Carnegie receives important federal and private grants for specific research purposes, including support from the Howard Hughes Medical Institute for researchers at the Department of Embryology.

Illustration of $100 Million Investment - Carnegie Returns vs. Average Returns for All Educational Institutions (2000-2012)



Average returns for educational institutions are taken from Commonfund reports on endowment performance.

Endowment Spending as a Percent of Ending Endowment Value*



*Includes debt financing.

Statements of Financial Position (unaudited)

June 30, 2012, and 2011

	2012	2011
Assets		
Current assets:		
Cash and cash equivalents	$ 2,224,055	$ 1,518,067
Accrued investment income	47,721	0
Contributions receivable	18,495,658	7,298,027
Accounts receivable and other assets	21,436,261	17,279,764
Bond proceeds held by Trustee	15,694	17,694
Total current assets	$ 42,219,389	$ 26,113,552
Noncurrent assets:		
Investments	794,835,568	795,672,507
Property and equipment, net	152,340,983	154,768,137
Total noncurrent assets	$947,176,551	$950,440,644
Total assets	$989,395,940	$976,554,196
Liabilities and Net Assets		
Accounts payable and accrued expenses	$ 11,449,485	$ 10,918,845
Amount held for others	0	0
Deferred revenues	29,670,190	31,307,772
Bonds payable	65,706,919	65,728,416
Accrued postretirement benefits	19,991,999	17,206,079
Total liabilities	$126,818,593	$125,161,112
Net assets		
Unrestricted	$253,993,414	$244,949,855
Temporarily restricted	553,628,669	551,513,903
Permanently restricted	54,955,264	54,929,326
Total net assets	$862,577,347	851,393,084
Total liabilities and net assets	$989,395,940	$976,554,196

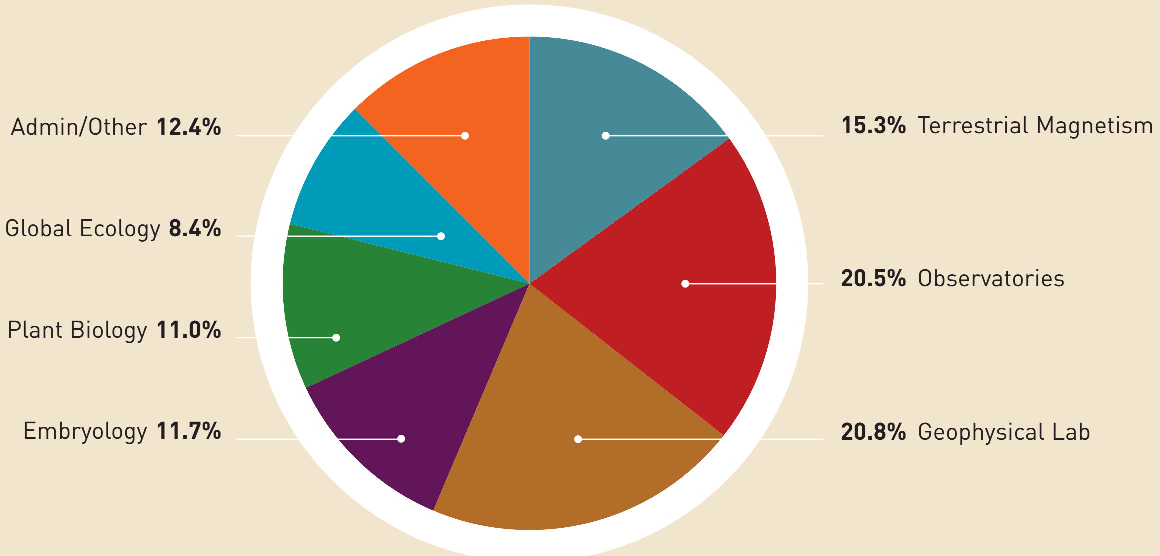
Statements of Activities[1] (unaudited)

Periods ended June 30, 2012, and 2011

	2012	2011
Revenue and support:		
Grants and contracts	$ 40,529,751	$ 40,480,694
Contributions, gifts	26,801,795	13,081,598
Other income	7,820,546	18,583
Net external revenue	$ 75,152,092	$ 53,580,875
Investment income and unrealized gains (losses)	$ 36,181,149	$153,142,080
Total revenues, gains, other support	$111,333,241	$206,722,955
Program and supporting services:		
Terrestrial Magnetism	$ 14,972,184	$ 11,957,202
Observatories	20,071,881	21,920,605
Geophysical Laboratory	20,425,062	19,962,665
Embryology	11,467,512	9,670,782
Plant Biology	10,778,313	10,032,715
Global Ecology	8,241,999	6,267,032
Other programs	852,665	1,050,387
Administration and general expenses	11,259,427	10,556,630
Total expenses	$ 98,069,043	$ 91,418,018
Change in net assets before pension related changes	$13,264,198	$115,304,937
Pension related Changes	(2,079,935)	(1,359,592)
Net assets at the beginning of the period	$851,393,084	$737,447,739
Net assets at the end of the period	$862,577,347	$851,393,084

[1] Includes restricted, temporarily restricted, and permanently restricted revenues, gains, and other support.

2012 Expenses by Department ($98.1 Million)



Personnel

July 1, 2011-June 30, 2012

Carnegie Administration

Cynthia Allen, *Director of Administration and Finance*[1]
Maceo Bacote, *Events Coordinator*[2]
Benjamin Barbin, *Manager of Advancement Activities*
Shalini Batra, *Events Coordinator*[3]
Shaun Beavan, *Systems Administrator*
Gloria Brienza, *Budget and Management Analyst Manager*
Donald Brooks, *Building Maintenance Specialist*
Marjorie Burger, *Financial Manager*
Cady Canapp, *Manager of Human Resources and Insurance*
Irene Chen-Sterling, *Manager of Advancement Operations*
Dianne Cross, *Events Coordinator*[4]
Iva Dennis, *Payroll Coordinator*[5]
Morgan Dissin, *Special Events and Building Asssistant*[6]
Robert Ellis, *Web Developer*[7]
Kristen Fisher, *Special Events and Facility Coordinator*
Alexis Fleming, *Special Events and Facility Coordinator*
Shawn Frazier, *Accounting Assistant*
Dina Freydin, *Senior Grants Accountant*
Susanne Garvey, *Director of External Affairs*
Darla Keefer, *Special Assistant for Administration and Building Operations*
Mulyono Kertajaya, *Business Data Analyst*
Ann Keyes, *Payroll Coordinator*[8]
Brian Kim, *Research Assistant*[9]
Yang Kim, *Deputy Financial Manager*
G. Gary Kowalczyk, *Director of Administration and Finance*[10]
Brian Loretz, *Senior Manager of Prospect Research*
Mark Maskell, *Web Developer*[11]
Tina McDowell, *Editor and Publications Officer*
Kelley McKutchin, *Special Events Coordinator*[12]
Richard A. Meserve, *President*
Natasha Metzler, *Science Writer*
Christina Naguiat, *Executive Assistant to the President*
June Napoco-Soriente, *Financial Accountant*
Alicia North, *Payroll Coordinator*[13]
Tessa Pagones, *Donor Vision Specialist*[14]
Mikhail Pimenov, *Endowment Manager*
Gotthard Sághi-Szabó, *Chief Information Officer*
C. Rick Sherman, *Chief Advancement Officer*
Harminder Singh, *Financial Accountant*
John Strom, *Multimedia Designer/Producer*
Gabor Szilagyi, *Information Systems Technician*[15]
Laura Unterholzner, *Special Events/Building Assistant*
Yulonda R. White, *Human Resources and Records Coordinator*
Jacqueline Williams, *Assistant to Human Resources and Insurance Manager*

[1] From April 2, 2012
[2] From April 25, 2012
[3] From August 1, 2011, to October 10, 2011
[4] From September 10, 2011, to November 20, 2011
[5] From July 11, 2011, to November 30, 2011
[6] From May 15, 2012
[7] To March 30, 2012
[8] To August 1, 2011
[9] From June 14, 2012
[10] To October 31, 2011
[11] From April 23, 2012
[12] From May 7, 2012
[13] From December 16, 2011
[14] From June 9, 2011, to November 30, 2011
[15] From September 14, 2011

Carnegie Academy for Science Education

Bianca Abrams, *Director, Math for America*
Brianna Anderson, *STARS Program Intern, D.C. Summer Youth Employment Program (SYEP)*[3]
Sarah Bax, *MfA Master Teacher, CASE Mentor*[1]
Cassandra Becker, *Math for America Fellow*[2]
Jeannette Benham, *Math for America Fellow*[2]
Guy Brandenburg, *First Light Instructor, CASE and former MfA Mentor*
Lawrence Chien, *Math for America Fellow*
Amy Danks, *Math for America Fellow*
Rebecca Dunn, *Math for America Fellow*
Julie Edmonds, *Codirector, CASE*
Anne Farrell, *Math for America Fellow*
Joseph Herbert, *Math for America Fellow*
Krystn Hodge, *Math for America Fellow*
Alexandra Horenstein, *CASE Teacher Fellow*[3]
Toby Horn, *Codirector, CASE*
Dasia Jacob, *STARS Program Intern (SYEP)*[3]
Marlena Jones, *Coordinator of CASE Programs*
Molley Kaiyoorowongs, *Math for America Fellow*
Brian Kim, *Research Assistant*[3]
Sarah Kennedy, *CASE Intern (SYEP)*[3]
Conor Kenney, *Math for America Fellow*
Ariel Kramer, *Math for America Fellow*
Sophia Lallinger, *Math for America Fellow*
Lindsay Mann, *Math for America Fellow*
Mirielle Mbipeh, *STARS Program Intern (SYEP)*[3]
Dakari McAdoo, *First Light Volunteer*
Jeanah McCall, *CASE Intern (SYEP)*[3]
Mychelle McCreary, *CASE Intern*[3]
Max Mikulec, *Math for America Fellow*
Jessica Ogle, *Math for America Fellow*
Maximilian Olivier, *Math for America Fellow*
Julia Penn, *Math for America Fellow*
Jessica Reynolds, *Math for America Fellow*
Grier Starling, *STARS Program Intern (SYEP)*[3]
Monica Thomas, *Program Manager, Math for America*[4]
Samuel Trichtinger, *Math for America Fellow*
Meredith Wachs, *Math for America Fellow*
Maya Washington, *STARS Program Intern (SYEP)*[3]
Heather Zelinsky, *Math for America Fellow*

[1] From September 1, 2011
[2] From May 31, 2012
[3] Summer 2011
[4] From April 16, 2012

EMBRYOLOGY *Front row* (left to right): Allan Spradling, Alex Bortvin, Marnie Halpern, Joe Gall, Steve Farber, Chen-Ming Fan, Christoph Lepper, Jeff Han, Fred Tan. *Second row:* Rafael Villagaray, Ming-Chia Lee, Lynne Hugendubler, Gabriela Rodriguez, Alexis Marianes, Patricia Cammon, Ella Jackson, Rejeanne Juste, Allen Strause, Sean Watson, Earl Potts. *Third row:* Xiaobin Zheng, Mahmud Siddiqi, Michael Sepanski, Chandra Harvey, Lucy Morris, Jun Wei Pek, Steven Ching, Rob Vary, Vanessa Quinlivan-Repasi, SiewHui Low, Lydia Li, Wilber Ramos, Eric Mills, Tom McDonaugh. *Fourth row:* Haiyang Chen, Troy Horn, Mohammed Shamim, Yuxuan Guo, Michael Harris, Svetlana Deryusheva, Chun Dong, Oni Mapp, Blake Caldwell, Sara Roberson, Rebecca Obniski, Eric Duboué, Aaron Katrikh, Sheryl Murray, Ethan Greenblatt. *Fifth row:* Eugenia Dikovskaia, Valeriya Gaysinskaya, Erin Zeituni, Alice Hung, Ona Martin, Dianne Williams, Vicki Losick, Elim Hong, Lei Lei, Vanessa Matos-Cruz, Jianjun Sun, Estela Monge, Ivana Celic, Michelle Macurak, Tagide deCarvalho, Allison Pinder, Yihan Wan, Abhignya Subedi, Glenese Johnson. *Sixth row:* Zhonghua Liu, Anna McGeachy, Shusheng Wang, Mario Izaguirre-Sierra, Matthew Sieber, Juliana Carten, Yue Zheng, Jen Anderson, Carol Davenport, Christine Pratt, Helan Xiao, Liangji Li, Reid Woods, Diana Camerota. *Seventh row:* Matthew Brown, Dolly Chin, Micah Webster, Axel Horn, Shiying Jin, Marlow Minor, Pavol Genzor, Irena Martirosyan.

Embryology

Research Staff Members

Alexsky Bortvin
Donald D. Brown, *Director Emeritus*
Chen-Ming Fan
Steven Farber
Joseph G. Gall
Marnie Halpern
Nicholas T. Ingolia
Allan C. Spradling, *Director*
Yixian Zheng

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Christoph Lepper[1]
David MacPherson

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Ivana Celic, *Research Specialist*[2]
Haiyang Chen, *Research Associate, NIH Grant (Zheng)*
Sung Gook Cho, *Research Associate, NIH Grant (MacPherson)*[3]
Tagide deCarvalho, *Research Fellow, NRSA Postdoctoral Fellowship*
Svetlana Deryusheva, *Visiting Scientist, Carnegie*
Erik Duboué, *Research Associate, NIH Grant (Halpern)*[4]
Lucilla Facchin, *Carnegie Fellow*[5]
Rebecca Frederick, *Research Fellow, American Cancer Society Fellowship*
Megha Ghildiyal, *Research Fellow, Jane Coffin Childs Fellowship*
Ben Goodman, *Carnegie Fellow*[6]
Daniel Gorelick, *Research Associate, NRSA Postdoctoral Fellowship*
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Elim Hong, *Research Associate, NIH Grant (Halpern)*[8]
Axel Horn, *Research Associate, NIH Grant (Han)*
Troy Horn, *Carnegie Fellow*[9]
Mario Izaguirre-Sierra, *Carnegie Fellow*
Junling Jia, *Research Associate, Howard Hughes Medical Institute (Zheng)*
Shiying Jin, *Research Associate, NIH Grant (Fan)*[10]
Youngjo Kim, *Research Associate, Howard Hughes Medical Institute (Zheng)*
Ming-Chia Lee, *Research Associate, Howard Hughes Medical Institute (Spradling)*
Lei Lei, *Research Associate, Howard Hughes Medical Institute (Spradling)*
Christoph Lepper, *Research Associate, NIH Grant (Fan)*[11]
Robert Levis, *Special Investigator, NIH Grant, (Spradling with Baylor College of Medicine)*
Zhonghua Liu, *Research Associate, Howard Hughes Medical Institute (Zheng)*
Vicki Losick, *Research Fellow, Jane Coffin Childs Fellowship*
Siew Hui Low, *Research Associate, NIH Grant (Fan)*
Safia Malki, *Carnegie Fellow*
Oni Mapp, *Carnegie Fellow*
Irena Martirosyan, *Research Associate, NIH Grant (Han)*
Lucy Morris, *Research Associate, Howard Hughes Medical Institute (Spradling)*
Sheryl Murray, *Research Associate, NIH Grant (Lepper)*[12]
Zehra Nizami, *Carnegie Fellow*[13]

Jessica Otis, *Carnegie Fellow*[14]
Jun Wei Pek, *Research Associate, NIH Grant (Gall)*[15]
Matthew Sieber, *Research Associate, Howard Hughes Medical Institute (Spradling)*[16]
Jianjun Sun, *Research Associate, Howard Hughes Medical Institute (Spradling)*
James Walters, *Research Fellow, NRSA Postdoctoral Fellowship*
Shusheng Wang, *Research Associate, NIH Grant (Zheng)*
Micah Webster, *Research Associate, NIH Grant (Fan)*[17]
Zheng-an Wu, *Special Investigator, NIH Grant (Gall)*
Helan Xiao, *Carnegie Fellow*
Erin Zeituni, *Carnegie Collaborative Fellow*
Xiaobin Zheng, *Research Associate, NIH Grant (Zheng)*

Predoctoral Fellows and Associates

Diana Camerota, *The Johns Hopkins University*[18]
Juliana Carten, *The Johns Hopkins University*
Julio Castañeda, *The Johns Hopkins University*
Valeriya Gaysinskaya, *The Johns Hopkins University*
Pavol Genzor, *The Johns Hopkins University*
Yuxuan Guo, *The Johns Hopkins University*[19]
Michael Harris, *The Johns Hopkins University*
Lydia Li, *The Johns Hopkins University*
Peter Lopez, *The Johns Hopkins University*
Alexis Marianes, *The Johns Hopkins University*
Vanessa Matos-Cruz, *The Johns Hopkins University*
Katie McDole, *The Johns Hopkins University*
Anna McGeachy, *The Johns Hopkins University*
Eric Mills, *The Johns Hopkins University*
Rosa Miyares, *The Johns Hopkins University*
Zehra Nizami, *The Johns Hopkins University*[20]
Rebecca Obniski, *The Johns Hopkins University*[21]
Vanessa Quinlivan-Repasi, *The Johns Hopkins University*[22]
Sara Roberson, *The Johns Hopkins University*[23]
Michelle Rozo, *The Johns Hopkins University*
Abhignya Subedi, *The Johns Hopkins University*
Gaelle Talhouarne, *The Johns Hopkins University*[24]
Crystal Wall, *The Johns Hopkins University*
Blake Weber, *The Johns Hopkins University*[25]
William Yarosh, *The Johns Hopkins University*
Yue Zheng, *The Johns Hopkins University*[26]

Supporting Staff

Arash Adeli, *Animal Technician*
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Susan Artes, *Carnegie Science Outreach Coordinator*[27]
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Lauren Burkowske, *Animal Technician*[28]
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Bianca Cabri, *Research Undergraduate*[29]
Blake Caldwell, *Research Technician*[30]
Patricia Cammon, *Howard Hughes Medical Institute Laboratory Helper*
Dolly Chin, *Administrative Assistant*
Steven Ching, *Research Technician*[31]
Karina Conkrite, *Research Technician*
Min Cui, *Research Specialist*
Karena Curtis, *Student Volunteer*[32]
Carol Davenport, *Howard Hughes Medical Institute Research Technician III*
Eugenia Dikovskaia, *Animal Facility Manager*
Chun Dong, *Research Scientist*
Andrew Eifert, *Assistant Facility Manager*[33]
Eugene Gardner, *Research Technician*
Chandra Harvey, *Carnegie Science Outreach Coordinator*[34]
Brittany Hay, *Animal Technician*
Roger Henry, *Student Assistant*
Amy Herbert, *Student Volunteer*
Lynne Hugendubler, *Research Technician*[35]
Alice Hung, *Summer Student*
Joseph-Kevin Igwe, *Summer Student*[36]
Ella Jackson, *Howard Hughes Medical Institute Laboratory Helper*
Fred Jackson, *P/T Animal Care Technician*[37]
Connie Jewell, *Microcomputer Support Specialist*
Glenese Johnson, *Laboratory Helper*
Rejeanne Juste, *Research Technician*
Aaron Katrikh, *Summer Student*[38]
Susan Kern, *Business Manager*
Gennadiy Klimachev, *Animal Technician*
Lindsey Knapp, *Student Volunteer*
Amy Kowalski, *Research Technician*[39]
Bill Kupiec, *Information Systems Manager*
Michelle Macurak, *Research Technician*
Ona Martin, *Howard Hughes Medical Institute Research Technician III*
Tom McDonaugh, *Facilities Manager*
Marlow Minor, *Animal Technician*[40]
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Earl Potts, *Animal Technician*
Christine Pratt, *Howard Hughes Medical Institute Administrative Assistant II*
Joan Pulupa, *Howard Hughes Medical Institute Laboratory Assistant*[41]
Ana Quintanal, *Laboratory Assistant*
Joshua Radebaugh, *Summer Student*[42]
Tula Raghaven, *Student Volunteer*[43]
Wilber Ramos, *Animal Technician*
Megan Reid, *Laboratory Assistant*[44]
Oscar Reyes, *Summer Student*[45]
Michael Rongione, *Research Technician* [46]
Hemi Ryu, *Research Technician*[47]
Samantha Satchell, *Research Technician*
Michael Sepanski, *Electron Microscopy Technician*
Mohammed Shamim, *Summer Student*[48]
Mahmud Siddiqi, *Microscope Specialist*
C. Evan Siple, *Research Technician*
Lakishia Smith, *Administrative Secretary*[49]
Loretta Steffy, *Accounting Assistant*
Allen Strause, *Machinist*
Maggie Sundby, *Research Technician*[50]
Liyang Tang, *Research Technician*
Robert Vary, *Carnegie Science Outreach Educator*
Rafael Villagaray, *Macintosh Support Specialist*
Sean Watson, *Asst. Facility Manager*[51]
Dianne Williams, *Howard Hughes Medical Institute Research Technician III*
Reid Woods, Research Technician[52]
Geoffrey Zearfoss, *P/T Animal Technician*[53]

Visiting Investigators and Collaborators

Hugo Bellen, *Baylor College of Medicine*
Robert Bittman, *Department of Chemistry and Biochemistry, Queens College of CUNY*
Rémy Bordonné, *Institut de Génétique Moléculaire de Montpellier (IGMM), Université Montpellier, Montpellier, France*
Vitor Bortolo de Rezende, *Universidade Federal de Minas Gerais, Brazil*
Christoph Cremer, *Kirchhoff Institute for Physics, University of Heidelberg, Germany*
Steven Ekker, *Department of Genetics, Cell Biology, and Development, University of Minnesota Medical School*
Matthias Hammerschmidt, *Cologne University, Institute of Developmental Biology, Germany*
Samer Hattar, *Department of Biology, The Johns Hopkins University*
Roger Hoskins, *Lawrence Berkeley National Laboratory*
Hao Jiang, *Laboratory of Molecular Cell Biology and Center of Cell Signaling, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences*
Rainer Kaufmann, *Kirchhoff Institute for Physics (KIP), University of Heidelberg, Germany*
Steven Leach, *Department of Surgery, Division of Surgical Oncology, The Johns Hopkins University School of Medicine*
Li Ma, *Laboratory of Molecular Cell Biology and Center of Cell Signaling, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences*
Cecilia Moens, *Fred Hutchinson Cancer Research Center*

Karen Oogema, *European Molecular Biology Laboratory, Germany*
Michael Pack, *Department of Medicine, University of Pennsylvania*
Michael Parsons, *Departments of Surgery and Oncology, The Johns Hopkins University School of Medicine*
John Rawls, *Department of Cell and Molecular Physiology, University of North Carolina*
Gerald M. Rubin, *Howard Hughes Medical Institute, Janelia Farm Research Campus*
Oystein Saele, *Department of Biology, University of Bergen, Norway*
Didier Stainier, *University of California, San Francisco*
C. Conover Talbot, Jr., *Institute for Basic Biomedical Sciences, The Johns Hopkins University School of Medicine*
Bernard Thisse, *Department of Cell Biology and the Morphogenesis and Regenerative Medicine Institute, University of Virginia*
Christine Thisse, *Department of Cell Biology and the Morphogenesis and Regenerative Medicine Institute, University of Virginia*
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Anying Zhang, *School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu, China*
Junqi Zhang, *Microbiology Department, Shanghai Medical College Fudan University*

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[1] From July 1, 2011
[2] From September 26, 2011
[3] To June 1, 2012
[4] From February 1, 2012
[5] To October 31, 2011
[6] To January 31, 2012
[7] From January 17, 2012
[8] From September 1, 2011
[9] From October 10, 2011
[10] From January 24, 2012
[11] To June 30, 2011
[12] From February 20, 2012
[13] From March 30, 2012
[14] From August 11, 2011
[15] From May 14, 2012
[16] From October 17, 2011
[17] From August 1, 2011
[18] From May 21, 2012
[19] From May 23, 2012
[20] To March 29, 2012
[21] From May 21, 2012
[22] From May 21, 2012
[23] From May 21, 2012
[24] From May 21, 2012
[25] From May 21, 2012
[26] From May 21, 2012
[27] To February 10, 2012
[28] From September 5, 2011
[29] To May 23, 2012
[30] From September 12, 2011
[31] From May 10, 2011
[32] From August 28, 2011
[33] To June 19, 2012
[34] From March 1, 2012
[35] From November 7, 2011
[36] From June 1, 2012
[37] To March 30, 2012
[38] From May 29, 2012
[39] To September 29, 2011
[40] From March 16, 2012
[41] To June 8, 2012
[42] From May 29, 2012
[43] From April 18, 2012
[44] To August 19, 2011
[45] From May 29, 2012
[46] From November 21, 2011
[47] From October 3, 2011
[48] From June 1, 2012
[49] To May 1, 2012
[50] To November 25, 2011
[51] From July 8, 2011
[52] From June 6, 2012
[53] To February 8, 2012

Geophysical Laboratory

Staff Scientists

George D. Cody
Ronald E. Cohen
Yingwei Fei
Marilyn L. Fogel
Alexander F. Goncharov
Robert M. Hazen
Russell J. Hemley, *Director*
Wesley T. Huntress, Jr., *Director Emeritus*
T. Neil Irvine, *Emeritus*
Ho-kwang Mao
Bjørn O. Mysen
Douglas Rumble III
Anat Shahar
Andrew Steele
Timothy A. Strobel[1]
Viktor V. Struzhkin

Senior Scientist

Reinhard Boehler, *EFree*

Senior Visiting Investigators

Dudley R. Herschbach, *Harvard University*
Charles T. Prewitt, *University of Arizona*
Dimitri A. Sverjensky, *The Johns Hopkins University*
Takamitsu Yamanaka, *Osaka University, Japan*

Research Scientists

Muhetaer Aihaiti, *ONR, CDAC*
Nabil Z. Boctor, *NASA, NASA Astrobiology Institute (NAI)*
Xiao-Jia Chen, *EFree*
Dionysis I. Foustoukos, *NSF, DCO*
Mihaela Glamoclija, *AMASE*
Malcolm Guthrie, *EFree*
Valerie Hillgren, *NASA*
Qi Liang, *CVD Diamond*
Ivan Naumov, *ONR, EFree*[2]
Karyn Rogers, *NASA*[3]
Craig Schiffries, *Director, DCO*[4]
Jinfu Shu, *HPCAT, Carnegie*
Maddury Somayazulu, *CDAC*
Timothy A. Strobel, *NSF*[5]
Chih-Shiue Yan, *CVD Diamond, CDAC, Carnegie*
Chang-Sheng Zha, *CDAC*

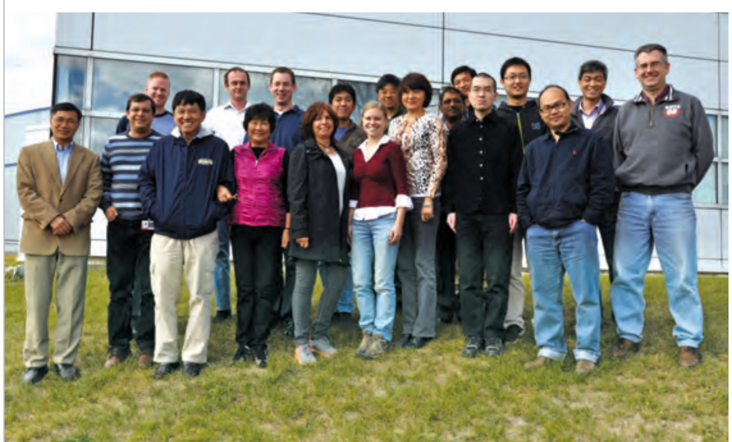
DOE Program/Departmental Outreach Coordinator

Stephen A. Gramsch

High Pressure Collaborative Access Team (HPCAT), High Pressure Synergetic Center (HPSynC) at the Advanced Photon Source (APS), Argonne National Laboratory, Chicago, IL; National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory, Upton, NY; Spallation Neutron Source (SNS) at Oak Ridge National Laboratory, Oak Ridge, TN

Maria Baldini, *Research Scientist, HPSynC*
Genevieve Boman, *Beamline Associate, HPCAT*[6]
Arunkumar S. Bommannavar, *Beamline Control Scientist, HPCAT*
Paul Chow, *Beamline Scientist, HPCAT*
Yang Ding, *Beamline Scientist, HPSynC*[7]
Cindy Doran, *Administrative Assistant, HPSynC*
Richard Ferry, *Technician, HPSynC*
Xiaojing Huang, *Postdoctoral Associate, HPSynC*[8]
Daijo Ikuta, *Beamline Associate, HPCAT*
Georgios Karotsis, *Postdoctoral Associate, SNS*[9]
Curtis Kenney-Benson, *Beamline Associate, HPCAT*
Lingping Kong, *Predoctoral Associate, HPSynC*
Yoshio Kono, *Research Scientist, HPCAT*

GEOPHYSICAL LABORATORY *Front row* (left to right): Andrea Mangum, Danielle Appleby, Garret Huntress, Lauren Cryan, Sami Mikhail, Michelle Scholtes, Charlene Estrada, Cecile Feuillie, Namhey Lee, Sandra Siljestroem, Morgan Phillips, Helen Venzon, Susana Mysen, George Cody, Agnes Mao, Ho-Kwang Mao. *Second row:* Roy Dingus, Yoko Kebukawa Mochizuki, Tingting Gu, Katherine Crispin, Takaki Muramatsu, Amol Karandikar, Yingwei Fei, Yuki Shibazaki, Robert Hazen, Marilyn Fogel, Dimitri Sverjensky, Ronald Cohen, Russell Hemley, Nabil Boctor, Caitlin Murphy, Malcolm Guthrie, Subhasish Mandal, Victor Lugo, Celia Dalou, Gefei Qian, Trong Nguyen, Jinfu Shu, Joseph Lai, Yufei Meng, Qi Liang, Junyue Wang, Shohei Ohara, Kevin Shu, Xiao-Jia Chen, Felix Krasnicki. *Third row:* John Armstrong, Qingyang Hu, Yonghui Zhou, Andrew Steele, Anat Shahar, Karyn Rogers, Roxane Bowden, Jeff Lightfield, Muhetaer Aihaiti, Christopher Glein, Dyanne Furtado, Merri Wolf, Shaun Hardy, Steve Coley, Doug Rumble, Viktor Struzhkin, Craig Schiffries, Timothy Strobel, Duckyoung Kim, Kadek Hemawan, Dionysis Foustoukos, Chang-Sheng Zha, Ileana Perez-Rodríguez, Codi Lazar, Adrian Villegas-Jiménez, Elissaios Stavrou, Maceo Bacote, William Key, Gary Bors, Liuxiang Yang, Stephen Hodge, Bing Li, Chi Zhang, Matthieu Gálvez.



HPCAT *Front row* (left to right): Guoyin Shen, Stanislav Sinogeiken, Ho-kwang (Dave) Mao, Agnes Mao, Veronica O'Connor, Genevieve Boman, Yue Meng, Daijo Ikuta, Yuming Xiao, Curtis Kenney-Benson. *Back row:* Eric Rod, Dmitry Popov, Jesse Smith, Yoshio Kono, Paul Chow, Arunkamar Bommannavar, Zhisheng Zhao, Hongping Yan, Changyong Park.

HPSYNC *Front row* (left to right): Meilan Qi, Agnes Mao, Cindy Doran. *Back row:* Jian-Bo Zhang, Xuliang Chen, Lin Wang, Ho-kwang (Dave) Mao, Wenge Yang, Bing Li, Xujie Lv, Cheng Ji, Yang Ding.

Katherine Lazarz, *Summer Intern, HPCAT*[10]
Bing Li, *Postdoctoral Associate, HPSynC*[11]
Fangfei Li, *Postdoctoral Associate, HPSynC*[12]
Kuo Li, *Postdoctoral Associate, SNS*[13]
Zhenxian Liu, *Beamline Scientist, NSLS*
Chunli Ma, *Predoctoral Associate, NSLS*[14]
Shinichi Machida, *Postdoctoral Associate, SNS*[15]
Ho-kwang Mao, *Executive Director, HPCAT*
Yue Meng, *Beamline Scientist, HPCAT*
Veronica O'Connor, *Office Manager, HPCAT*
Changyong Park, *Beamline Scientist, HPCAT*
Dmitry Popov, *Beamline Scientist, HPCAT*
Eric Rod, *Beamline Technician, HPCAT*
Guoyin Shen, *Director, HPCAT*
Sean Shieh, *Visiting Investigator, HPSynC*[16]
Stanislav Sinogeikin, *Beamline Scientist, HPCAT*
Jesse Smith, *Postdoctoral Associate, HPCAT*
Erik Wang, *Summer Intern, HPCAT*[17]
Junyue Wang, *Postdoctoral Associate, HPSynC*[18]
Lin Wang, *Research Scientist, HPSynC*
Luhong Wang, *Visiting Investigator, HPSynC*[19]
Yuming Xiao, *Beamline Scientist, HPCAT*
Wenge Yang, *Director, HPSynC*
Kirill Zhuravlev, *Beamline Scientist, GSECARS, APS*[20]

Postdoctoral Fellows and Postdoctoral Associates

David M. Baker, *Visiting Investigator, NSF*
Dina Bower, *NAI Fellow*[21]
Henderson James Cleaves II, *Visiting Investigator, NASA and NAI*[22]
Katherine Crispin, *Carnegie Fellow*[23]
Célia Dalou, *Carnegie Fellow*[24]
D. Allen Dalton, *Postdoctoral Associate, CDAC and NSF*[25]
Liwei Deng, *Carnegie Fellow*
Floyd Fayton, Jr., *Postdoctoral Associate, NSF CMG, ONR*[26]
Kadek Hemawan, *Postdoctoral Associate, CDAC, WDLP*
Daniel Hummer, *Carnegie Fellow*[27]
Yoko Kebukawa, *JSPS-GL Fellow*
Svetlana Kharlamova, *Postdoctoral Associate*[28]
Duck Young Kim, *Carnegie Fellow*[29]
Kateryna Klochko, *Postdoctoral Associate, NAI and NSF*[30]
Oleksandr Kurakevych, *Postdoctoral Associate, DARPA*[31]
George Lazar, *Carnegie Fellow*
Yufei Meng, *Postdoctoral Associate*
Sami Mikhail, *Carnegie Fellow*[32]
Takaki Muramatsu, *Postdoctoral Associate, DOE*[33]
Lane Nixon, *Postdoctoral Associate, ONR*[34]
Shohei Ohara, *Carnegie Fellow*[35]
Ileana Pérez-Rodríguez, *Carnegie Fellow*[36]
Robert Potter, *Postdoctoral Associate, DOE*
Christopher Seagle, *Carnegie Fellow*[37]
Yuki Shibazaki, *JSPS Fellow*[38]
Vincenzo Stagno, *Postdoctoral Associate, EFree*[39]
Adrián Villegas-Jiménez, *Carnegie Fellow*[40]
Ying Wang, *Carnegie Fellow*[41]
Liuxiang Yang, *Postdoctoral Associate, EFree, Carnegie*
Chi Zhang, *Carnegie Fellow*[42]
Li Zhang, *Postdoctoral Associate, NASA*[43]

Predoctoral Fellows and Predoctoral Associates

Charlene Estrada, *Predoctoral Fellow, NSF*
Patrick L. Griffin, *Research Assistant, Predoctoral Associate, Keck Foundation, DCO*[44]
Tingting Gu, *Predoctoral Associate, China Scholarship Counci*[45]
Amol Karandikar, *Predoctoral Associate, EFree*
Namhey Lee, *Predoctoral Fellow, The Johns Hopkins University*
Moses Ntam, *Predoctoral Associate, Auburn University, NSF-EAR*[46]
Joseph Rodriguez, *Predoctoral Associate, NAI*[47]
Derek Smith, *Predoctoral Fellow, Dartmouth College*
Verena Starke, *NASA Marshall Space Flight Center*
Renbiao Tao, *Predoctoral Associate, NSF*[48]

College Interns

Collin Black, *University of Connecticut*[49]
Walter Ferguson, *Lancing College, U.K.*[50]
Alyssa Frederick, *Research Assistant, American University*[51]
Juliana Mesa Garcia, *Universidad EAFIT, Colombia*[52]
Gary Grim, *Colorado School of Mines*[53]
Maimon Rose, *University of Chicago*[54]

Summer Scholar Interns (Summer 2012)

Louis Loubeyre, *Université de Paris VII, France*
Timothy Nelson, *University of North Carolina-Chapel Hill*
Viktor Rozsa, *Hillsdale College*
Nichole Valdez, *Colorado College*

High School Interns

Justin Chang, *Montgomery Blair High School*[55]
Samantha Cody, *Montgomery Blair High School*[56]
Jessica Garland, *Sidwell Friends School*[57]
Katherine Jin, *Montgomery Blair High School*[58]
Lori Kaufman, *Montgomery Blair High School*[59]
Thomas McHale, *Montgomery Blair High School*[60]
Elena Polozova, *Montgomery Blair High School*[61]
Maimon Rose, *Melvin J. Berman Hebrew Academy*[62]

Support Staff

Danielle J.-H. Appleby, *Assistant to the Director, Departmental and Institutional Affairs*
John Armstrong, *Microbeam Specialist*
Maceo T. Bacote, *Building Engineer*[63]
Gary A. Bors, *Building Engineer*[64]
Roxane Bowden, *Lab Manager, Stable Isotope Facility*
Stephen D. Coley, Sr., *Instrument Shop Supervisor*
Lauren Cryan, *DCO Program Associate*
Roy R. Dingus, *Facility Manager*[65]
Pablo D. Esparza, *Maintenance Technician*[66]
Dyanne Furtado, *Staff Accountant*
Paul Goldey, *Electronics/Microbeam Specialist*[67]
Christos G. Hadidiacos, *Electronics Engineer*
Shaun J. Hardy, *Librarian*[68]
Stephen Hodge, *Instrument Maker*
Garret W. Huntress, *Systems Administrator, Systems Developer*
William E. Key, *Building Engineer*[69]
Szczesny (Felix) Krasnicki, *CVD Diamond Senior Engineer*
Joseph Lai, *CVD Diamond Lab Manager*
Jeff Lightfield, *Controller*
Victor Lugo, *Instrument Maker*
Andrea Mangum, *DCO Program Manager*
Quintin Miller, *Building Engineer Apprentice*[70]
Susana Mysen, *EFree Project Administrator*
Trong T. Nguyen, *Assistant Controller*
Morgan D. Phillips, *Assistant to the Director, Science and CDAC*
Scott Price, *Electronics Specialist*[71]
Gefei Qian, *Systems Administrator*
Pedro J. Roa, *Maintenance Technician*[72]
Haiyun (Kevin) Shu, *CVD Diamond Technician*
Helen Venzon, *Accounts Payable Specialist*
Merri Wolf, *Library Technical Assistant*[73]
Pamela L. Woodard, *Web/Departmental Assistant*[74]
Thomas Yu, *CVD Diamond Technician*

Visiting Investigators (Washington, DC)

David Baker, *Smithsonian Institution*
Patrick Boehnke, *UCLA*
Jodie Bradby, *Australian National University*
Leonid Burakovsky, *Los Alamos National Laboratory*
Adam Cadien, *George Mason University*
Andrew J. Campbell, *University of Maryland*
Razvan Caracas, *Université de Lyon, École Normale Supérieure de Lyon, France*
Bin Chen, *University of Michigan*
Jennifer Ciezak, *U.S. Army Research Laboratory, Aberdeen Proving Grounds*
Claire Cousins, *Birbeck College, U.K.*
Ranga Dias, *Washington State University*
Mark Dudash, *Goddard Space Flight Center*
Albert Epshteyn, *U.S. Naval Research Laboratory*
Joseph Feldman, *U.S. Naval Research Laboratory*
Thomas Fitzgibbons, *Pennsylvania State University*
Marc Fries, *NASA JPL*
Carl Frisby, *University of Southern California*
Lev Gasparov, *University of North Florida*
Alexander Gavriliuk, *Institute of Crystallography, Russia*
Brent Grocholski, *Massachusetts Institute of Technology*
Neal Sanchayan Gupta, *Bryant University*
Shigeto Hitai, *Stanford University*
Qingyang Hu, *George Mason University*
Haijun Huang, *Wuhan University of Technology*, *PR China*
Simon Hunt, *University College London*, *U.K.*
Pierre-Eymeric Janolin, *École Centrale Paris, France*
Alex Jessett, *Durham University*, *U.K.*
Xiulan Jiang, *Jilin University, PR China*
Chi-Chang Kao, *NSLS, Brookhaven National Laboratory*
Jae-Hyun Kim, *Hallym University*, *Republic of Korea*
Norio Kitadai, *Kanazawa University*, *Japan*
Jae-Hyeon Ko, *Hallym University*, *Republic of Korea*
Kai Landskron, *Lehigh University*
Amy Lazicki, *Lawrence Livermore National Laboratory*
Peter Lazor, *Uppsala University, Sweden*
Jiachao Liu, *University of Michigan*
Sergey Lobanov, *V.S. Sobolev Institute of Geology and Mineralogy*, *Russia*
Konstantin Lokshin, *University of Tennessee*
Xuan Luo, *Unaffiliated*
Mohammad Mahmood, *Howard University*
Manik Mandal, *Lehigh University*
Roland Mathieu, *Uppsala University*, *Sweden*
Charles Meade, *RAND Corporation*
Francis McCubbin, *University of New Mexico*
Stewart McWilliams, *Howard University*
John Nance, *University of Maryland*
Tomoya Nakase, *Osaka University*, *Japan*
Nora Noffke, *Old Dominion University*
Aaron Palke, *Stanford University*
Dominic Papineau, *Boston College*
Glenn Piercey, *Memorial University of Newfoundland*, *Canada*
Masafumi Sakata, *Osaka University*, *Japan*
Yingxia Shi, *Stanford University*
V. Shrinivasan, *George Mason University*
Howard Sheng, *George Mason University*
Yuki Shibazaki, *Tohoku University*, *Japan*
Camelia Stan, *Princeton University*
Elissaios Stavrou, *Max Planck Institute for Solid State Research*, *Germany*
Jack Tossell, *University of Maryland*
Chris Tulk, *Oak Ridge National Laboratory*
Paola Valenti, *GFZ German Research Centre for Geosciences*
Willem van Westrenen, *Vrije University, The Netherlands*
Norman Wainwright, *Charles River Laboratories*
Laura Walker, *Goddard Space Flight Center*
Wilson Wanene, *University of Nevada, Reno*
Hikaru Yabuta, *Osaka University, Japan*
Jin Zhang, *University of Illinois*
Susan Ziegler, *Memorial University of Newfoundland*, *Canada*

Visiting Investigators (Geophysical Laboratory Synchrotron Facilities)

Sourav Adak, *Los Alamos National Laboratory*, *HPCAT*
Christopher Adams, *Los Alamos National Laboratory*, *HPCAT*
Daniel Antonio, *University of Nevada – Las Vegas*, *HPCAT*
Chantal Aracne, *Lawrence Livermore National Laboratory*, *HPCAT*
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Arnab Banerjee, *University of Chicago*, *HPCAT*
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Gustav Borstad, *Washington State University*, *HPCAT*
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Przemeslaw Dera, *University of Chicago*, *HPCAT*
Yang Ding, *Argonne National Laboratory*, *HPCAT*
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Vadym Drozd, *Florida International University*, *HPCAT*
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Brent Grocholski, *National Museum of Natural History*, *NSLS*
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Bianca Haberl, *Australian National University*
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Barbara Lavina, *University of Nevada – Las Vegas*, *HPCAT*
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Fangfei Li, *Jilin University*, *HPCAT*
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Jose Mardegan, *University of Campinas*, *HPCAT*
Luke Marshall, *University of Texas at Austin*, *HPCAT*
Brian Mattern, *University of Washington*, *HPCAT*
Lisa Mauger, *California Institute of Technology*, *HPCAT*
Marina Diaz Michelena, *INTA*, *HPCAT*
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Francisca Rein, *Los Alamos National Laboratory*, *HPCAT, NSLS*
John Robinson, *University of Nevada – Las Vegas*, *HPCAT*
Andrei Rode, *Australian National University*, *HPCAT*
S. Rostom, *University of Tennessee*, *NSLS*
Viktor Rosza, *Hillsdale College*, *HPCAT*
Young-Jay Ryu, *Washington State University*, *HPCAT*
Ramon Saavedra, *Los Alamos National Laboratory*, *HPCAT*
Tatsuya Sakamaki, *University of Chicago*, *HPCAT*
Gopi Samudrala, *University of Alabama – Birmingham*, *HPCAT*
Chrystele Sanloup, *University of Edinburgh*, *HPCAT*
Surendra Saxena, *Florida International University*, *HPCAT*
Henry Scott, *Indiana University – South Bend*, *HPCAT*
Thomas Sharp, *Arizona State University*, *HPCAT*
Lingjuan Shen, *University of Illinois at Urbana-Champaign*, *HPCAT*
Hongwei Sheng, *George Mason University*, *HPCAT*
Sang-Heon Shim, *Massachusetts Institute of Technology*, *HPCAT*
Yu Shu, *Yanshan University*, *HPCAT*
Adam Simon, *University of Nevada – Las Vegas*, *HPCAT*
Konstantin Skokov, *Leibniz Institute for Solid State and Mineral Research*, *HPCAT*
Quinlan Smith, *University of Nevada – Las Vegas*, *HPCAT*
Spencer Smith, *University of Alabama – Birmingham*, *HPCAT*
Daniel Sneed, *University of Nevada, Las Vegas*, *HPCAT*
Yang Song, *University of Western Ontario*, *NSLS*
David Sprouster, *Australian National University*, *HPCAT*
Gerald Stevens, *NSTec*, *HPCAT*
E. Stevenson, *National Museum of Natural History*, *NSLS*
Sergei Stishov, *Russian Academy of Sciences*, *HPCAT*
Y. Sun, *Florida International University*, *NSLS*
Paul Syers, *University of Maryland*, *HPCAT*
Elizabeth Tanis, *University of Nevada – Las Vegas*, *HPCAT*
Joshua Townsend, *Northwestern University*, *HPCAT*, *NSLS*
Sally June Tracy, *California Institute of Technology*, *HPCAT*
Oliver Tschauner, *University of Nevada – Las Vegas*, *HPCAT*
Georgiy Tsoy, *University of Alabama – Birmingham*, *HPCAT*
T. Tyson, *New Jersey Institute of Technology*, *NSLS*
Walter Uhoya, *University of Alabama – Birmingham*, *HPCAT*
C. Unterborn, *Ohio State University*, *NSLS*
Arturas Vailionis, *Stanford University*, *HPCAT*
Nichole Valdez, *Colorado College*
Derrick VanGennep, *University of Nevada – Las Vegas*, *HPCAT*
Nenad Velisavljevic, *Los Alamos National Laboratory*, *HPCAT, NSLS*
Yogesh Vohra, *University of Alabama – Birmingham*, *HPCAT*
Luhong Wang, *Harbin University of Technology*, *HPCAT*
Shanmin Wang, *Los Alamos National Laboratory*, *HPCAT*
Shibing Wang, *Stanford University*, *HPCAT*
Yanbing Wang, *University of Chicago*, *HPCAT*
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Junjie Wu, *University of Texas at Austin*, *HPCAT*
T. Wu, *New Jersey Institute of Technology*, *NSLS*
Fan Yang, *Stanford University*, *HPCAT*
G. Yang, *Brookhaven National Laboratory*, *NSLS*
Dongli Yu, *Yanshan University*, *HPCAT*
Tony Yu, *University of Chicago*, *HPCAT*
Xiaohui Yu, *Los Alamos National Laboratory*, *HPCAT*
Zhenhai Yu, *Harbin University of Technology*, *HPCAT*
Qiaoshi Zeng, *Stanford University*, *HPCAT*
Zhidan Zeng, *Stanford University*, *HPCAT*
Eloisa Zepeda-Alarcon, *University of California – Berkeley*, *HPCAT*
Fuming Zhang, *University of Michigan*, *NSLS*
Fuxhing Zhang, *University of Michigan*, *HPCAT*
Yanfei Zhang, *University of Chicago*, *HPCAT*
Mikhail Zhernenkov, *Argonne National Laboratory*, *HPCAT*
Qiang Zhou, *Jilin University*, *HPCAT*
Jinlong Zhu, *Los Alamos National Laboratory*, *HPCAT*
Igor Zibrov, *Russian Academy of Sciences*, *HPCAT*

[1] From September 1, 2011
[2] From January 23, 2012
[3] From September 22, 2011
[4] From November 1, 2011
[5] To August 31, 2011; *Staff Scientist* from September 1, 2011
[6] From March 1, 2012
[7] To July 15, 2011
[8] To February 7, 2012
[9] To January 23, 2012
[10] To August 5, 2011
[11] From June 25, 2012
[12] To May 31, 2012
[13] From August 3, 2011
[14] From May 1, 2012
[15] From January 17, 2012
[16] From March 1, 2012
[17] To September 9, 2011
[18] From October 3, 2011
[19] From November 1, 2011
[20] From May 16, 2012
[21] To January 13, 2012
[22] To July 31, 2011
[23] From September 21, 2011
[24] From September 12, 2011
[25] To March 23, 2012
[26] To January 27, 2012
[27] To March 31, 2012
[28] To August 31, 2011
[29] From August 4, 2011
[30] To June 30, 2012
[31] From October 17, 2011
[32] From October 26, 2011
[33] From September 12, 2011
[34] To December 5, 2011
[35] From July 1, 2011, to February 29, 2012; *JSPS Fellow* from March 1, 2012
[36] From November 1, 2011
[37] To November 4, 2011
[38] From April 23, 2012
[39] From September 1, 2011
[40] From July 1, 2011
[41] To April 29, 2012
[42] From September 1, 2011
[43] To December 31, 2011; *Research Scientist* from January 1, 2012
[44] To December 31, 2011
[45] From December 12, 2011
[46] From July 6, 2011, to August 5, 2011
[47] To August 12, 2011
[48] To January 10, 2012
[49] To August 5, 2011
[50] From July 12, 2011, to August 12, 2011
[51] To May 1, 2012
[52] From June 5, 2012
[53] From June 4, 2012 to June 8, 2012
[54] From August 23, 2011, to September 16, 2011; From December 16, 2011, to December 31, 2011; From June 13, 2012
[55] To August 19, 2011
[56] From July 27, 2011, to August 17, 2011
[57] To July 2011
[58] From July 27, 2011, to August 17, 2011
[59] To August 12, 2011
[60] From June 9, 2012
[61] From June 12, 2012
[62] To August 1, 2011
[63] Joint appointment with DTM
[65] Joint appointment with DTM
[66] Joint appointment with DTM
[67] From August 4, 2011
[68] Joint appointment with DTM
[69] Joint appointment with DTM
[70] Joint appointment with DTM
[71] To July 14, 2011
[72] Joint appointment with DTM
[73] Joint appointment with DTM
[74] To May 30, 2012

Global Ecology

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K. Dana Chadwick, *Stanford University*[9]
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Kyla Dahlin, *Stanford University*
Luis Fernandez, *Stanford University*
Rebecca Hernandez, *Stanford University*
Jennifer Johnson, *Stanford University*
Kelly McManus, *Stanford University*
Alex Nees, *Stanford University*[11]
Marina Oster, *Stanford University*[12]
Yoichi Shiga, *Stanford University*[13]
Aaron Strong, *Stanford University*[14]
Yuntao Zhou, *Stanford University*[15]

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Catherine Ashe, *Laboratory Technician*[16]
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Shane Easter, *Laboratory Technician*
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Gabriela Meckler, *Laboratory Intern*[28]
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Marion O'Leary, *Senior Advancement Consultant*
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Eric Slessarev, *Laboratory Intern*[31]
Todd Tobeck, *Laboratory Manager*
Guillaume Tochon, *Visiting Intern*[32]

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[1] From March 16, 2012
[2] To March 31, 2012
[3] From September 1, 2011
[4] From October 3, 2011
[5] From September 1, 2011, to November 5, 2011
[6] To February 19, 2012
[7] To August 31, 2011
[8] From July 1, 2011
[9] From February 28, 2011, to September 15, 2011
[10] From July 8, 2011
[11] To June 30, 2011
[12] From September 15, 2011
[13] From July 1, 2011
[14] From September 1, 2011
[15] From August 31, 2011
[16] From April 16, 2012
[17] From February 26, 2012
[18] To April 27, 2012
[19] From April 16, 2012
[20] From September 16, 2011
[21] To November 30, 2011
[22] From June 1, 2012
[23] From June 25, 2012
[24] To November 18, 2011
[25] To February 15, 2012
[26] To August 31, 2011
[27] From September 1, 2011
[28] From November 1, 2011, to February 27, 2012
[29] To July 31, 2011
[30] From November 16, 2011
[31] From December 1, 2011
[32] From January 16, 2012, to June 22, 2012

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Patrick McCarthy
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Eric Murphy, *Postdoctoral Associate*
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Ryan Quadri, *Hubble Fellow*
Iván Ramírez, *Sagan Fellow*[9]

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Carlos Ferreira, *Pontificia Universidad Católica de Chile*
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Mike Gladders, *The University of Chicago*
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Dariusz Graczyk, *Universidad de Concepción, Chile*
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Xianzhong Zheng, *Purple Mountain Observatory, CAS, China*

[1] From June 15, 2012
[2] From October, 1, 2011
[3] From September 1, 2011
[4] To December 22, 2011
[5] To September 14, 2011
[6] To September 30, 2011
[7] To October 31, 2011
[8] To August 31, 2011
[9] To November 30, 2011
[10] From May 1, 2012
[11] To August 3, 2011
[12] To July 20, 2011
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[14] To December 31, 2011
[15] To June 3, 2012
[16] From July 11, 2011
[17] From January 1, 2012
[18] From October 1, 2010; not reported previously
[19] From December 6, 2011
[20] To May 31, 2011
[21] From April 2, 2012
[22] To September 30, 2011; GMT Site Testing Support
[23] From October 15, 2011
[24] To December 18, 2011
[25] From June 7, 2011; not reported previously
[26] To August 29, 2011

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Plant Biology

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[1] From July 2, 2011
[2] From December 1, 2011, to March 1, 2012
[3] From January 23, 2012, to June 30, 2012
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[28] From June 4, 2012
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[31] To July 15, 2011
[32] To September 15, 2011
[33] To October 15, 2011
[34] From May 29, 2012
[35] From July 1, 2011, to December 31, 2011

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Dmitri Ionov, *Université Jean Monnet, St. Etienne**
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Francis Nimmo, *University of California, Santa Cruz**
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Joseph Rodriguez, *George Mason University*
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Martha K. Savage, *Victoria University, New Zealand*
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[3] To December 18, 2011
[4] From September 1, 2011
[5] To September 1, 2011
[6] From January 17, 2012
[7] To December 31, 2011
[8] From September 1, 2011
[9] From July 12, 2011
[10] From February 1, 2012
[11] From April 2, 2012
[12] To September 22, 2011
[13] To September 9, 2011
[14] From April 9, 2012
[15] To August 31, 2011
[16] To December 20, 2011
[17] From September 1, 2011
[18] From April 1, 2012
[19] November 2011
[20] Joint appointment with Geophysical Laboratory
[21] From September 2, 2011
[22] To May 2, 2012

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Bibliography

EMBRYOLOGY

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