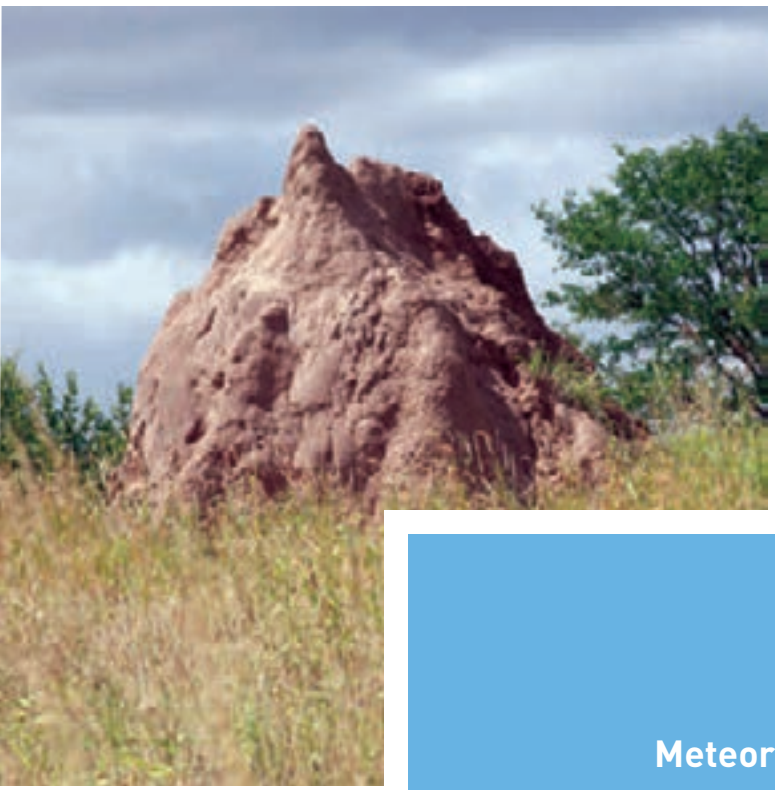
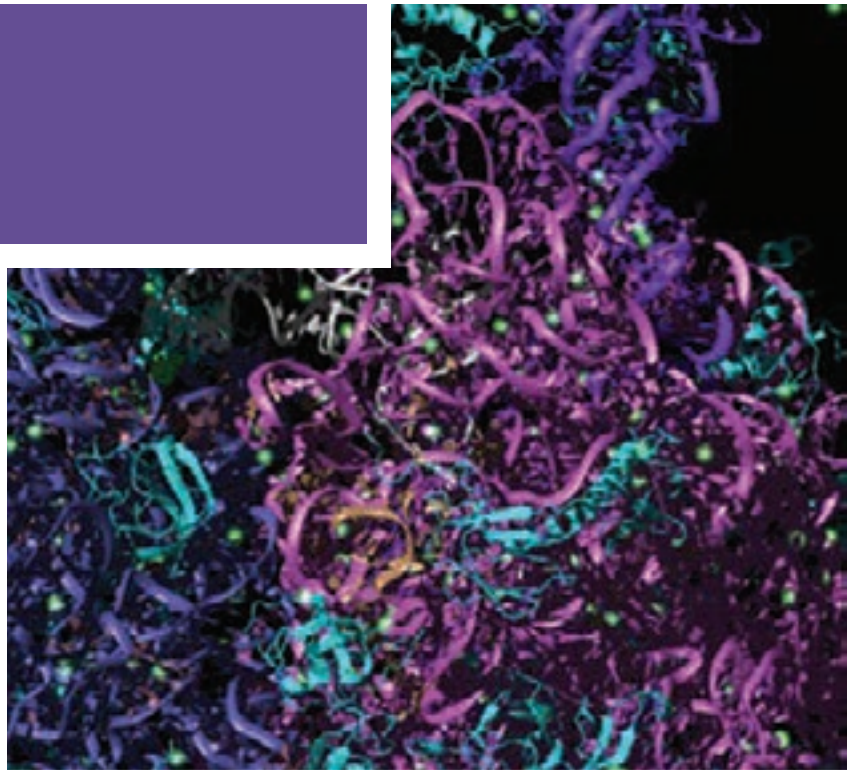
CarnegieScience

The Newsletter of the Carnegie Institution

SPRING 2011

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





On the Inside

Carnegie's department directors handle countless organizational responsibilities for Carnegie. It's a wonder that they can remain leaders in their respective scientific fields.

The destructive effects of climate change make understanding Earth's dynamics increasingly urgent. *Chris Field* pioneered new approaches to ecosystem studies and is the founding director of the Department of Global Ecology. Field has an international reputation as an excellent scientist, innovator, mentor, and influential liaison between the scientific community and climate change policymakers. He cochairs the UN's Intergovernmental Panel on Climate Change Working Group 2, which is preparing a new report on climate change impacts and adaptation.

Eighty years after Edwin Hubble discovered that the universe is expanding, *Wendy Freedman*, the Observatories' director, led the Hubble Space Telescope (HST) Key Project to determine the age, size, and expansion rate of the universe. Freedman developed novel techniques to refine and calibrate the most precise "standard candles"—pulsating stars known as Cepheid variables whose distances can be measured and thereby the rate of expansion can be calculated. Cosmic acceleration, supernovae, dark energy, and next-generation telescopes now command her attention.

Plants provide food, shelter, and medicine. Plant Biology director *Wolf Frommer* looks at the basic mechanism of how plants transport molecules into and out of cells. Sensing mechanisms at the cell's surface probably inform the cell about outside conditions so that it can adjust to varying situations. Frommer and colleagues designed a number of groundbreaking techniques for monitoring these processes. He is world renowned for identifying the first sucrose, amino acid, and ammonium plant transporters.

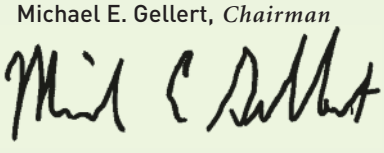
Materials exhibit unexpected behaviors in environments such as hot, compressed planetary interiors. Geophysical Laboratory director *Russell Hemley* examines these properties. He blends high-pressure/high-temperature experimental data with theoretical studies in condensed matter physics, Earth and planetary science, and materials science. He has discovered new phenomena in dense hydrogen and has invented new superconductors, magnetic structures, glasses, and more. His internationally recognized group develops original instrumentation at numerous large-scale facilities.

Terrestrial Magnetism director *Sean Solomon* is a global leader in planetary geology and geophysics, seismology, marine geophysics, and geodynamics. Solomon's experience ranges from oceanographic expeditions on Earth to spacecraft missions to Venus, Mars, Mercury, and the Moon. He is the principal investigator of the MESSENGER mission to Mercury, the first spacecraft to orbit that planet. Solomon has had a defining role in developing planetary tectonic models and in expanding our understanding of the thermal structures of planetary interiors. He has served on over 30 professional committees for NASA alone.

Through research and technology development, Embryology director and Howard Hughes Medical Institute Investigator *Allan Spradling* has transformed the discipline of stem cell research. His group pioneered the use of the tiny fruit fly as a model organism for human stem cell studies, and he has developed tools for studying gene structure, function, and location. His research into the complex process of egg development in flies led to a broader understanding of stem cell maintenance, renewal, and differentiation, and the dependence that the growing egg has on its cellular environment.

Andrew Carnegie's original vision was to support exceptional individuals with the expectation that they would contribute significantly to world knowledge. Clearly, our directors epitomize that goal.

Michael E. Gellert, *Chairman*



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

202.387.6400
www.CarnegieScience.edu

TrusteeNews

Giant Telescope and Black Holes Punctuate Trustees' Meetings

The 133rd session of the board of trustees met at the Observatories in Pasadena, California, November 18 and 19, 2010. Meetings of the Finance and Development committees and the first session of the board took place on November 18. Afterward, there were tours of the Observatories and a dinner featuring a talk by astronomer Luis Ho. The next morning, the second session of the board followed a meeting of the Nominating Committee.

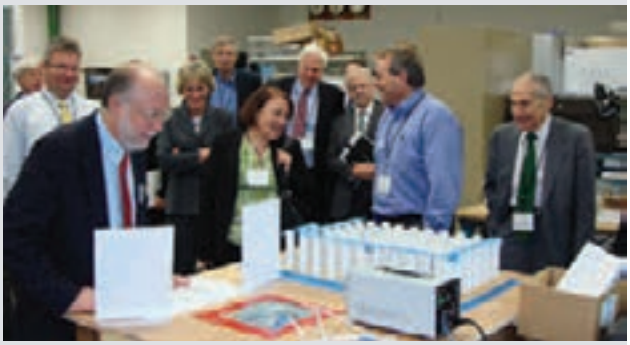
After Thursday's business, the trustees were treated to an update of activities at the Observatories. Patrick McCarthy, director of the Giant Magellan Telescope Organization (GMTO), discussed that program's progress. He described the science that can only be accomplished with an enormous next-generation telescope. He talked about the GMT's novel design, how the GMTO has transitioned to a separate 501(c)(3) entity, its new location, changes to the administrative staff, and the new GMTO Web site.

Stephen Shectman then took the crowd into the Observatories instrument shop to describe how the giant telescope mirror support system works. He demonstrated the flotation actuation systems; air pressure under the mirror is adjusted so that mirror components can move to accommodate changing environmental conditions.

Alan Dressler described the technical advances of and the scientific results obtained by the Inamori Magellan Areal Camera and Spectrograph (IMACS), putting the instrument into the context of telescope history and presenting an overview of how it works. IMACS is the largest field camera in the world, with superb imaging and spectroscopic capabilities and the capacity to measure thousands of celestial objects at one time.

In the instrument shop, Ian Thompson gave a brief history of the shop's accomplishments and the instruments made there, including the recently shipped Four Star near-infrared imager, which is now at Las Campanas. He also described the newest generation of charged coupled devices (CCDs) fashioned in the shop. CCDs are essential to contemporary astronomical imaging.

At dinner that evening, Luis Ho lectured on what astronomers have learned about black holes, particularly the search for black hole "seeds." He described the mysteries of rare quasars powered by supermassive black holes and the relationship of galaxies to their central black holes. He also addressed the question of whether every black hole has to be associated with a galactic bulge. □



Astronomer and instrument designer Steve Shectman (left front) describes how the mirror flotation actuation system works as part of the trustees' tours. Changes in air pressure under the Giant Magellan Telescope mirror control the movement of the mirror to adjust for changing environmental conditions.

Observatories' Alan Dressler, the mastermind behind the Inamori Magellan Areal Camera and Spectrograph (IMACS), talks about the capabilities of the instrumentation that can simultaneously observe thousands of distant objects.

Ian Thompson describes the types of charged coupled devices (CCDs) made in the Observatories shop.

Global Ecology's Steven Davis

More Than Go With The Flow

A team of geologists led by Global Ecology's Steven Davis has discovered that some 55 million years ago a river as large as the modern-day Colorado flowed through Arizona into Utah, the opposite direction from the present-day Colorado River. Their work was published in the October 2010 issue of the journal *Geology*.

The ancient river system was discovered by taking samples of sedimentary deposits in Utah and southwest Arizona. The team analyzed grains of sand made of the mineral zircon to study uranium and lead isotopes that were present in the grains. It found that the sand in both locations originated at the same source—igneous bedrock in the Mojave region of southern California.

The deposits in Utah, which are called the Colton Formation by geologists, are about 55 million years old. They form a delta where the river once emptied into a large lake more than 430 miles (700 kilometers) to the northeast of their source in California.

The river was similar to the modern Colorado–Green River system, but it flowed in the opposite direction. The modern Colorado has its headwaters in the Rocky Mountains and flows to its mouth in the Gulf of California.

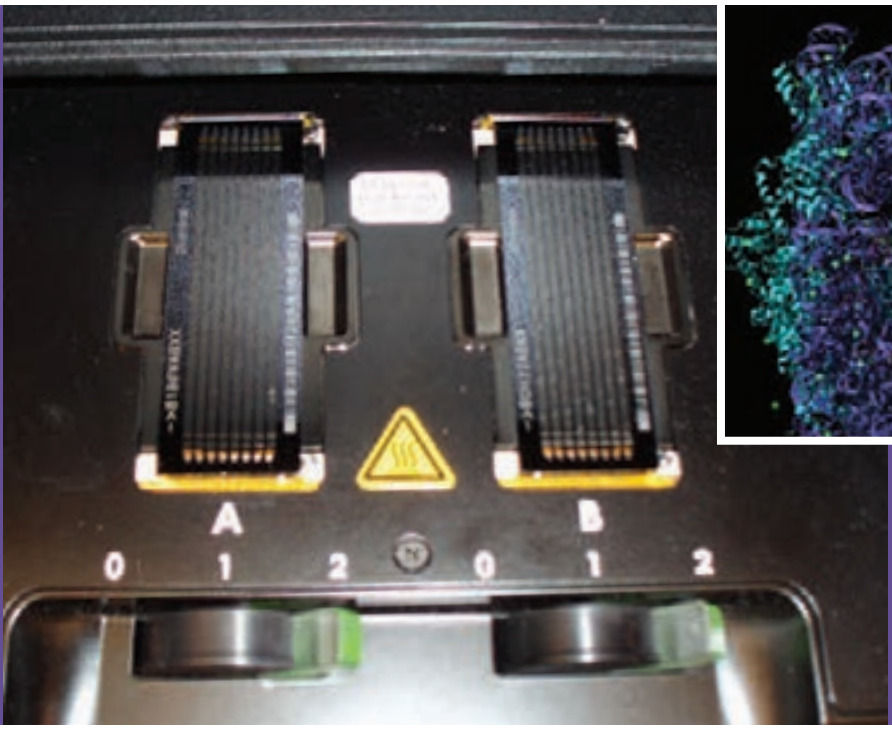
This ancient California river likely met its end as the Rocky Mountains rose and the northern Colorado Plateau tilted, reversing the slope of the land surface and the direction of the river's flow to create the present Colorado–Green River system.

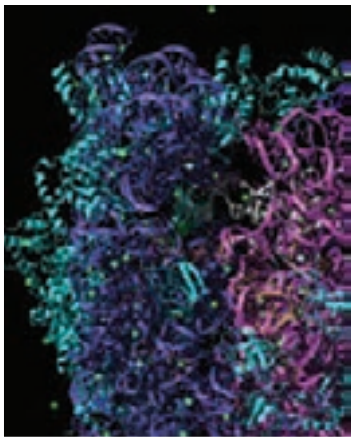
Davis and his team have not yet determined when the direction change took place. The California river could have persisted for as long as 20 million years before the topography shifted enough to reverse the flow.

The Colorado River began eroding the Grand Canyon less than 20 million years ago. Other scientists have speculated that rivers older than the Colorado may have carved a proto–Grand Canyon during this period. But Davis's team sees no evidence to support this theory, because there aren't enough zircon grains from that area present to indicate the major erosion of a canyon. □

A view of the modern-day Colorado River (top left) from the Toroweap Outlook in Grand Canyon National Park. A team of geologists led by Global Ecology's Steven Davis found that an ancient river flowed along a similar path, but in the opposite direction.

Image courtesy the U.S. National Park Service



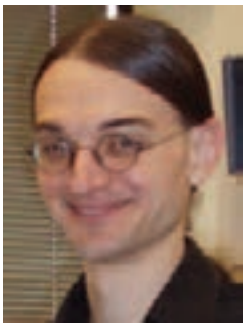


Ingolia and team learn which genes are actually being turned into protein, not just mRNA. Ingolia describes his work as a combination of an old technique with new advances in high-throughput sequencing. He uses new sequencing technologies to analyze mRNA fragments that are actually being translated into protein. This sequencing is performed on the Illumina HiSeq, shown at left in a close-up photo of its flowcells. A sequencing sample is pumped into tiny channels in the glass slides where it sticks and forms a microscopic spot. Chemicals are then pumped through the channels to perform the nucleotide sequencing, and the results are read out by photographing those microscopic spots. The next step involves computational analysis of the sequencing results, containing billions of individual bases, in order to better understand protein translation.

Ribosomes attach to mRNA and, based on mRNA instructions, manufacture proteins (right).

Image courtesy Los Alamos National Laboratory

Ribosome Riddle



Nick Ingolia in his lab in Baltimore

Nick Ingolia, the newest staff scientist at Carnegie's Department of Embryology, has a plush black blob sitting on a shelf in his office, just over his computer. Handmade by the first student who rotated through his Carnegie lab, it is a plush version of a ribosome—the cellular organelle that forms the heart of his research and is involved in protein production. Ingolia, who joined Carnegie last October, has made a specialty of using ribosomes in a new way.

Cells have genes that provide instructions for how to make proteins. 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, attaches to a ribosome, which Ingolia described as a protein factory, and is *translated* into a sequence of amino acids that, when complete, form a protein.

Usually scientists detect and measure the mRNA that is transcribed, which tells them when a gene is turned on. But, according to Ingolia, studying mRNA alone doesn't give the full picture. His method examines the translation of that mRNA into protein.

"What you actually want to know is which proteins the cell is actually making," Ingolia said in an interview. "So what I've developed is a better technique of looking specifically at what proteins are being made . . . And if you can measure what proteins the cell is actually making, we get a better picture of cell physiology."

Ingolia and his team isolate and look at each piece of mRNA that sits inside a ribosome, learning which genes are actually being turned into protein, not just mRNA. They can also tell how many ribosomes are translating different genes. As a result, they can see that some genes are translated highly and that there are others for which the mRNA is never used to form a protein.

Ingolia suspects that in the latter case, where DNA is transcribed into mRNA but not translated into a protein, the choice is determined by cellular conditions such as stress responses or disease. For example, he said, "The cell needs to be able to respond very quickly to some change in its environment, some difficulty, and so it produces these transcripts for genes that would help it respond to that situation, and holds them inactive, but it can very quickly switch them on." Using this new technique, Ingolia and his team have found some exceptions to prevailing theories about how different genes are turned into proteins, particularly regulatory genes.

Ingolia has received interest from the scientific community in using his technique, but he doesn't think it will replace the traditional mRNA measurements. "Both have a place, but I do think it could reach a point pretty quickly, where people will be choosing to use our method instead of the old one, rather than in addition," he said. □

Meteorite Linked to a Mysterious Celestial Body

This photograph shows the Nubian Desert in northeastern Sudan (Red Sea is top right). A car-sized meteorite exploded there in 2008, strewing fragments across the land.

Image courtesy NASA Goddard Space Flight Center

Back in 2008 when a car-sized asteroid exploded over Sudan, Carnegie Geophysical Lab scientist Doug Rumble collaborated with the University of Khartoum to study one of the fragments. Then, in 2010, he expanded his work to examine 11 of the meteorite pieces that had been strewn across the Nubian Desert. His new findings, published in a special December issue of the journal *Meteoritics and Planetary Science*, demonstrated the diversity of the fragments, with major implications for the meteorite's origin.

The first time around, Rumble proved that the fragment he studied fell into a very rare category of meteorite called ureilites. Ureilites have a very different composition from most other meteorites. It has been suggested that all members of this meteoric family might have originated from the same source, called the ureilite parent body, which could have been a protoplanet.

When he expanded his work to examine 11 meteorite fragments in 2010, Rumble focused on the presence of oxygen isotopes. Isotopes are atoms of the same element that have extra neutrons in their nuclei. Oxygen isotopes can be used to identify the meteorite's parent body and determine whether all the fragments indeed came from the same source. Each parent body of meteorites in the Solar System, including the Moon, Mars, and the large asteroid Vesta, has a distinctive signature of oxygen isotopes that can be recognized even when other factors, such as chemical composition and type of rock, are different.

Tiny crumbs of the 11 meteorite fragments were heated with a laser and reacted chemically to release oxygen. Rumble and his team then used a mass spectrometer to measure the concentrations of each oxygen isotope. The results showed that the full range of oxygen isotopes known to be present in ureilites were also present in the studied fragments.

"It was already known that the fragments in the Nubian Desert came from the same asteroid. Taking that into account, these new results demonstrate that the asteroid's source, the ureilite parent body, also had a diversity of oxygen isotopes," said Rumble.

The diversity of oxygen isotopes found in ureilites probably arises from the circumstances of the parent body's formation. Rumble theorizes that the rock components of this parent body were heated to the point of melting and then cooled into crystals so quickly that the oxygen isotopes present could not come to an equilibrium distribution throughout. □

This fragment of meteorite 2008 TC3 (black) was found in the Sudan's Nubian Desert.

Image used with permission from Peter Jenniskens of the SETI Institute

STAR THROB

Cepheids are a class of giant pulsating stars—

the best known is the North Star, or Polaris—that are frequently used to measure distances to nearby galaxies. Scientists have long disagreed on the masses of Cepheid stars as derived from theoretical calculations. Recent research from Carnegie scientist Ian Thompson and his colleagues provides strong evidence for Cepheid masses as predicted from one particular theory.

The atmosphere of a Cepheid is unstable, the pulsation results from it alternating between a compact state and an expanded state as the pressures and temperatures within the star cause it to grow larger and gravity causes it to get smaller again.

The period of these pulses, along with the star's brightness, can be used to calculate a Cepheid's distance and to establish a distance scale for other celestial objects. For example, Cepheids were used by Observatories' director Wendy Freedman and her colleagues to measure the distances to galaxies using the Hubble Space Telescope and to determine the Hubble Constant, the rate of expansion of the universe.

A theoretical analysis of the Cepheid pulsation can be used to calculate an estimate of a Cepheid's mass. However, the results of this type of calculation disagree with the results found using a different method based on theoretical models of the evolution of these massive stars. The discrepancy between these two models ranges from 15% to 30%, an unacceptably high uncertainty in the understanding of objects that contribute in a fundamental way to the measurement of the galactic distance scale.

In a paper published in *Nature* in November 2010, Thompson and his colleagues were able to locate a specific Cepheid and use an entirely different type of measurement to determine its mass, in this case to a precision of 1%.

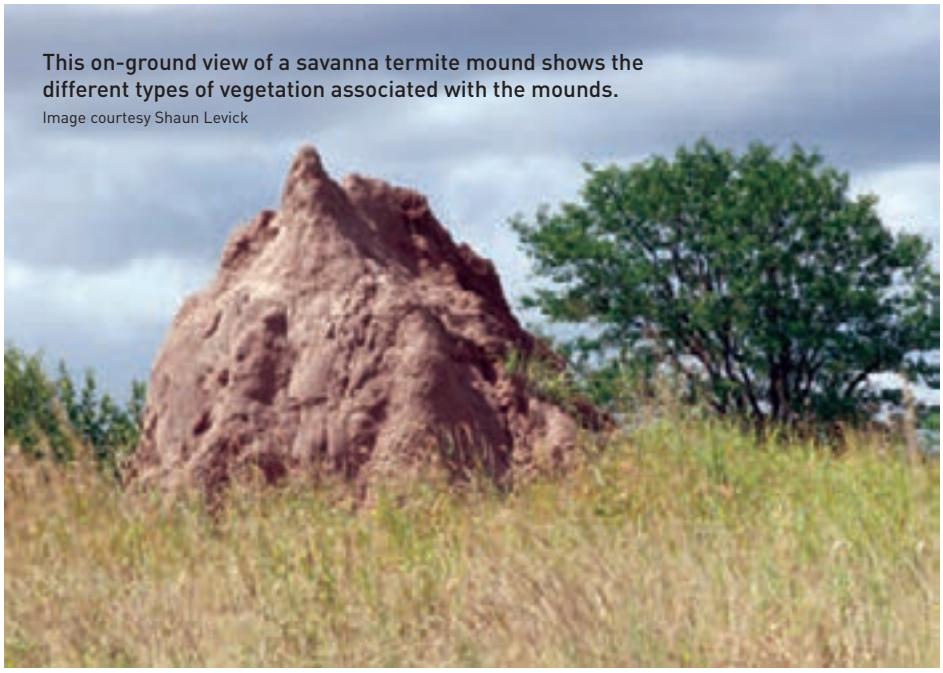
The team located a classical Cepheid—not to be confused with a lower-mass type-II Cepheid—which is part of a system of two stars orbiting around a shared center mass. This binary star system is located in the Large Magellanic Cloud, a nearby galaxy. The orbit of the binary was measured from radial velocity measurements of the component stars of the binary and was used to calculate the mass of each star. Thus, the researchers could empirically determine the Cepheid's mass and validate one or other of the competing theories.

Their result agreed with the mass estimate determined from the star's pulsation period, providing evidence for the accuracy of the masses determined from stellar pulsation theory. In their paper the researchers proposed that the higher masses calculated using stellar evolution theory could be due to Cepheids losing significant amounts of mass during the pulsations. □

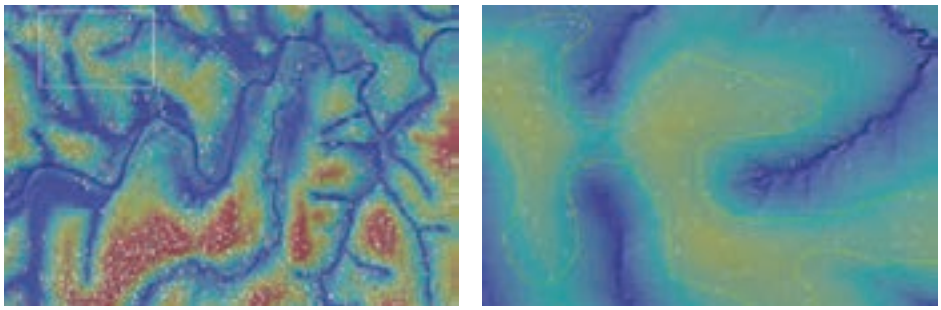
This NASA Hubble Space Telescope view is of the NGC 4603 spiral galaxy, where Cepheid stars have been found.
Image courtesy NASA Headquarters, Great Images of NASA

(Left) Carnegie's Ian Thompson

Termites: Beacons of Climate Change



This on-ground view of a savanna termite mound shows the different types of vegetation associated with the mounds.
Image courtesy Shaun Levick



This map from the Carnegie Airborne Observatory shows the distribution of termite mounds relative to seeplines, parts of savanna slopes where water has flowed belowground through sandy, porous soil and backs up at areas rich in clay. Warm colors indicated higher elevations above river channels; the dots indicate termite mounds.
Image courtesy *Nature Communications* and Shaun Levick

Scientists at the Department of Global Ecology mapped more than 40,000 termite mounds over 192 square miles in the African savanna and found that their size and distribution is linked to vegetation and landscape patterns associated with annual rainfall. The results reveal how the savanna terrain has evolved and show how termite mounds can be used to predict ecological shifts caused by climate change.

Mound-building termites in the Kruger National Park in South Africa tend to build their nests in well-drained soils on slopes of savanna hills above boundaries called seeplines, where water flows belowground through sandy, porous soil and backs up at areas rich in clay. Typically, woody trees prefer the well-drained upslope side, where the mounds tend to locate, while grasses dominate the wetter areas downslope.

"These relationships make the termite mounds excellent indicators of the geology, hydrology, and soil conditions," commented lead author Shaun Levick. "And those conditions affect what plants grow and thus the entire local ecosystem. We looked at the mound density, size, and location on the hills with respect to the vegetation patterns."

Most research into the savanna ecology has focused on the patterns of woody trees and shorter vegetation over large, regional scales. Until now, work at the smaller, hillslope scales has been limited to two-dimensional studies on specific hillsides. The Carnegie research was conducted by the Carnegie Airborne Observatory (CAO)—the unique airborne mapping system that operates like a diagnostic medical scan. It penetrates the canopy all the way to the soil level and can probe about 40,000 acres per day. The CAO uses a waveform LiDAR system (light detection and ranging) that maps the three-dimensional structure of vegetation and, in this case, termite mounds. It combines that information with spectroscopic imaging that reveals chemical fingerprints of the species below.

The researchers found that precipitation, along with elevation and hydrological and soil conditions, determines whether the area will be dominated by grasses or woody vegetation and that the size and density of termite mounds correlate with certain environmental conditions.

The advantage of monitoring termite mounds in addition to vegetation is that mounds are so tightly coupled with soil and hydrological conditions that they make it easier to map the hill slope seeplines. Furthermore, vegetation cover varies a lot between wet and dry seasons, whereas the mounds do not share these fluctuations.

"By understanding the patterns of the vegetation and termite mounds over different moisture zones, we can project how the landscape might change with climate change," remarked coauthor Greg Asner. "These changes will depend on complex but predictable hydrological processes along hill slopes, which will correspond to pattern changes in the telltale termite mounds we see today from the air." □

This research, published in the September 7, 2010, advanced online edition of *Nature Communications*, was funded by a grant from the Andrew Mellon Foundation. The Carnegie Airborne Observatory is supported by the W. M. Keck Foundation and William Hearst III. SANParks provided logistical support.

OBSERVATORIES FELLOWS

Crane and Simon Join Scientific Staff

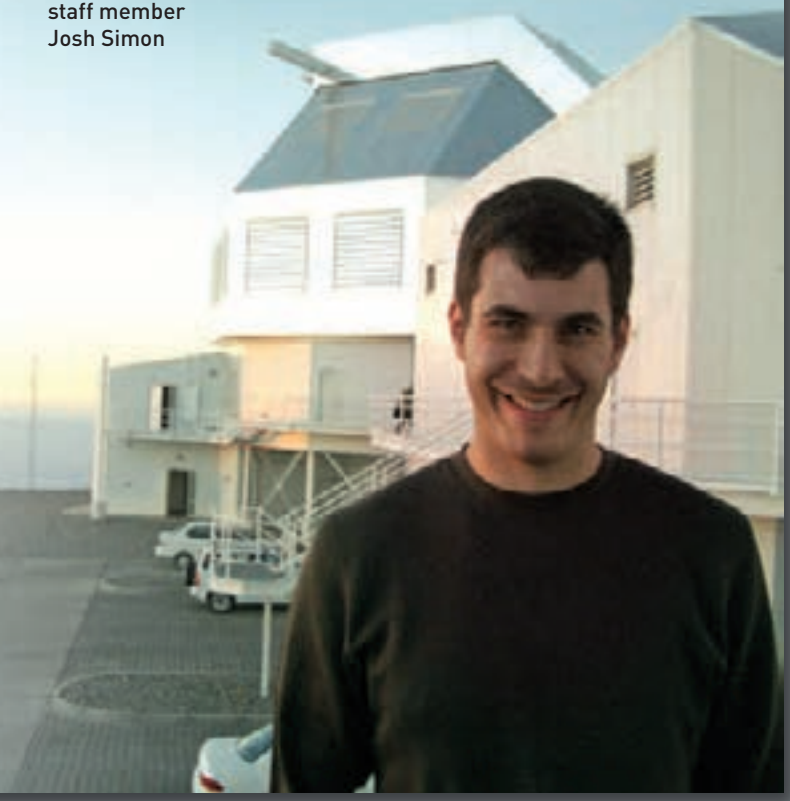
Observatories staff associate Jeffrey Crane

Former fellow Jeffrey Crane is now a staff associate at the Observatories. Crane is particularly interested in developing astronomical instruments, searching for and characterizing extrasolar planets, and understanding the structure, formation, and evolution of the Milky Way. He has married two of these interests with his design and implementation work with the Planet Finder Spectrograph (PFS)—a high-resolution, optical echelle spectrograph on the Magellan Clay telescope. Spectrographs take light and scatter it into a spectrum of wavelengths. Elements absorb light at different wavelengths, making small absorption lines in the spectra. This instrument measures shifts in these lines that are caused by changes in a star's motion as an orbiting extrasolar planet exerts a gravitational tug on its star. Velocity trends can determine the planet's orbital masses and other features. The precision needed, especially for Earth-like planets, is hard to achieve. The original goal for the Planet Finder was to measure velocities to within 2.2 miles per hour (1 meter per second), considered state-of-the-art, but the velocity precision of the PFS may be as good as 1.5 miles per hour (66 centimeters per second).

Josh Simon, also a former fellow, is now a research staff member. He observes nearby galaxies to study dark matter, chemical evolution, star formation, and the process of galaxy evolution. Dark matter is the mysterious nonluminous material that makes up about 25% of the universe. In one study he found that nearby dim dwarf galaxies—small galaxies with just a few million stars at most—are considerably more massive than their brightness would indicate. Simon and a colleague found that they have the highest measured densities of dark matter of any galaxy type, making dim dwarfs ideal laboratories to study dark matter.

In another study, Simon and team found that an old star outside the Milky Way, in the nearby dwarf galaxy Sculptor, had a chemical makeup similar to that of the Milky Way's oldest stars. The finding supports theories that the Milky Way grew by absorbing dwarf galaxies and other galactic building blocks. The discovery of the unusually low elemental abundances of the star marks a significant step towards understanding how our galaxy was assembled and substantiates the idea that the halo of the Milky Way was formed by absorbing a lot of dwarf galaxies. □

Observatories staff member Josh Simon



Potentially Habitable Planet Discovered

Astronomers, including Terrestrial Magnetism's Paul Butler, have found a new, potentially habitable Earth-sized planet around the star Gliese 581, some 20 light-years away. The planet, Gliese 581g is located in a "habitable zone"—a distance from the star where the planet receives just the right amount of energy from its star to maintain liquid water at or near the planet's surface. The 11-year study, published in the *Astrophysical Journal*, was the topic of a National Science Foundation press conference and created controversy within the planet-finding community. However the researchers are confident in the data and suggest that the fraction of stars in the Milky Way with potentially habitable planets could be much greater than previously thought.

"Our calculations indicate that the planet is between 3.1 and 4.3 Earth-masses, has a circular 36.6-day orbit, and a radius between 1.2 and 1.5 Earth radii,"...

The new study brings the total number of planets around Gliese 581 to six. As in our own Solar System, they orbit their star in nearly circular orbits. The Lick-Carnegie Exoplanet Survey scientists collected 11 years of radial velocity data on the star. This method measures a star's tiny movements resulting from the gravitational tug of orbiting bodies. The team tracked the motion of the planets to a precision of about 3.6 miles per hour (1.6 meters per second).

The amplitude and phasing of the star's subtle gravitational reactions allow researchers to determine a planet's mass and orbital period. The planet's radius is estimated by making assumptions about its composition, and its surface gravity is calculated from its mass and radius. Astronomers can also determine the planet's equilibrium and surface temperatures to help determine the potential for habitability. Equilibrium temperature reflects the balance between the energy emitted from the planet and the thermal energy received from the star. The surface temperature is estimated by the planet's distance from the star and assumptions about the composition of its atmosphere. To be habitable, the temperatures must not be so hot to vaporize water, nor too cold.

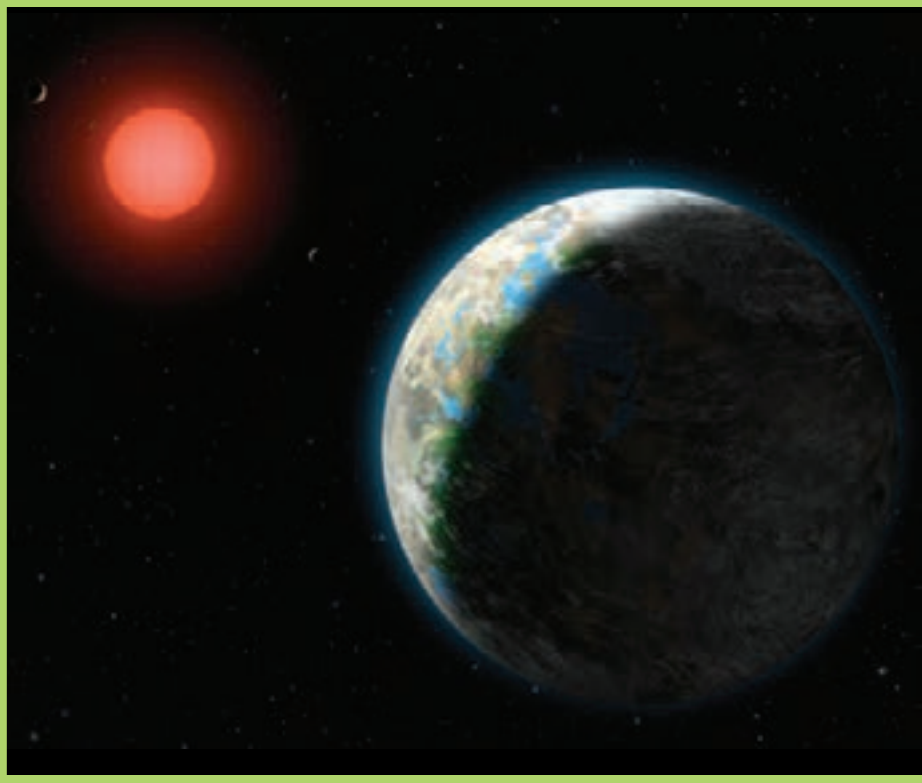
"Our calculations indicate that the planet is between 3.1 and 4.3 Earth-masses, has a circular 36.6-day orbit, and a radius between 1.2 and 1.5 Earth radii," remarked Butler. Its semimajor axis—half the length through the long direction of its elliptical orbital path—is 0.146 astronomical units (one AU is the distance between the Earth and the Sun), and its habitability depends on many factors, not just the temperature. The gravity has to be strong enough to hold an atmosphere, for instance, and the temperature must be lower than about 26°F somewhere on the planet. The planet's surface gravity is similar to Earth's at 1.1 to 1.7 g.

The researchers estimate that the surface temperature of the newly discovered planet is between -24°F and 10°F. The surface would be hot on the side facing the star and cold on the dark side. The planet might be tidally locked to the star—one side would always face the star, while the other side would be dark and cold. This orientation stabilizes the planet's surface climates, according to Steven Vogt, coauthor and professor of astronomy and astrophysics at the University of California, Santa Cruz. The most habitable zone on the planet's surface would be along the line between shadow and light, with surface temperatures decreasing toward the dark side and increasing toward the light side.

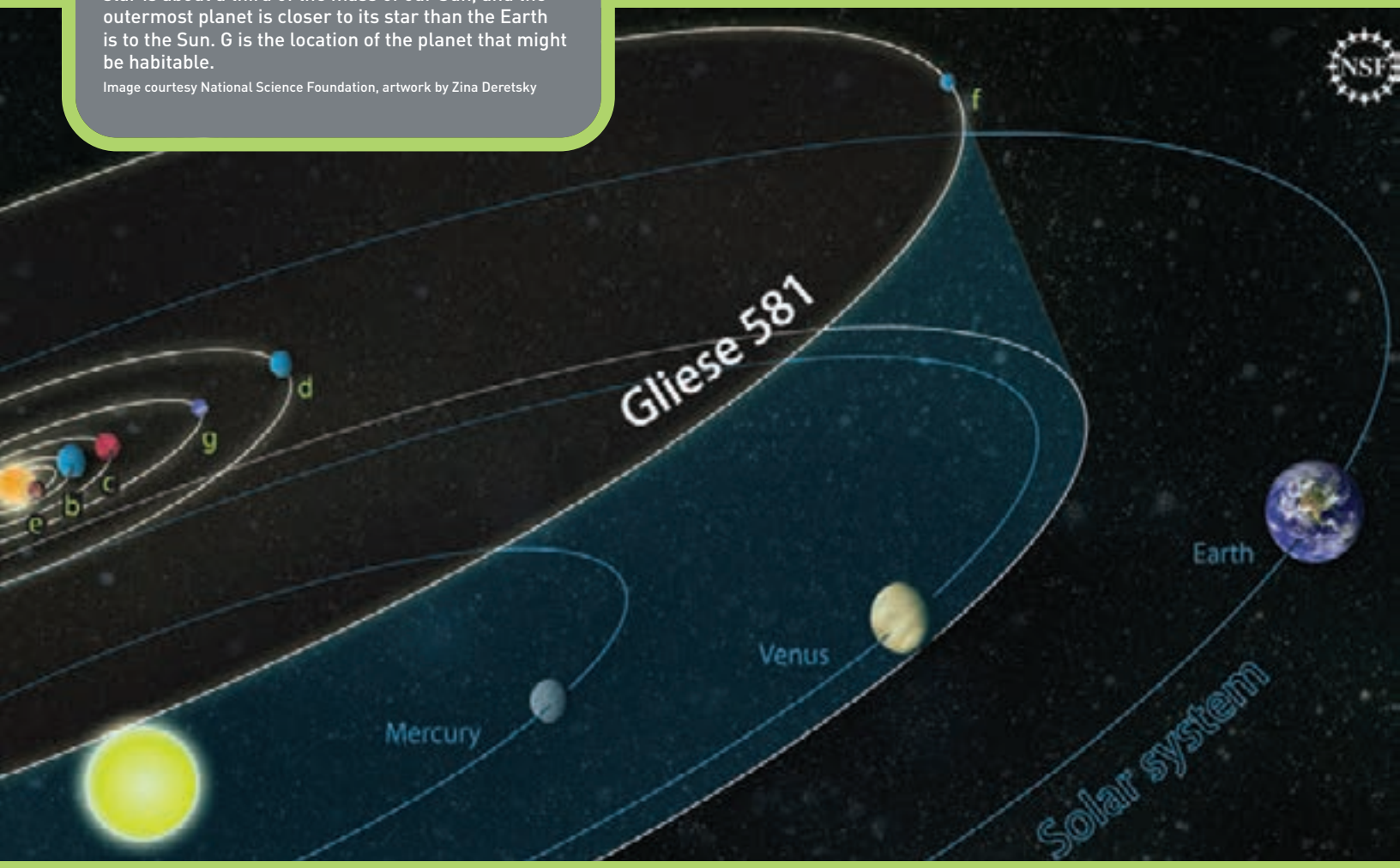
Temperatures on Earth vary tremendously, and life can thrive in very extreme environments, ranging from Antarctica, where the temperature can get to -94°F, to extremely hot hydrothermal vents, which roil at 235°F. □

Authors on the paper are Steven Vogt, UCO/Lick Observatory, UCSC; Paul Butler, Carnegie Institution for Science, Department of Terrestrial Magnetism; UCSC associate research scientist Eugenio Rivera; Associate Astronomer Nader Haghighipour, Institute for Astronomy at the University of Hawaii-Manoa; and Professor Gregory Henry and Michael Williamson of Tennessee State University. The research was funded by NSF, NASA, and Carnegie.

Terrestrial Magnetism's Paul Butler participated in the televised press conference about the discovery of the potentially habitable planet.
Image courtesy National Science Foundation

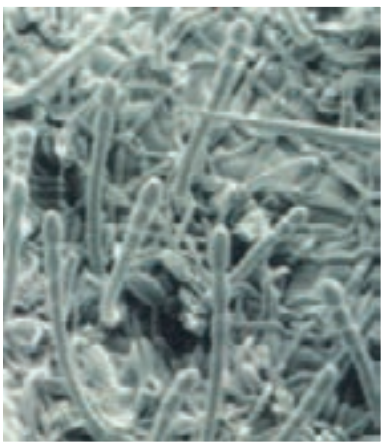


This artwork shows the Gliese 581 system. The star is a red dwarf star about 20 light-years away. The potentially habitable planet, GJ 581g (foreground), is only three to four times the mass of Earth.
Image courtesy National Science Foundation, artwork by Lynette Cook



Our Solar System is shown at bottom, with the Gliese 581 system at top for comparison. The Gliese 581 star is about a third of the mass of our Sun, and the outermost planet is closer to its star than the Earth is to the Sun. G is the location of the planet that might be habitable.
Image courtesy National Science Foundation, artwork by Zina Deretsky

Hijacking Plants



Powdery mildew disease is one plant pathogen that might be controlled through the mechanisms the Plant Biology team identified. The infection has been reported on more than 9,000 plant species. The image at left is a scanning electron micrograph of the surface of an *Arabidopsis* leaf with the disease. The leaf is covered with a mat of fungal filaments from which vertical stalks have emerged to release a new generation of spores.

Disease-promoting pathogens hijack the nutrient apparatus of plants at a cost of some $500 billion annually. For the first time, a research team led by the Department of Plant Biology has developed a trick for identifying how pathogens take control of plant nutrients. The team discovered a novel family of pores that transport sugar out of the plant. Bacteria and fungi hijack the pores to access the plant sugar so they can reproduce. This is the first time scientists have had a direct handle on controlling the food supply to pathogens, and, consequently, they now have a new avenue for potentially preventing a wide range of crop diseases. The study was published in the November 25, 2010, issue of *Nature*.

In the absence of a pathogen the pore proteins, called SWEETs, supply sugars to the developing pollen; these proteins may also be the long-sought suppliers of nectar in flowers. When the pore-protein genes are mutated, they prevent pathogen infection. The researchers found that humans and animals make a similar pore protein, which may play a role in the release of sugars from animal cells of the intestine, liver, and testes, and from mammary cells.

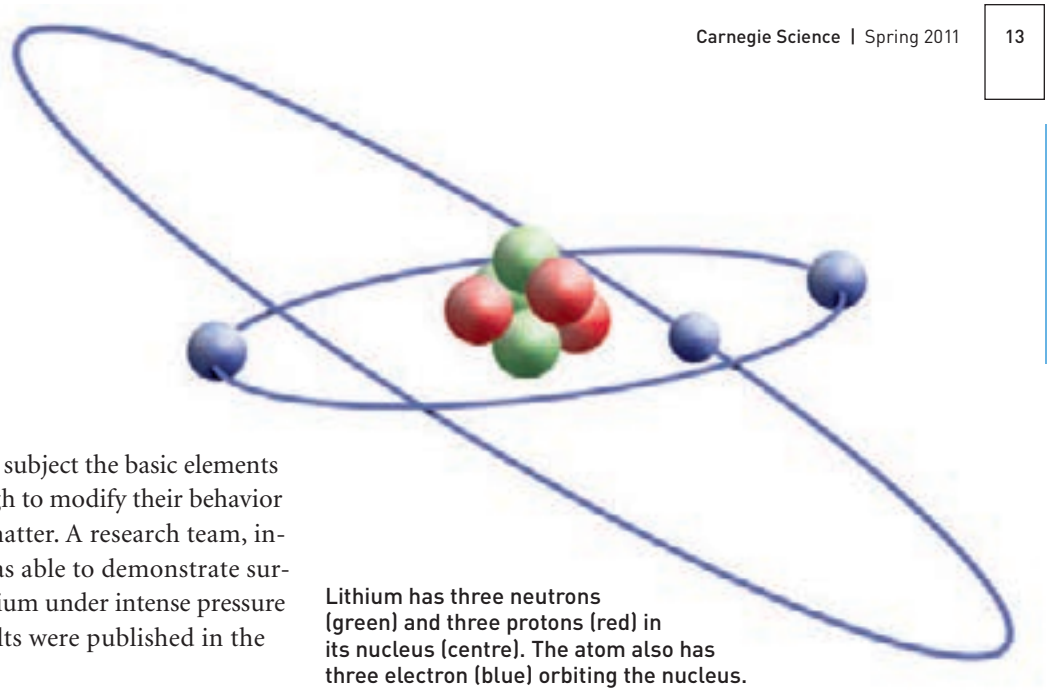
Li-Qing Chen, the lead author of the study, explained the pathogenic process: "The primary goal of a pathogen is to tap the plant's nutrient resources. The pathogens enter the spaces between the cells, where they camp out, feed, and reproduce. Pathogenic bacteria inject activator proteins into the cell that directly induce expression of what we call sugar efflux transporters. The novel sugar transporters at the cells' plasma membrane—little floodgates that release sugar from the cell—turn out to be essential for bacterial reproduction." Before this study, the same lab identified import mechanisms that drive sugar into cells, and had been searching for the sugar-pumping mechanism that exports sugar out of cells.

The researchers use the method of introducing fluorescence resonance energy transfer (FRET) sugar nanosensors into plants to identify the interactions between proteins. The work led them to hypothesize that yet-unknown sugar pores must be present in plants. They looked for potential sugar transporters by screening for genes that might create porelike activities in the cell membrane in *Arabidopsis*, a relative of mustard used widely for research. They expressed these genes, with their FRET sensors, in human cells that are very inefficient in taking up sugars, such that the nanosensors did not report sugar transport. However, when sugar-pore genes were expressed with the nanosensors, the researchers saw sugar transport.

The scientists found that pathogenic bacteria and fungi causing powdery mildew disease hijacked different *SWEET* family members to access the plant's nutrient resources. The *SWEET* genes are the cousins of one of the most important rice blight resistance genes used to prevent blight infections. The researchers showed that the rice blight resistance gene *Xa13* also functions as a sugar pore. When production of the pore is suppressed, the plant becomes resistant to the blight. Since different pathogens try to hijack different pore genes, a drug that could block the activity of all *SWEET* cousins at the same time would turn off sugar supply to a pathogen. The fact that the researchers also found a similar gene *HsSWEET1* in humans that mediates sugar outflow in the liver and intestine suggests that study of this gene could open up a new avenue for diabetes research. □

This work was funded by grants from NIH 5-R01-DK079109-04, DOE DE-FG02-04ER15542 (WBF), and the National Science Foundation Plant Genome Project (FW).

Making Lithium Melt in the Cold



Lithium has three neutrons (green) and three protons (red) in its nucleus (centre). The atom also has three electron (blue) orbiting the nucleus.

Sophisticated tools allow scientists to subject the basic elements of matter to conditions drastic enough to modify their behavior and expand our understanding of matter. A research team, including three Carnegie scientists, was able to demonstrate surprising properties of the element lithium under intense pressure and at low temperatures. Their results were published in the journal *Nature Physics.*

Lithium is the first metal in the periodic table and is the least-dense solid element at room temperature. It is most commonly known for its use in batteries for consumer electronics, such as cell phones and laptop computers.

With only three electrons per atom, lithium should behave like a model, simple metal. But, surprisingly, this research showed that under pressures ranging between about 395,000 atmospheres (40 Gigapascals or GPa) and about 592,000 atmospheres (60 GPa), lithium behaves in a manner that's anything but simple.

Not only does lithium under these conditions become a liquid at room temperature, it then refuses to freeze until the temperature reaches a chilly -115°F. At pressures above about 592,000 atmospheres (60 GPa), when lithium does eventually solidify, it is into a range of highly complex, crystalline states. The highest pressure reached in the team's research was about 1.3 million atmospheres (130 GPa).

The research team, including Malcolm Guthrie, Stanislav Sinogeikin, and Ho-kwang (Dave) Mao, all of Carnegie's Geophysical Laboratory, believes that this exotic behavior is directly due to the exceptionally low mass of the lithium atom. An elementary result of quantum physics is that atoms continue to move, even when cooled to the lowest possible temperature. As the mass of an atom decreases, the importance of this residual, so-called zero-point, energy increases.

The researchers speculate that, in the case of lithium, the zero-point energy *increases* with pressure to the point that melting occurs. This work raises the possibility of uncovering a material that *never freezes.* The prospect of a metallic liquid existing at even the lowest temperatures raises the intriguing possibility of an entirely novel material, a superconducting liquid, as proposed previously by theorists for hydrogen at very high pressure. □

Malcolm Guthrie of the Geophysical Lab

Ho-kwang (Dave) Mao of the Geophysical Lab

Stanislav (Stas) Sinogeikin of the Carnegie Geophysical Lab's HPCAT Lab

Carnegie Welcomes Rick Sherman,

Chief Advancement Officer

For the last seven years Rick Sherman has been the director of advancement for the Chemical Heritage Foundation (CHF) in Philadelphia. The nonprofit organization "fosters an understanding of chemistry's impact on society," by maintaining collections of instruments, art, photographs, and other artifacts, and offering public education programs. Working with the chancellor, president, and board of directors, he managed the fundraising and related activities for a recently completed $75- million fundraising campaign, which established the new museum and conference center at CHF.

With a bachelor of science degree from the State University of New York, Sherman spent 20 years in various manufacturing, sales, marketing and strategic planning roles in the pulp and paper industry. His transition to the nonprofit sector was preceded by a M.S. finance degree from Drexel University. Sherman is particularly excited about the breadth of Carnegie science and its impact on the broader scientific community. □

Rediscovering Arthur L. Day

BY SHAUN HARDY

Arthur L. Day—the Geophysical Laboratory's (GL) first director—died half a century ago, leaving a formidable legacy. One of the leading American scientists of his generation, he pioneered the application of physics and chemistry to geological problems. During his tenure (1906-1936), the lab established itself as a global leader in high-temperature and high-pressure research. Day also distinguished himself in industrial research and development, overseeing the modernization of America's optical glass industry during World War I. He was instrumental in organizing large-scale, cooperative studies of earthquakes in southern California, including the establishment of the Seismological Laboratory at Caltech. His book *Hot Springs of the Yellowstone National Park*, coauthored with E. T. Allen and published by the Carnegie Institution in 1935, remains a classic today.

Yet for all of his far-reaching contributions to science, Day left almost no trace of professional and personal correspondence. For decades it was presumed that his personal papers were either destroyed or lost. Now, two significant private collections have unexpectedly come to light.

Four hundred fifty letters Day wrote to his parents between 1889 and 1898 have been in the possession of H. William Birgfeld III since the 1960s, when he discovered them in Day's former house in Bethesda, Maryland. The letters document Day's years at Yale University, first as an undergraduate and graduate student and later as a physics instructor, as well as his move to Germany in 1897 to join the Imperial Physical-Technical Institute in Charlottenburg. Mr. Birgfeld generously donated the collection to the GL archives in October.

An even larger collection of Day material was acquired many years ago by Robert Weed of Westminster, Maryland. Spanning roughly 1900 to 1920, the correspondence, research files, and technical reports that constitute Weed's collection illuminate Day's return to the U.S. from Germany and his early association with both Carnegie and Corning Glass. Mr. Weed brought his collection to the attention of Broad Branch Road librarian Shaun Hardy last winter and is kindly allowing copies to be made for the archives, where interested scholars will be able to access them.

Taken together, the Birgfeld and Weed collections promise to shed new light on a seminal figure from Carnegie's past. □

(Above) Julie Edmonds, Nancy Gilstrap, Bill Birgfeld, and Jim Edmonds (left to right) visited the Broad Branch Road library in October to present Birgfeld's collection of Day letters to the archives.

(Below) Arthur L. Day sits as his desk at the Geophysical Lab's original quarters in downtown Washington, D.C., ca. 1906.

InBrief

Three New AGU Fellows

Carnegie had an impressive representation of new American Geophysical Union (AGU) Fellows at the December 2010 meeting. Fellows are elected because they have made "exceptional scientific contributions to the Earth and space sciences." Only some 0.1% of all AGU members, over 58,000 worldwide, are elected annually. This year the honor was conferred on three Carnegie scientists: Yingwei Fei of the Geophysical Laboratory, Ken Caldeira of Global Ecology, and Steven Shirey of Terrestrial Magnetism (shown left to right).

TRUSTEES AND ADMINISTRATION

❶ President **Richard A. Meserve** gave a presentation on Oct. 1 at the symposium "Global Energy Future" at Washington U. in St. Louis. He participated in the Harvard board of overseers meetings Oct. 2-3, Dec. 4-5, and Feb. 5-6. He made a presentation on energy policy to a joint meeting of the NAS and the Russian Academy of Sciences on Oct. 7. He participated in meetings of the Blue Ribbon Commission on America's Nuclear Future in Washington, DC, Chicago, and Aiken, GA. He cochaired a meeting of the National Academies' Committee on Science, Technology, and Law Oct.25-26 in Washington, DC, and chaired a meeting of the IAEA's International Nuclear Safety Group on Nov. 9-12 in Vienna, Austria. He chaired a meeting of the National Academies' Nuclear and Radiation Studies Board on Dec. 2-3. He participated in a board meeting of Carnegie Canada in Montreal on Dec. 6 with board member **William Turner**. Meserve traveled to Carnegie's Las Campanas Observatories in Chile on Jan. 26-30 with guests, including trustee **Rush Holt**. He served as the cochairman of a workshop on nuclear development in new-entrant countries at Tufts U. on Feb. 24, and gave a presentation at the Radioactive Waste Management Conference in Phoenix on Feb. 28.

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Executive assistant to President Meserve, **Lisa Klow**, left Carnegie to move to Chicago with her husband. **Christina Naguiat** took her place.

❶ Carnegie president Richard A. Meserve

Carnegie trustee William Turner

Carnegie trustee Rush Holt

EMBRYOLOGY

Director **Allan Spradling** attended the annual David and Lucile Packard Foundation meeting in Monterey, CA, and the Scientific Advisory Board meeting at the Curie Institute in Paris. He also presented lectures at NIH, U. Iowa, U. Michigan, UC-San Francisco, the Cold Spring Harbor Symposium on germ cells, and the Stowers Institute for Medical Research 10th Anniversary Symposium. He participated in a two-week course in Santiago, Chile, and presented a lecture at the biennial meeting of the Latin American Society for Developmental Biology in Santa Cruz, Chile.

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Joe Gall was an invited speaker at the 13th International *Xenopus* Conference in Sept. and a Special Interest Subgroup–invited speaker at the American Society for Cell Biology meeting in Dec.

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Don Brown was an invited speaker at the 13th International *Xenopus* Conference in Sept. and participated in the USA Science and Engineering Festival on the National Mall in Oct.

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Marnie Halpern attended the Pew Scholars Alumni meeting. She also presented seminars at U. Miami, Virginia Commonwealth U., and was a *Nifty Fifty* speaker at Gaithersburg High School as part of the USA Science and Engineering Festival in Oct. **Steve Vary** and **Rob Vary** assisted her at the expo by setting up live embryos on microscopes.

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Carnegie Staff Participate in First USA Science and Engineering Festival

The first USA Science and Engineering Festival was held Oct. 10-24 in Washington, DC. Its mission is to inspire Americans about science. Carnegie was among the more than 500 science and engineering organizations participating in the event and is one of the original festival partners. On Oct. 23 and 24 Carnegie scientists staffed booth 644 on the Mall and hosted a teacher workshop with the Society for Developmental Biology. Three Carnegie scientists were also chosen to be Nifty Fifty Lecturers for the festival from 500 applicants. They are biogeochemist Marilyn Fogel, developmental biologist Marnie Halpern, and astronomer Stella Kafka.

(Top) Postdoctoral fellow James Walters (foreground, red cap) and staff member Steve Farber (blue cap) participated in the USA Science and Engineering Festival.

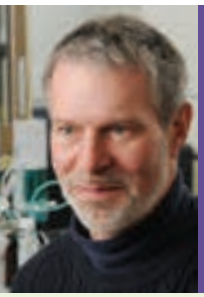
(Bottom) Embryology director emeritus Don Brown (white t-shirt) chats with attendees at the USA Science and Engineering Festival.

Knowledge is Power

On Nov. 11 the dept. hosted 70 eighth-grade students from the Knowledge Is Power Program (KIPP) school in Baltimore. KIPP is a network of charter public schools with curricula that target the needs of middle school students from low-income backgrounds. These students focus on the college application process early and spend longer hours in school than other children [nine and a quarter hours weekdays, three and half hours on Saturdays, and six and a half hours for three weeks during the summer]. The KIPP students saw circulating hemocytes—cellular components of blood—in the fruit fly and blood cells in the zebrafish. They examined mouse chimeric embryos and skeletal preparations, and looked at the giant lampbrush chromosomes from newts and frogs. The visit was organized by Mentoring to Inspire Diversity in Science, a graduate student group in the Johns Hopkins biology program that focuses on the recruitment and retention of underrepresented students in the biological sciences.

(Above) Graduate student Katie McDole explains work in the Zheng lab.

(Left) Zehra Nizami, a graduate student in the Gall lab, was one of the organizers of the event.



Robert Hazen
was named the 2011 Linnaeus Lecturer of the U. of Uppsala, Sweden. The lecture and awards dinner took place in Feb.

❷ Douglas Rumble

❸ Anat Shahar

Image courtesy Stanford U.

❹ Bill Anderegg

Image courtesy Stanford U.

❹ Michael Mastrandrea

❺ Luiz Fernandez
Image courtesy EPA

Yixian Zheng presented her work at the 13th International *Xenopus* Conference, at the Ray Wu Symposium in Beijing, and at a workshop in Baeza, Spain, titled "Centrosome Structure, Function, and Dynamics." She attended the Encyclopedia of Life Sciences board meeting in the UK and the American Society for Cell Biology meeting in Dec. with lab members **Katie McDole**, **Ben Goodman**, **Youngjo Kim**, and **Junling Jia**.

—

Steve Farber attended the Pew Scholars Alumni meeting and presented a seminar at the Johns Hopkins School of Public health. He co-organized a symposium at the Fondation des Treilles in France titled "Non-mammalian Models for Human Lipid and Related Diseases." He also participated in the USA Science and Engineering Festival by manning a booth with the Society for Developmental Biology.

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Alex Bortvin presented lectures at U. Colorado, U. Pennsylvania, and, in Dec., at the annual meeting of the Environmental Mutagen Society in Fort Worth, TX.

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Nick Ingolia attended a European Molecular Biology Laboratory conference, "From Functional Genomics to Systems Biology," in Frankfurt in Nov.

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Spradling lab postdoctoral fellow **Don Fox** spoke at the International Meeting on Notch Signaling in Athens, Greece, and postdoctoral fellow **Lucy Morris** spoke at the Stowers Institute for Medical Research 10th Anniversary Symposium. Members of the Spradling lab spent two and a half days working at the HHMI Janelia Farms in Virginia identifying a number of potentially useful new *Drosophila* genetic strains.

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Koshland lab graduate student **Margaret Hoang** has accepted a postdoctoral position in Bert Vogelstein's lab at the Johns Hopkins School Medicine. Graduate student **Dean Calahan** defended his Ph.D. thesis, "The Genetics of Desiccation Tolerance in *Saccharomyces cerevisiae,*" in Dec.

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Postdoctoral fellow **Itay Onn** accepted a faculty position at Bar-Ilan U. in Israel, to begin in Sept. 2011.

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New postdoctoral fellow **Erin Mathieson**, who received her Ph.D. from SUNY-Stony Brook, is a Carnegie Collaborative Fellow in the Farber and Zheng labs and is developing a vertebrate genetic system to study the function of nuclear lamina in vivo during intestine development.

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Graduate student **Tim Mulligan** left the Farber lab in Dec. for a postdoc position at NIH.

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Postdoctoral fellow **Mary Goll** left the Halpern lab for a faculty position at the Sloan-Kettering Institute. **Estela Monge** joined the lab as an animal-care technician.

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Caroline Flournoy, who received her Ph.D. from UVA, joined the Fan lab as a postdoctoral fellow.

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Bortvin lab postdoctoral fellow **Safia Malki** gave a talk at the Cold Spring Harbor Germ cell meeting.

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Irena Martirosyan, who received her Ph.D. from the RAS Institute of Gene Biology in Moscow, joined the Han lab as a postdoctoral associate.

GEOPHYSICAL LABORATORY

Director **Russell J. Hemley** gave the following invited talks: "Molecules under Pressure" at EUCMOS 2010 in Florence, Italy, Sept. 1-5; "Materials Chemistry under Extreme Conditions," Pacifichem 2010, in Honolulu, HI, Dec. 17-20; and "New Findings and Phenomena in Materials under Extreme Conditions" at the Army Research Laboratory Fellows Symposium in Aberdeen, MD, Oct. 6. He helped organize the Exploring Giant Planets on NIF: A New Generation of Condensed Matter Workshop at Lawrence Livermore Laboratory on Dec. 17, where he also chaired the session "Hydrogen and Helium at Extreme Densities."

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Robert Hazen was organizer and lecturer of the Pardee Symposium on Mineral Evolution at the GSA meeting in Denver, Oct. 31-Nov. 3. Hazen, **Rus Hemley**, and **Connie Bertka** organized a session on Deep Carbon Science at the AGU meeting in San Francisco in Dec. Hazen was also a keynote lecturer at origins of life conferences in Austria and Holland, and presented lectures on mineral evolution at Rutgers and Trinity universities.

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❷ **Douglas Rumble** was named a laureate of the Bureau de Recherche et de l'Innovation by the Mairie de Paris, France. He will work on the oxygen isotope composition of meteorites in the laboratory of Pierre Cartigny in the Institut de Physique du Globe de Paris for six months beginning in Feb.

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❸ **Anat Shahar** gave an invited talk at AGU in the planetary cores session.

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Muhetaer Aihaiti presented an invited talk at the Army Research Laboratory titled "Spectroscopic studies of Polymers, Gelatin, and AlON" on Oct. 21.

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Jim Cleaves hosted a seminar by Armen Mulkidjian on Sept. 23 and gave a seminar at U. Hawaii, Manoa, on Dec. 13. He also gave a talk at Pacifichem in Honolulu Dec. 17.

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High Pressure Synergetic Consortium (HPSynC)
Arrivals: Maria Baldini, staff scientist from Stanford U.; **Svetlana Kharlamova**, postdoctoral researcher from Carnegie and Argonne National Laboratory; **Xiaojing Huang**, postdoctoral researcher from Stony Brook U.; **Fangfei Li**, postdoctoral researcher from Jilin U., China; and **Lingping Kong**, Ph.D. student from Harbin Institute of Technology, China.

DEPARTMENT OF GLOBAL ECOLOGY

Chris Field moderated a roundtable of speakers at a memorial celebration and scientific symposium for the late Stephen Schneider at Stanford Alumni Center. Field lab's **Bill Anderegg** was a student speaker, and he and ❹ **Michael Mastrandrea** performed in a musical tribute to Schneider.

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An interview with **Ken Caldeira** appeared in *Discover* magazine online Sept. 13. Caldeira also gave a seminar for Stanford's CEES Computational Geoscience group on Oct. 18.

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Greg Asner met with government leaders in Thailand to advance their climate mitigation strategy on deforestation and carbon emissions. He also presented new methods for tracking rain forest biodiversity change at the UN Framework Convention on Biological Diversity in Nagoya, Japan.

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The Spectranomics team, including **Greg Asner**, **Loreli Carranza**, Alberto Escudero, Nestor Jarmillo, **Robin Martin**, Paola Martinez, Felipe Sinca, and Raul Tupayachi, completed four more field campaigns in lowland Peru, Ecuador, and at a mid-elevation site in Ecuador, bringing the total number of samples collected to almost 8,000. Each sample is analyzed for 21 chemical traits.

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❺ The Field lab's **Luis Fernandez** received a USDA grant to serve as a plenary speaker at the IV Congress for Biofuels and Renewable Energy (IV COBER) at Molina Agricultural U. in Lima, Peru. Oct.11-16. His talk was "Sustainable Rural Development: Integrated Land Use and Conservation of Natural Capital." On Oct. 13 he was the keynote speaker at a workshop on sustainable development at the National Amazonian U. of Madre de Dios in Puerto Maldonado, Peru. He was a guest on the Peruvian cable news network's (Canal N) news analysis program *Hora N with Jaime de Althaus*

A Tough Day's Work

The Global Ecology Spectranomics team collects samples and maps the tropical forests with a vengeance. On the ground, third world four-legged conveyances carry first world high-tech equipment for analyzing the jungle canopy (A). The team collects samples in many ways, including shooting them out of the trees (D). Once they obtain samples, team members process them in on-site labs (B). After the day's grueling work, the group gets to sack out (C).

Images courtesy Greg Asner.


A


B


C


D


❻ Miguel Roth


❼ Steve Shectman


❽ Luis Ho


❾ Josh Simon

on Oct. 15 and spoke about the recent increase in deforestation in Peru's southern Amazonian forests and mercury contamination of the region's watersheds. He gave a presentation to the Forestry Committee of the Association of Foreign Exporters (ADEX) in Lima. He was featured in the fall 2010 issue of the *Virginia Quarterly Review* in the article "Mother of God, Child of Zeus" about his ongoing research on the area's land-use change and mercury contamination.

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Thirteen people associated with Chris Field's lab visited Carnegie's Mountain Experimental Stations at Camp Mather and Timberline in Oct.

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The Caldeira lab's **Kenny Schneider** was on Heron Island, Great Barrier Reef, for three weeks in Nov.-Dec. concluding a nine-month Coral Proto-Free Ocean Carbon Enrichment System (CP-FOCE) experiment. The experiment measured the growth rate of corals under present-day and future conditions with high atmospheric CO_2. The project is a collaboration with Davey Kline from the lab of Ove Hoegh-Guldberg at U. Queensland, Lida Teneva from Rob Dunbar's lab at Stanford, and Matthew Valetich from Bradley Opdyke's lab at Australian National U.

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Julie Pongratz attended the Global Land Project Open Science Meeting in Tempe, AZ, Oct. 17-19 and gave the talk "Biophysical Versus Carbon Cycle Effects of Historical Deforestation." At the AGU fall meeting she gave a talk titled "Relevance of Preindustrial Land Cover Change and Emissions for Attribution of Excess Atmospheric Carbon Dioxide."

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The Asner lab's CLASlite team continued training government partners on satellite monitoring of deforestation in Peru, Ecuador, and Colombia. They also worked with partners at the World Wildlife Fund to complete deforestation and carbon mapping in Madagascar.

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The CAO team worked with partners in Ecuador to map carbon stocks in the Ecuadorian Amazon.

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Two Asner Lab interns, **Rebecca Nguyen** and **Priscilla Ngo**, presented their poster titled "Using Leaf Samples to Establish a Library of Tropical Leaf Fingerprints" at the Dec. AGU meeting. They worked closely with **Chris Anderson**, **Mona Houcheime**, and **Parker Weiss** to learn analyses in the Spectranomics lab.

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Matt Colgan organized the annual Carnegie hog roast on Oct. 29.

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Arrivals: Rebecca Hernandez and **Mary McManus** joined the Field lab as doctoral students in Sept. **Ijah Garfield** joined the Asner lab as a technician on Sept. 27, and **Kevin Smith** became a full-time Asner lab technician on Oct. 16.

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Departures: George Ban-Weiss left the Caldeira lab on Oct. 29 for a position at Lawrence Livermore National Lab. **Ho-Jeong Shin** left the Caldeira lab on Oct. 29 for a postdoc at MIT. **Shaun Levin** left the Asner lab on Sept. 29 for a faculty position in New Zealand. Lab technician **Parker Weiss** left the Asner lab on Sept. 15. **Adam Wolf** of the Berry lab left Oct. 15 for a postdoc position at Princeton U.

OBSERVATORIES

❻ On Sept. 24 **Wendy Freedman** and **Miguel Roth** attended a luncheon with His Excellency Sebastián Piñera Echenique, president of Chile, hosted by Gov. Arnold Schwarzenegger and U. California Chancellor Gene Block, celebrating the expanding educational partnership between Chile, California, and U. California. As chair of the Cosmology Selection Advisory Board for the 2010 Gruber Cosmology Prize, Freedman attended its Celebratory Luncheon on Oct. 15. She also attended the Chandrasekhar Centennial Symposium at U. Chicago Oct. 16 and 17. In Nov. she presented the 2010/2011 John M. Chermeda Lectures at Penn State U. Freedman attended the Celebration of 40 Years of Astronomy at Las Campanas Observatory and a celebration in honor of **Miguel Roth's** 65th birthday in Santiago, Chile, in Dec.

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❼ In Sept. staff astronomer **Steve Shectman** chaired the Phase B Final Design Review for the European Extremely Large Telescope at the European Southern Observatory in Garching, Germany. In Dec. he attended the Celebration of 40 Years of Astronomy at Las Campanas and a birthday celebration in honor of Miguel Roth in Santiago, where he gave a talk on the Magellan Project.

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❽ Staff astronomer **Luis Ho** gave an invited talk at the meeting "Accretion and Outflow in Black Hole Systems" in Kathmandu, Nepal. He attended IAU Symposia 277, "Tracing the Ancestry of Galaxies," in Ouagadougou, Burkina


⓾ Sue Rhee


⓫ Kathy Barton


⓬ Eva Huala


⓭ Guido Grossmann


⓮ Tie Liu

Faso. He gave colloquia at Northwestern U. and at the Very Large Array, New Mexico. He also gave a popular talk on black holes at the Carnegie board of trustees dinner.

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In Oct. staff astronomer **Andrew McWilliam** gave an invited talk at the Giant Magellan Telescope meeting at Seoul U., South Korea.

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❾ Staff associate **Josh Simon** attended the conference "Blitzed 65" in Berkeley on Oct. 29-30. He gave an invited talk entitled "Testing the L(eo)CDM Model on Small Scales."

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In Sept. Carnegie Fellow **Janice Lee** gave an invited talk at the Joint European and National Astronomy Meeting in Lisbon, and a colloquium at George Mason U. in Fairfax, VA. In Nov. she gave an invited seminar at UC-San Diego.

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Postdoctoral research associate **Nimish Hathi** presented a poster at "Science with the Hubble Space Telescope - III: Two Decades and Counting" conference Oct. 11-14, in Venice, Italy. His poster "UV-dropout Galaxies in the GOODS-South Field from WFC3 Early Release Science Observations" presented first results from the WFC3/UVIS camera on the Hubble Space Telescope. He attended a two-day workshop on slitless spectroscopy with HST Nov. 15-16 at the Space Science Telescope Institute, Baltimore.

PLANT BIOLOGY

Director **Wolf Frommer** attended the 15th International Plant Membrane Biology Workshop in Adelaide, Australia, Sept. 16- 25. He presented the opening lecture and a talk. He also chaired a workshop on advanced imaging on Sept. 20 and lectured on "A Revolution in Optical Methods over the Past 15 Years." On Dec. 2 he was invited to give a talk at Lausanne U., Zurich. On Dec. 6 he gave a two seminars on FRET: one at IPK, Gatersleben, Germany, and the other at Erlangen U., Germany.

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Winslow Briggs participated in the Einstein Professorship Lecture Tour in China Dec. 6-15. He gave the following talks: Dec. 6 at the Graduate U., Chinese Academy of Sciences, Beijing, on LOV domains; and Dec. 7 and 9 at the Institute of Botany, Chinese Academy of Sciences, Beijing, and the Institute of Oceanology, Chinese Academy of Sciences, Tsingtao, respectively, on "Vegetation Recovery after a California Wildfire: A New Class of Plant Growth Regulators in Smoke." He also talked about LOV domains there on Dec. 9. On Dec. 13 he spoke at the Zhejiang Agricultural Academy of Sciences, Hangzhou, about 60 years as a plant biologist. On Dec. 14 and 15 he spoke about LOV domains at the Institute of Plant Physiology and Ecology, Chinese Academy of Sciences, and at the Shanghai Jiao Tong U.

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⓾ On Aug. 30-Sept. 2 **Sue Rhee** attended the Consortium of Plant Sciences in Ardmore, OK. On Sept. 8-10 she presented a poster at the NSF PGRP Awardees' Meeting in Arlington, VA.

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⓫ **Kathy Barton** was an invited speaker at the Sept. 20-21 Developmental Biology Center and Stem Cell Institute at U. Minnesota on the role of the ad/abaxial network in leaf development. She presented the same invited seminar on Oct. 22 at the U. Wisconsin Genetics Colloquium.

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Zhiyong Wang attended the FASEB meeting in Saxton River, VT, Aug. 16-21 and talked about brassinosteroid signaling. On Oct. 17-21 he attended a DOE awardee meeting in Baltimore and talked about a proteomic study of brassinosteroid response in plants. Nov.18-19 he presented a seminar at the 2nd International Symposium on "Frontier in Agriculture Proteome Research" held in Tsukuba, Japan.

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⓬ Sept. 6-9 **Eva Huala**, director of TAIR, and **Tanya Berardini** and **Donghui Li**, TAIR curators, attended the Gene Ontology Meeting held in Bar Harbor, ME.

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On Sept. 19-24 **Devaki Bhaya** attended the workshop "Redefining Microbial Genomics" at the Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, ME.

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Martin Jonikas attended an NSF Ideas conference titled "Surpassing Evolution: Transformative Approaches to Enhance the Efficiency of Photosynthesis" Sept. 13-17.

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Staff scientists attended the meeting of nonprofit Plant Biology Institutes in Dallas, TX, held at the Noble Foundation Aug. 30- Sept. 2. **Martin Jonikas** gave a talk titled "Transformative Genetic Tools to Discover New Pathways," **Wolf Frommer** spoke on the history and future of Carnegie's Dept. of Plant Biology and the Frommer lab projects, and **Zhiyong Wang** talked about brassinosteriod signaling.

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⓭ Frommer lab postdoctoral associate **Guido Grossmann** attended the 2nd Symposium on Image Mining in Obergurgl, Austria. He gave a talk at the Patchy Prague 2010 conference in Prague Oct. 15 and at the US-EMBO Fellows Meeting in La Jolla, CA, Nov. 5-7. On Nov. 8 he presented an invited talk, "Formation, Dynamics, and Function of Microdomains in the Plasma Membrane of Yeast and Plants" at UC-San Diego.

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Brigg's lab postdoc **Tong-Seung Tseng** presented a poster on PHOT2 interacting proteins at the annual meeting of the American Society of Plant Biologists in Montreal July 31-Aug. 4, and Barton lab's ⓮ **Tie Liu** presented a poster at the FASEB meeting at Saxton River, VT, Aug.15-20.

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TAIR group members presented several talks: **Kate Dreher** on Sept. 13 at Lehman College, CUNY, and **Peifen Zhang** and **Tanya Berardini** at the Biocuration 2010 meeting in Tokyo Oct. 10-16.

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Arrivals: Cindy Ast (U. Potsdam, Germany) joined the Frommer lab as a DAAD Fellow on Oct. 16. **David Nelson** started his Carnegie Fellowship in the Briggs lab from a postdoctoral position in Australia on Oct. 1. The Grossman lab welcomed new postdoctoral research associate **Munevver Aksoy** (CUNY) on Sept. 1. The Wang lab welcomed two new members: **Shuolei Bu**, a predoctoral student from Hebei Normal U., China, on Oct. 11 and **Rafael Arenhart**, a predoctoral student from Federal U. Rio Grande do Sul, Brazil, on Dec. 16. The Jonikas lab welcomed **Spencer Gang** (Santa Clara U.) as a laboratory technician on Sept. 20. Two interns joined the dept.: **Leanna Racine** in the Evans lab on Nov. 22 and **Dasha Savage** in the Rhee lab on Oct. 13. **April Wensel** (Pomona Coll.) joined TAIR on Dec. 1 as a programmer. On Oct. 4 **Faatuai Williams** joined the administrative staff as a procurement clerk and receptionist.

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Departures: Sylvie LaLonde, director of the imaging facility in the Frommer lab, returned to Montreal in Dec. Postdoctoral associate **David Swarbeck** resigned from the TAIR group in Oct. to join EBI in England. **Rosario Gomez Garcia**, a postdoctoral associate in the Bhaya lab, departed Oct. 15.

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Ta-Yan Leong, a former postdoctoral research associate in the Briggs's lab in the late 1970s, retired from CSIRO in Sept. 2010. He was awarded the prestigious CSIRO Lifetime Achievement Medal by the Australian Science Minister in Oct. 2010 for his contribution to science collaboration between Australia and other countries.

TERRESTRIAL MAGNETISM

In Oct. **Sean Solomon** served on a visiting committee to the Div. of Geological and Planetary Sciences at Caltech. In Nov. he attended the second joint MESSENGER-BepiColombo workshop on Mercury's coupled exosphere and magnetosphere, held at U. Colorado, Boulder. In Dec. he represented the MESSENGER mission at a NASA Discovery Science Workshop in

Washington, DC. In Jan. he chaired a meeting of the MESSENGER Science Team at U. Arizona in Tucson.

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In Oct. **Alan Boss** had several live television interviews with Fox News about **Paul Butler**'s discovery of the first potentially habitable world, Gliese 581g. Boss chaired meetings of the NASA Advisory Council's Astrophysics Subcommittee in Oct. and Dec. that dealt, respectively, with NASA's plans for implementing the Astro2010 Decadal Survey recommendations and cost and schedule overruns for the James Webb Space Telescope. He also gave a colloquium at the Astrophysics Science Div. at NASA Goddard Space Flight Center, Greenbelt, MD. He spoke about the Decadal Survey at the IAU symposium on "The Astrophysics of Planetary Systems" in Turin, Italy. Boss spoke about habitable planets in a live radio interview for NPR's Diane Rehm Show in Dec. In Jan. he hosted a special session on the latest results from NASA's Kepler Mission at the AAS meeting in Seattle.

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At the GSA annual meeting in Denver in Oct., **Paul Butler** gave a talk at the session "Exploring for Life in the Cosmos: Celebrating Five Decades of Astrobiology." On Nov. 9 he was featured in the KidsPost section of the *Washington Post* highlighting his visit to Stoddert Elementary School, where he answered questions about the first extrasolar planet found in a habitable zone. Later that month, Butler, with collaborators, was featured on Hawaiian television KIVT in a segment about their continuing planet-hunting research.

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Richard Carlson presented seminars at the Lamont-Doherty Earth Observatory in Oct. and Princeton U. in Nov. Both talks were on the evidence for chemical differentiation of the early Earth relative to the current chemical structure of Earth's interior.

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⓯ Alycia Weinberger

⓰ Broad Branch Road librarian Shaun Hardy visited the *Terrestrial Physics* art exhibition based on DTM's 1930s physics experiments at the Museum of Contemporary Art in Denver.

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GEORGE TILTON DIES

George Robert Tilton, professor emeritus of geology at UC-Santa Barbara, died at the home of his daughter in Eugene, Oregon, on October 12, 2010. He conducted research at Carnegie from 1951 to 1965 and served as professor of geochemistry at UCSB from 1965 to 1991.

Born June 3, 1923, in Danville, Illinois, he attended Blackburn College until World War II, when he served in the army and received a Purple Heart for his wounding in Alsace. Tilton then studied chemistry at the U. of Illinois, where he met Elizabeth Jane Foster. They married Feb. 7, 1948. He attended graduate school at the U. of Chicago, where he obtained a Ph.D. in chemistry. His graduate work at Chicago with colleague Clair Patterson pioneered the uranium-lead isotopic method of determining the age of rocks, formulating the basic procedures for analysis that are still used today. The work led to the calculation of the age of the Earth and Solar System at 4.56 billion years. He received numerous honors and awards for his research.

In Nov. **Larry Nittler** attended a workshop on presolar grains and isotopic anomalies at Clemson U. In Jan. he attended the MESSENGER Science Team meeting in Tucson and a workshop on applications of secondary ion mass spectrometry in Taipei, Taiwan.

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Steven Shirey was inducted as a fellow and received a fellowship medallion from the AGU on Dec. 15. He was honored for his research in isotope geochemistry and the formation and evolution of the continents.

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⓯ **Alycia Weinberger** gave an invited talk at "GMT 2010: Opening New Frontiers with the Giant Magellan Telescope" in Seoul, South Korea, in Oct. In Jan. she attended meetings of the AAS and the Exoplanet Exploration Program Analysis Group as a member of the Executive Committee. Both meetings were held in Seattle. That month she also chaired the SOFIA Science Program Council in Palmdale, CA.

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In Dec. **Steven Golden** presented a poster at the AGU meeting in San Francisco titled "AcquiControl: Seismic Data Logger Control via iPhone." The presentation was coauthored by **Benjamin Horkley**, a DTM research intern last summer. AcquiControl is a software package developed in-house to ease seismic fieldwork. It allows field crews to use an iPhone or iPod Touch to control seismic data loggers.

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The 42nd annual meeting of the Div. for Planetary Sciences of the AAS took place in Oct. in Pasadena, CA. DTM presenters included **Alan Boss**, **Erik Hauri**, and **Scott Sheppard**. Other DTM presenters at the AGU fall meeting included **Rick Carlson**, **David James**, **Alan Linde**, **Larry Nittler**, **Selwyn Sacks**, **Steve Shirey**, **Sean Solomon**, and postdoctoral fellows **Chin-Wu Chen**, **Wendy Nelson**, **Jonathan O'Neil**, **Deborah Smith**, and **Daoyuan Sun.**

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Arrivals: Postdoctoral fellows **Deborah Smith**, who received her Ph.D. from Caltech, and **Zan Peeters**, who received his Ph.D. from Leiden U., Netherlands, arrived at DTM in Nov. **Zachary Kaden** also joined DTM in Nov. to begin a research internship. As of Jan. **Eloise Gaillou**, previously of the Smithsonian Institution, has transitioned from visiting investigator to postdoctoral fellow. Also in Jan. DTM welcomed senior visiting investigator **Cecily Wolfe**, who will visit DTM for part of her sabbatical from U. Hawaii.

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Departures: Visiting investigator **Pamela Arriagada** returned to the Pontificia Universidad Católica de Chile in Santiago after her two-month visit to DTM. **Matt Sanborn**, a student of Meenakshi Wadhwa at Arizona State U., visited DTM in Oct. and Nov. to determine ages for angrites, a group of meteorites.

DTM-GL

⓰ In Sept. librarian **Shaun Hardy** visited the art exhibition *Terrestrial Physics*. The installation, recreating DTM's atom-splitting experiments of the 1930s, opened last spring at the Museum of Contemporary Art in Denver. *Terrestrial Physics* was created by Washington, DC, artist Jim Sanborn, who worked from original material in the DTM archives. In Oct. Hardy also participated in the Geoscience Information Society's annual meeting in Denver. □

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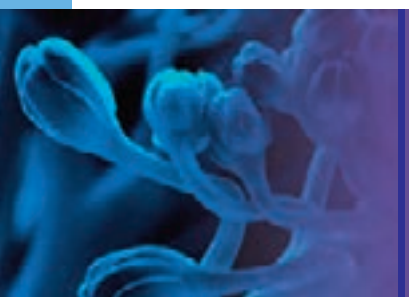

Giant in Cosmology Allan Sandage Dies

Carnegie's Allan R. Sandage, Edwin Hubble's former observing assistant and one of the most legendary astronomers of the last century, died November 13, 2010, at his home in San Gabriel, California, of pancreatic cancer.

Born in Iowa City, Iowa, on June 18, 1926, Sandage grew up to define the fields of observational cosmology and extragalactic astronomy. He received his B.A. in 1948 from the University of Illinois and his Ph.D. from the California Institute of Technology in 1953, where he was the famous astronomer Walter Baade's Ph.D. student in stellar evolution. During the early 1950s he served as Edwin Hubble's observing assistant at the Mount Wilson and Palomar observatories. Hubble, for whom the space telescope is named, discovered that the universe is larger than the Milky Way and that it is expanding.

Sandage joined the staff of the Carnegie Observatories in 1952 and, after Hubble's death in 1953, became responsible for the cosmology program using the Mount Wilson and Palomar telescopes. He carried on Hubble's work to determine the rate at which the universe is expanding, research he continued for six decades. Even though he officially retired September 1, 1997, he was still actively working until August of last year.

During the course of his studies he made seminal contributions to dating stars and the expansion age of the universe, classifying galaxies, and understanding galaxy formation and evolution. He led the first major redshift—or distance—surveys of galaxies, from which he created a three-dimensional map to explore galaxy distribution and the dynamics of the nearby universe. Sandage was the first to recognize the existence of quasars without strong radio emission. Quasars are the brightest and most distant objects in the universe. He developed new techniques for observing, which affected a broad range of astronomical topics.

Sandage's prolific work yielded him numerous honorary degrees and awards from the most prestigious institutions. He is survived by his wife, Mary, of San Gabriel, California, and two sons, David Sandage and John Sandage. There will be an event to celebrate his accomplishments at the Huntington Library June 10, 2011. □

Carnegie cosmologist Allan Sandage