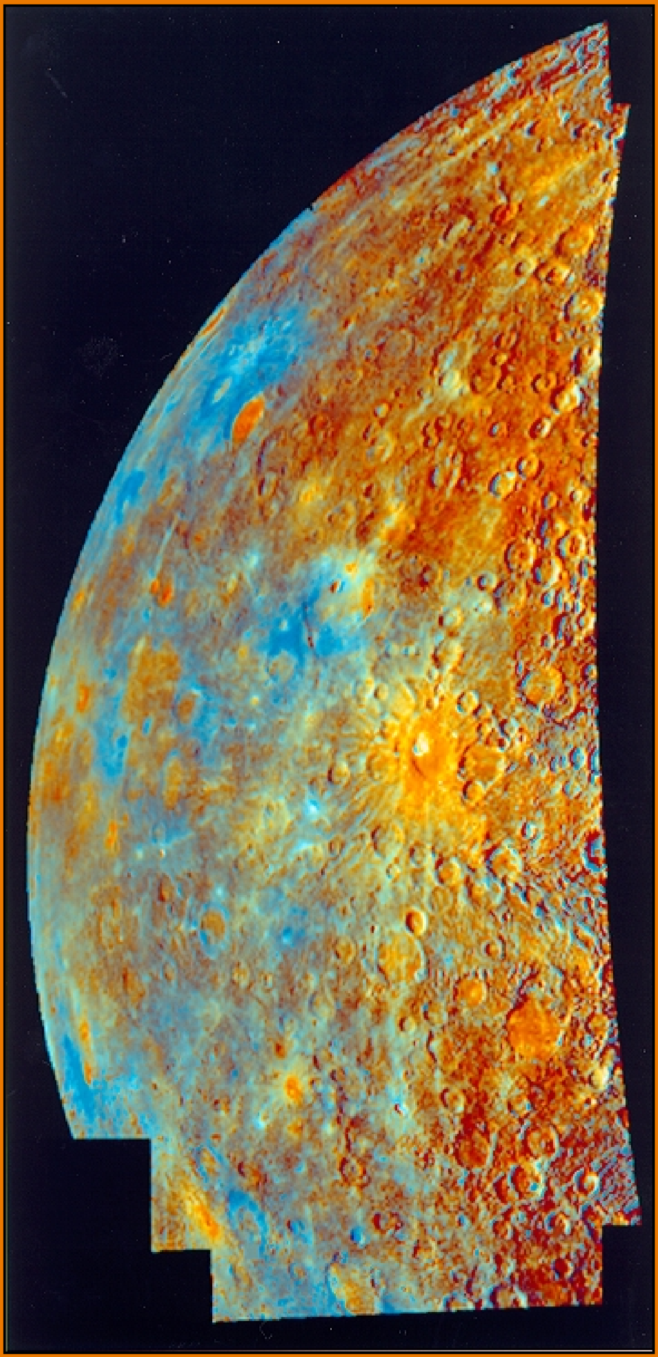
SPECTRA

Fall 1999

THE NEWSLETTER OF THE CARNEGIE INSTITUTION OF WASHINGTON



INSIDE:

The planet Mercury, as revealed by color mosaics. In 1997, scientists manipulated original data and produced a color image of Mercury that depicts compositional differences across its stark surface. The scientists used improved technologies in computing and image-processing, and a better understanding of how light reflects off planetary surfaces than was available at the time of the *Mariner 10* program in the mid-1970s to produce the image. See the story on pages 7-9 about DTM director Sean Solomon and the upcoming MESSENGER program to study the innermost planet. (Image courtesy of the Johns Hopkins University, Applied Physics Laboratory.)

LETTER FROM THE CHAIRMAN

Tom Urban

Science is inherently unpredictable. Hypotheses are formed and experiments test them, but along the way unimaginable surprises and discoveries can result. Andrew Carnegie knew this. He founded this institution to help the U.S. lead the world in the "domain of discovery." But it is hard to believe that even he could have imagined the amazing new twists and turns the institution has taken.

Examples abound. Embryology's Andy Fire and colleagues have discovered a new way to inhibit gene expression in a single generation of an organism. Unanticipated new forms of materials continue to emerge from Dave Mao and Russell Hemley's high-pressure work at the Geophysical Lab. New effects from the greenhouse gas carbon dioxide are discovered, and surprises about the human role in its production are revealed by Chris Field and colleagues at Plant Biology.

Recently, science at the institution has taken a very exciting new turn. NASA selected Sean Solomon, director of DTM, to head a $286 million mission to the innermost planet, Mercury (see p. 7). Most of us couldn't even have dreamed of this a few years ago.

Every year the face of research at the institution changes. New results can—and do—lead scientists down new paths. Each time this happens we realize just how right the founding principles are. It all comes down to the people and allowing them the freedom to choose their lines of scientific investigation. This guiding principle is our strength now and will keep us at the forefront of research in the decades to come.

Tom Urban

CARNEGIE INSTITUTION

OF WASHINGTON

1530 P Street, N.W.
Washington, D.C. 20005-1910
(202) 387-6400
web site: http://www.ciw.edu

Centennial Update From Margee Hazen

Planning for the Carnegie Centennial in 2002 is under way. Trustee Michael Gellert chairs the Centennial Steering Committee while I provide support. In keeping with suggestions made by the committee during its meeting last fall, the institution's hundred-year anniversary will be marked by a variety of activities including, most intriguingly, the possibility of launching a new research initiative. Following a pattern that was established by the institution's founders in 1902, the committee has begun its deliberations by soliciting advice from internationally known experts in a variety of scientific fields. Two fascinating discussions have taken place so far, and three more are scheduled for October of this year. Soon thereafter, the five Carnegie directors will evaluate these suggestions and discuss their own ideas during the directors' conference in Chile. In early December, the trustees will review the proposals and the next step in the process will be determined.

A second centennial initiative centers on the installation of a celebratory public exhibition at the administration building on P Street. This exhibition, to be mounted in collaboration with the Smithsonian's National Portrait Gallery, will use portraits, scientific instruments, archival documents, and interpretive text to tell the story of Carnegie's illustrious past while reaffirming its commitment to excellence and creativity in the next century. It is hoped that by highlighting the stories of some of the extraordinary people who have worked at the institution over the years, we will reveal something fundamental–even inspirational–about the pursuit of science in modern America. Interviews with local design firms, one of which will be chosen to help translate this hope into a reality, have happened. Exhibition scripting and object "collecting" will begin soon. If there is a Carnegie scientist whose story you'd particularly like to have told in this context, we'd like to hear about it.

Other Centennial projects are also in the planning stages. A proposal for a postage stamp commemorating Carnegie science has been submitted to the U.S. Postal Service. Plans for the publication of individual departmental histories as well as a broader, institution-wide, historical document are under way. A Carnegie-wide gala has also been proposed. Such a celebration would unite the various Carnegie philanthropies in a day long program that would explore the benefits of philanthropy. Each department is urged to consider one or more appropriate events.

Thoughts or comments? Please contact me, Margee Hazen (mhazen@pst.ciw.edu) or speak to one of the departmental representatives on the Centennial Steering Committee.

Spin city

A new angle on research

A shiny, rotund instrument with truly unique capabilities is celebrating its first birthday at the Geophysical Laboratory. For the last year, the device has been characterizing the chemistry of complex inorganic and organic solids; it is a solid-state Nuclear Magnetic Resonance (NMR) spectrometer. George Cody, staff scientist at the Geophysical Lab, brought the NMR to Carnegie with the help of grants from the National Science Foundation and the W. M. Keck Foundation.

The heart of the instrument is an enormous magnet generating a field that is 70,000 times stronger than that of Earth's. It can disrupt credit cards, pacemakers, and other magnetically sensitive devices. The magnetic field is generated by a perpetual electrical current maintained in a superconducting coil immersed in liquid helium at 4 degrees above absolute zero.

How it works

Many elements have isotopes whose nuclei possess a permanent magnetic moment (a magnetic dipole of a specific strength and direction) in addition to angular momentum. They have a property referred to as spin, which is essential to the operation of the device. When placed in an enormous magnetic field the nuclei will attempt to align themselves with the field. A small energy difference exists between nuclei aligned parallel to the magnetic field and those not parallel to it. This energy difference is proportional to the strength of the magnetic field and it is a fundamental property unique to each nucleus. What makes the NMR particularly useful is that nuclei are surrounded by a cloud of electrons that move in the variety of atomic and molecular orbits. The orbiting electrons generate a small but measurable disturbance to the main magnetic field. This disturbance results in subtle energy shifts, which are related to specific characteristics of the electronic environment revealing variations in chemical bonding. This phenomenon is called chemical shielding; it is the foundation of NMR spectroscopy.

One of the triumphs of NMR theory is the discovery that if a solid sample physically spins at extremely high speeds at a special "magic angle" (54.7°) to the main magnetic field a single narrow absorption band emerges.

Jay Brandes is tuning the NMR at far left, while George Cody works at the console.

Using Cody's NMR

To use the NMR, a sample in a container together weighing up to one gram is inserted into the chamber. An air cushion supports the sample, while tiny air jets spin it up to nearly 2,000,000 RPM. The spectrometer can excite up to three different nuclei while zeroing in on the effects on one nucleus, all at the same time. This is where the new instrument at the Geophysical Laboratory truly shines.

Although the Geophysical Laboratory is the official owner of the instrument, Cody is working to educate all researchers at Broad Branch Road on the benefits of NMR spectroscopy. The applications of this instrument are as varied as its capabilities.

Cody and Conel Alexander (Department of Terrestrial Magnetism) are using proton, carbon, and nitrogen NMR spectroscopy to determine the structure of the extraterrestrial organic matter in chondritic meteorites. To understand the chemistry of the fungal degradation of wood–a crucial recycling element in the global carbon cycle–Tim Filley, a GL fellow, and Cody are applying carbon NMR spectroscopy. Marilyn Fogel's biogeochemistry studies of proteins and DNA use the NMR's carbon and nitrogen spectroscopy. In this case, the machine provides a complementary tool for tracing diagenesis–the chemical and physical changes that occur in sediments during and after they are deposited but before they consolidate.

To better understand the relationship between melt chemistry and matter flow, Bjørn Mysen is using the instrument to obtain fundamental information on the effects on the structure of silicate melts when adding trace phosphorus and fluorine. Charles Prewitt and Yingwei Fei will use the NMR to study the crystallographic habits of hydrogen in dense hydrated phases synthesized with the multianvil press. Finally, Rus Hemley, Dave Mao, and colleagues are planning to investigate hydrogen under extreme pressure by designing a combined diamond-anvil cell/NMR probe that will fit within the superconducting magnet.

Clearly, the year-old, solid-state NMR spectrometer has had a full initiation. It will continue to assist scientists at the Geophysical Lab and the Department of Terrestrial Magnetism as well as visiting researchers from other organizations for a long time to come.

“Stuck” on chromosomes

A step toward understanding mitosis

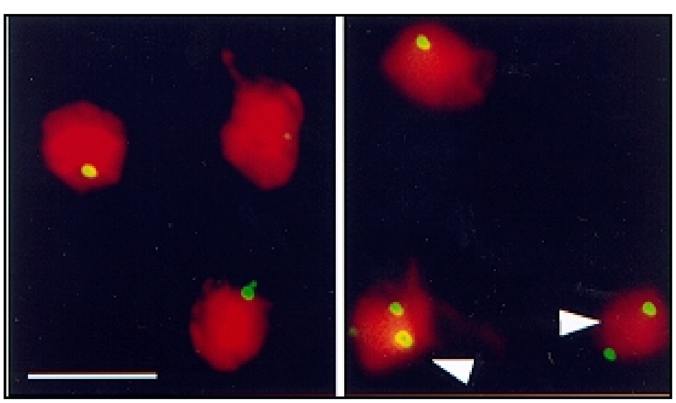
Scientists are making headway on defining the “glue” that holds our chromosomes together, an important step in understanding the mechanism of mitosis. Mitosis is the process of nuclear division where replicated chromosomes, called sister chromatids, are equally segregated to daughter cells. They achieve this segregation by attaching to and moving on microtubules–proteinaceous guide wires that emanate from opposite ends of dividing cells. Attachment of sister chromatids to the microtubules is mediated by DNA sequences called centromeres. Before the initiation of mitosis, the duplicated chromosomes are held together by a sort of molecular “glue” that occurs along their length, and near a region of the centromere. This molecular glue is essential because it ensures attachment of paired sister chromatids to microtubules originating from opposite sides of the cell. Exactly what makes up the glue near the centromere and how the glue is directed to the region is investigated by Carnegie’s Department of Embryology scientists Douglas Koshland (staff member) and Paul Megee (postdoctoral fellow). The results appeared in the July 9, 1999, issue of *Science.*

In order to understand the glue that causes cohesion, scientists are studying the DNA and associated chromosomal proteins of the budding yeast, *Saccharomyces cerevisiae.* The Koshland lab reports on an assay developed specifically to identify and study DNA sequences that recruit the cohesion factors. This assay used small circular pieces of chromosomes known as minichromatids. These small samples have a limited number of cohesion points, so scientists have a better chance of monitoring dissociation–or “ungluing.” The researchers showed that sister minichromatids lacking centromere sequences dissociated prematurely from one another, while minichromatids containing centromere sequences remained associated. The scientists concluded that the centromere itself contains DNA sequences that mediate sister minichromatid cohesion.

This observation is exciting because the same DNA sequences previously had been shown to be important for assembly of the kinetochore, the protein complex that binds to centromere DNA and attaches chromosomes to microtubules. This observation suggested a previously unsuspected mechanism whereby a common DNA element and its associated proteins coordinate two essential aspects of mitosis, the gluing of sister chromatids and their attachment to the guide wires.

The role of the centromere in cohesion of replicated chromosomes has been analyzed further in recent experiments done in collaboration with former Carnegie postdoctoral fellow Vincent Guacci, the results of which are published in September’s edition of *Molecular Cell.* These experiments showed that the centromere directs the loading of cohesion proteins, identified in earlier studies, onto DNA sequences adjacent to the centromere. The association of cohesion proteins near the centromere creates a large region that behaves like a molecular velcro, holding sister chromatids together.

This discovery is an important step on the path to understanding the multiple steps essential for the segregation of chromosomes. Studies of mitosis, such as these, have important biomedical implications since aberrant segregation of chromosomes can lead to chromosome loss–or aneuploidy–which is often associated with cancer and birth defects.



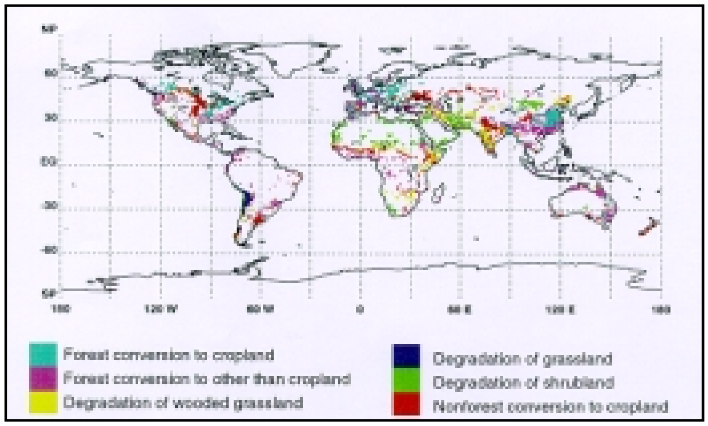
These images show nuclei prepared from mitotic cells containing sister minichromatids that retained a centromere (centric, left) or lacked the centromere (acentric, right). A digoxigenin-labeled DNA probe, shown in green or yellow, was used to detect the minichromatids. Total chromosomal DNA is shown in red. Arrowheads indicate nuclei with dissociated sister minichromatids.

Humans and CO_2: Not a New Story

Since the industrial age, fossil fuel use by humans has been the main source of carbon dioxide added to the atmosphere. But a study presented at the meeting of the Ecological Society of America in Spokane, Washington, on August 11, 1999, by Christopher Field at the Department of Plant Biology and Ruth DeFries at the University of Maryland indicates that human-induced vegetation changes over time have substantially contributed to atmospheric carbon quantities. The study shows that vegetation lost through logging, burning, and agriculture throughout human history is equal to about 180 billion tons of carbon–carbon transferred to the atmosphere as carbon dioxide. This represents about 75% of the total amount of carbon emitted from fossil fuel burning.

Previous calculations of carbon losses from changes in Earth’s vegetation compared the way things were in 1850 with the way things are today. This new study is the first to take into account human land use prior to the mid-1800s. The scientists found that an additional 60 billion tons of carbon was emitted to the atmosphere before the industrial age. "There has been a huge loss of carbon from the world's ecosystem over the time that humans have been involved in agriculture, and this loss has intensified terrifically in the last few centuries," said Field.

The study used an "untouched-by-human-hands" model of the vegetation cover extrapolated from current land-use data and data collected by National Oceanic and Atmospheric Administration (NOAA) satellites. The researchers compared the information on existing vegetation with a best guess of what the landscape would be like without human disturbance. The study focused on areas altered by humans including forests turned into cropland or pasture, woodlands that have been degraded, and savannas that are now desert.



This map shows where human activities have changed land-use patterns. About 11% of the land area has undergone a transition from one type of vegetation to another, representing a loss of carbon to the atmosphere of about 185 billion tons.

Most of the carbon loss from the Earth's vegetation today occurs in the tropics, where forests are burned for agriculture. But this was not always the case. Prior to 1850, massive portions of European, Asian, and North American forests were cleared. "Historically, it was a much more global problem," said Field. "It's simply that we deforested much of the midlatitudes before the start of the century." The largest amount of carbon loss, amounting to about 70 billion tons, came from Asia. North America, Europe, and Africa lost between 20 and 30 billion tons each.

Interestingly, there are a variety of land-use practices today that are helping to take up atmospheric carbon dioxide through photosynthesis during plant growth. These include farmland abandonment and subsequent forest regrowth in the midlatitudes, changing agricultural practices, and the prevention of forest fires. Field warns, though, that carbon dioxide absorbed by regrowing forests cannot possibly compensate for the amount that humans are currently adding to the atmosphere. "It's not going to grow us out of the carbon problem," he said.

CO_2 Affects Soil Structure

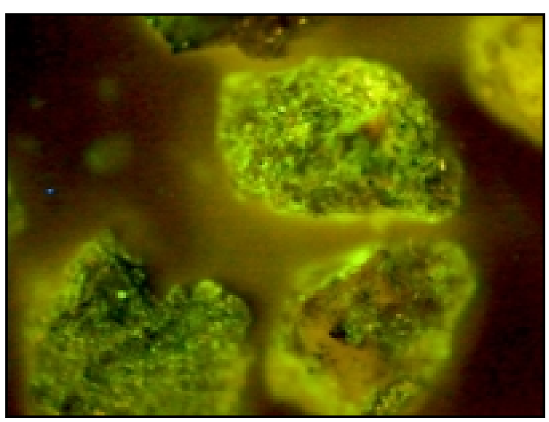
Scientists Matthias Rillig at the University of Montana, and Christopher Field at the Department of Plant Biology with others have discovered a new twist to what atmospheric CO_2 does. It affects the structure of soil, including properties that are important in preventing erosion and maintaining fertility. Their results were published in the August 12, 1999, issue of *Nature.*

A healthy soil has many small particles that are structured into clumps called aggregates. These aggregates provide a myriad of tiny caves and cracks that help hold nutrients, water, and organic matter. The researchers examined soils from three ecosystems and experimentally exposed them to a range of different atmospheric concentrations of CO_2 for three to six years. The results were that elevated CO_2 appears to stimulate changes in soil structure, increasing the abundance, stability, or size of the aggregates.

The explanation for this change is not entirely clear, but a fungus that forms symbiotic relationships with plants appears to be instrumental in the process. Increases in CO_2 almost always lead to increases in CO_2 fixation or plant photosynthesis. Some of the extra carbohydrate resulting from this increase is transferred to the fungi, which return the favor by providing the plants with nutrients. The extra carbohydrate is also used by the fungi to produce more of a protein-sugar complex called glomalin. And glomalin appears to play a critical role in producing and stabilizing soil aggregates.

According to Field, "We think the fungi may use glomalin as a kind of lubricant, allowing them to extend their hyphae–a rootlike filament structure–through the soil. But, it also appears to act as a kind of glue, holding particles together and forming larger particles from smaller ones. This effect of elevated CO_2 on soil structure creates the possibility of a whole class of not-yet-studied indirect effects of elevated CO_2. In the long run, we may find that CO_2 effects on erosion and fertility are comparable in importance to its effect on plant growth."

This picture shows glomalin as a green fluorescence on the surface of soil particles.



Redefining mineralogy

The future of the science and the Geophysical Laboratory

The traditional definition of a mineral is "a naturally occurring crystalline element or compound having definite chemical composition, and formed as a product of inorganic processes." As Russell Hemley, of the Geophysical Laboratory, explains in his "Perspectives" article in the August 13, 1999, issue of *Science*, this definition no longer applies to the field of mineralogy. Technological advances have yielded new and synthesized minerals; they have revealed previously unknown complexities at extremely small scales; they have shown interactions between the organic and inorganic; and they have been used to obtain and examine mineral samples from extraterrestrial sources. This enormous leap in information has fueled the evolution of the field. It is now an interdisciplinary science whose niche covers a lot of ground. Not surprisingly, research at the Geophysical Laboratory (GL) has been instrumental in the discipline's expansion.

In his article, Hemley looks at the directions mineralogy is moving in. He states that "four themes are emerging: an expanded domain of materials and processes, new views of complexity, connections to life, and new roles in advancing fundamental science and technology." In many ways, work at GL mirrors these directions.

More materials and processes

As the science grows, more minerals and materials are discovered, as are the processes that affect them. Scientists are now able to peer deeply into planetary interiors with instruments that simulate conditions there. Hemley and his colleagues Dave Mao and Yingwei Fei study the Earth's interior by using the diamond-anvil cell and the multianvil apparatus to simulate conditions there. These high-pressure, high-temperature "windows" into the terrestrial interior have led to discoveries of new dense minerals and new forms of metals. Former GL director and current staff scientist Charles Prewitt's studies combine crystallography and high-pressure physics. Prewitt was instrumental in initiating GL's membership in the Center for High Pressure Research (CHiPR) consortium; access to these facilities has led to synthesis and characterization of new mineral phases at GL.

New complexity

The more scientists learn about mineralogy at ever-increasing microscopic and macroscopic scales, the more intricate the materials and minerals appear. This complexity has recently led scientists to examine the *whole* rock. This means, for example, looking at melts within a specimen and the interactions they have with mineral grains instead of examining the rock for its mineral content alone. The acquisition of more knowledge has thus opened a sort of Pandora's box of mineralogy. The technology to study minerals allows scientists to look at their specimens at higher temperatures, with greater resolution, and in more detail. Although many questions have been answered, a myriad of new ones emerge. Some examples include the studies of Bjørn Mysen, David Virgo, and John Frantz. Their research concerns melts and aqueous fluids at the microscopic scale. Recent innovations at GL have allowed for their materials to undergo increasingly higher temperatures and pressures. Interesting thermochemical properties have resulted, refining insights into properties of materials in the Earth. Samples of Martian meteorites are also now being examined, and questions consequently arise concerning comparisons between Earth and Mars.

Minerals and life

New research has shown that biology and geology are not independent. Microbes have recently been shown to control some ore deposition processes. Biogeochemistry, a branch of geochemistry that deals with the effects of life processes on the distribution and fixation of chemical elements in the biosphere, is a "hot" research area as connections are made between the Earth's soil and nutrients and agriculture. Marilyn Fogel and Doug Rumble use stable isotopes in their studies of past climates and environments. George Cody uses fossil organic molecules in his quest to tie together the biologic and inorganic realms. And GL scientists who are part of NASA's Astrobiology Institute are striving to establish the chemistry of early life, and how minerals of the early Earth may have acted as catalysts for the production of biologically important molecules. Among the GL staff collaborating on these efforts are George Cody, Robert Hazen, Hatten Yoder, Marilyn Fogel, Doug Rumble, Russell Hemley, and Wes Huntress.

New roles in advancing fundamental science and technology

Ronald Cohen's studies in ferroelectrics (the study of dielectric properties) have been instrumental in advancing the field of ceramic materials and their role in technology. Cohen also produces highly complex models of such phenomena as mineral phase changes, crystallization, and magnetic collapse. These models, made possible only by the advent of newly developed computational techniques, are examples of technology's cutting edge.

GL scientists have long been involved in the study of fundamental physical and chemical phenomena. Now, a newly formed high-pressure collaborative research team at the Advanced Photon Source (Argonne National Laboratory, Illinois) led by Dave Mao will boost this area of research. At this facility, the latest x-ray beam lines and megabar-pressure vessels will be used in experimental studies. The team will continue to observe novel physical and chemical phenomena of materials subjected to the some of highest pressures to date.

Carnegie recently hosted a conference entitled "Mineralogy at the Millennium" (see *Spectra*, July 1999). While this conference was held to honor the careers of two of GL's prominent scientists, Larry Finger and Charles Prewitt, it was also an opportunity to highlight current progress in research and to establish the directions of mineralogical research in the upcoming years for the entire mineralogical community. The diversity of the presentations and talks at the conference helped underscore the conference's message that the field of mineralogy is vibrant and expanding. (See http://www.gl.ciw.edu/mineral2k/ for a program of the conference.)

Blast off

DTM's director Sean Solomon goes to Mercury

Hard-won goals are the sweetest. After three years of intensive work and anticipation, on July 7, 1999, Sean C. Solomon was selected by NASA to lead a $286 million mission to Mercury; it will be the first mission in three decades to explore the closest planet to the Sun. The scientific investigations planned for the project will round out Solomon's research portfolio of the terrestrial planets. Over the years, he has studied the surfaces and interiors of Venus and Mars, in addition to those of the Earth and the Moon. He has been involved with strategic planning for exploring Mercury for over twenty years and now, finally, he's off to the planet of extremes (see sidebar, right).

DTM's director, Sean Solomon, poses with a model of the MESSENGER craft.

The MErcury Surface, Space ENvironment, GEeochemistry and Ranging mission (MESSENGER) is part of NASA's Discovery program. The program consists of smaller, cheaper missions to explore the solar system. It emphasizes technology transfer to the private sector and has an education and outreach component. For MESSENGER, the Carnegie Academy for Science Education (CASE) is one of several educational organizations that will participate (see p. 9).

As the lead scientist for the Mercury mission, Solomon will head a consortium of twelve coinvestigating organizations. The orbiting spacecraft will be constructed and managed by DTM's offspring organization, the Applied Physics Laboratory (see p. 8) at the Johns Hopkins University. The mass of the squat spacecraft (1.62 x 1.65 x 1.32 meters) will be 1066 kilograms (2350 lbs.) at launch, 60% of which will be fuel needed for insertion into Mercury orbit.

The ship's payload is a suite of seven miniaturized instruments. They will be used to investigate aspects of the planet's interior, surface, and atmosphere, including the composition and structure of the surface (paying particular attention to its mysterious polar caps that are possibly ice); its geologic and volcanic history; the structure of the core and mantle; the constituents of the thin atmosphere called the exosphere; and the strength and variability of planet's magnetic field.

MESSENGER will blast off in 2004 and fly by Venus twice–in 2006 and again in 2007. In addition to using that planet's gravity to propel it toward its final destination, the craft will take a look at Venus and compare the new observations with those from past missions.

Flyby of Venus

Solomon has studied Venus for years. A bonus of the Mercury mission will be to add to the body of information about Venus during the two flybys. The craft will image the planet's cloud layer, study the interaction of the solar wind with the ionosphere, investigate the composition of the upper atmosphere, and search for lightning on the night side. (Venus has the slowest rotation in the solar system; one complete rotation takes 243 Earth days.) Instruments will also probe the altitude of the cloud deck, and it may be possible to image the surface through the thick atmosphere with the onboard visible-infrared spectrometer.

Mercury: the terrestrial extreme

Of the four rocky planets inside the asteroid belt, Mercury has the most extreme temperatures during the course of its day, ranging from -300°F at night to 800°F during the afternoon. It is the smallest terrestrial planet, and has the largest uncompressed density. Like Earth, Mercury has a magnetosphere, which Venus and Mars lack. Oddly, out of the entire solar system, it is the only planet that does not tilt on its axis; its poles are thus permanently shadowed from the Sun. The angle at which Mercury's orbit is inclined to the ecliptic—the plane of Earth's orbit around the Sun—ranks second only to Pluto's in severity. Even with all these curiosities, Mercury is the second-least-studied planet in the solar system. (Pluto ranks dead last.) The only mission to investigate this innermost world was *Mariner 10* in the mid-1970s. Then, only 45% of its surface—one face—was photographed. However, that mission did discover the planet's magnetic field, measured atmospheric elements, and discerned some surface characteristics.

At the time this issue went to press, NASA's budget was still in the appropriations process. Under one scenario, the MESSENGER mission would be cut.

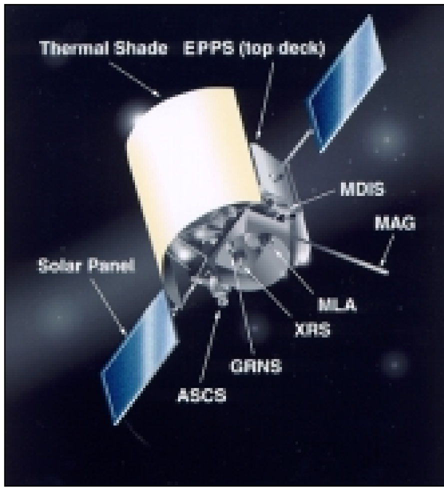
KEEPING IT IN THE FAMILY

The Applied Physics Laboratory (APL) at the Johns Hopkins University is the architect of the compact MESSENGER spacecraft. The organization is also the child of Carnegie's Department of Terrestrial Magnetism (DTM) where Sean Solomon is currently director.

The Allied victory of World War II took the combined efforts and ingenuity of many people, including researchers at DTM. Under the leadership of Merle A. Tuve, DTM engineered an invention called the proximity fuze into mass production. The device was a radio-controlled sensor installed in the nose of artillery. It detected a radio-reflecting target and triggered detonation when it was at a specific distance from its mark.

Work on the fuze proceeded at DTM from 1940 until 1942, when it became apparent that large-scale evaluation and production would require bigger facilities. In March of that year, the defense contract was moved to the Johns Hopkins University and the project was housed in an abandoned automobile agency in Silver Spring, Maryland. The Applied Physics Laboratory, named by Tuve, was officially born on March 10 with about seventy-five Carnegie researchers. Tuve remained in charge until the war was over, when he returned to DTM and became director in 1946.

APL thrives today as a research and development organization assisting the Department of Defense, NASA, and other federal and state agencies. In honor of its founder, Building 1 at APL is known as the Merle A. Tuve Building. Tuve's portrait hangs in the foyer.



The MESSENGER craft is shown with the following instrument suite: the energetic particle and plasma spectrometer (EPPS), Mercury dual imaging system (MDIS), magnetometer (MAG), Mercury laser altimeter (MLA), x-ray spectrometer (XRS), gamma-ray and neutron spectrometer (GRNS), and atmospheric and surface composition spectrometer (ASCS). *(Image courtesy of the Johns Hopkins University, Applied Physics Laboratory.)*

Once the ship leaves Venus, it will go to Mercury where it will make two flybys–in January and October 2008. Some of the best images of the planet's southern hemisphere will be taken during this period. In addition, the flybys will help fine-tune the scientific operations before the craft orbits Mercury in 2009 for an Earth-year of data collection.

Orbiting Mercury

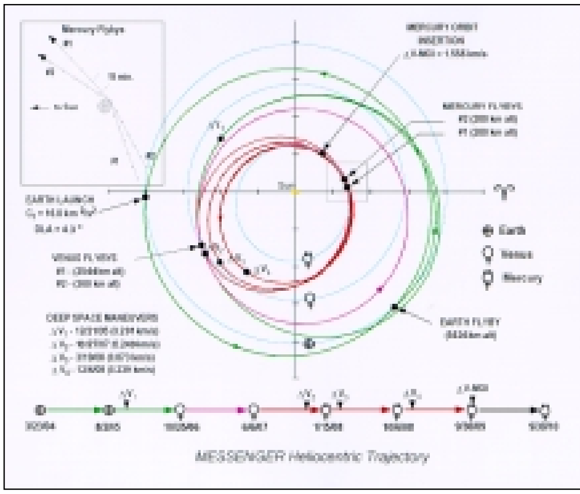
Understanding Mercury is key to understanding how all the terrestrial planets evolved. Solomon's particular interests in the mission are to learn more about the Mercury's bulk composition and what that reveals about planet formation in general. He wants to investigate the volcanic, tectonic, and internal evolution of Mercury and see how that information compares with what is known about the evolution of the other terrestrial planets. Finally, he is interested in understanding how the planet's magnetic field originated and what that indicates about its core and magnetic dynamos in general. MESSENGER will explore these areas and others with its suite of seven instruments.

Mercury's composition

Mercury has the highest ratio of metal to silicates of any planet or satellite in the solar system; this gives it the highest uncompressed density, with the possible exception of some asteroids. Based on its density, 65% of Mercury would be metal-rich core; this amount is twice that of Earth. Detailed information about which elements are present on the planet's surface will be obtained from x-ray, gamma-ray and neutron spectrometers. Images from the stereo camera and data from the infrared spectrometer will detect the different minerals on the planet's surface. The combined data will help resolve different hypotheses on why Mercury is so dense. One explanation for the planet's density is that the early Sun evaporated easily volatilized elements, leaving behind the heavier ones. Another is that a giant impact stripped Mercury of an early crust and much of the mantle. Under this scenario, the impact would have heated and melted much of what remained of the planet. The rapid differentiation of the silicate-rich outer portion would then have left a crust depleted in elements normally associated with crustal formation. Additionally, the later partial melting of the remaining mantle would produce lavas retaining a signature of the crustal stripping event.

Mercury's geologic evolution

The craft's imaging instrumentation and the laser altimeter will give scientists a close look at Mercury's topography and structure. The 1974/75 *Mariner 10* mission mapped only 45% of the surface. From those observations four major terrains were identified: heavily cratered regions, intercrater



MESSENGER's trajectory from blast-off in 2004 to orbit insertion in 2009 is shown here. *(Image courtesy of the Johns Hopkins University, Applied Physics Laboratory.)*

plains, hilly and lineated areas, and smooth plains. However, the *Mariner* images were not high enough in resolution to determine whether some landforms are volcanic in origin. The images did reveal, however, a unique feature: large faults that are thought to be contractions from global cooling. MESSENGER will test this idea. Its higher-resolution images, topographic profiling of the faults, and imaging of the unseen half of the planet will clarify the planet's tectonic, volcanic, and cratering history.

Mercury's core and magnetic field

Mercury has a weak magnetic field–a surprise discovery from *Mariner 10.* A planetary magnetic field is thought to arise from a metallic core that is at least partly molten. Convection stirs the metallic fluid and a dynamo generating electricity and a magnetic field results. MESSENGER will be able to determine whether Mercury still has a liquid outer core. The laser altimeter will measure the planet's libration–the wobble of the planet around its axis of rotation. If there is a liquid core, the resulting libration will be twice what it would be if the core were solid. Since Mercury is smaller than Earth, scientists believe that the core should have cooled and solidified long ago. Solid cores are not thought to generate a magnetic field. If the core turns out to be solid, it is possible that the weak magnetism is a frozen remnant of the past.

Icing on the cake

Although Solomon's interests are primarily focused on the surface and interior, the mission will look at other aspects of the planet, too–"icing on the cake for me," according to the mission leader.

Mercury has an exosphere–a tenuous atmosphere. It is a covering of gas so thin the molecules don't even collide. The ultraviolet spectrometer and energetic-particle spectrometer will determine what this envelope is made of.

MESSENGER will look at the structure and variability of Mercury's weak magnetosphere–the volume of space shielded from the solar wind by Mercury's magnetic field. The magnetometer will measure the strength and variability of the field, while the energetic-particle and plasma spectrometer will determine how electrically charged solar particles interact with it.

In 1991, radar images revealed that craters at the permanently shadowed poles contain a highly reflective material. Many believe this mystery material is ice. MESSENGER will solve the mystery by looking for the presence of hydrogen with the gamma-ray and neutron spectrometers. The ultraviolet and energetic-particle spectrometers will investigate previously detected vapors in those regions and specifically look for sulfur.

CARNEGIE ACADEMY FOR SCIENCE EDUCATION (CASE) WILL GO ALONG FOR THE RIDE

The MESSENGER mission is a natural education tool. As part of NASA's Discovery program nine educational institutions, including CASE, will participate in the science and excitement of the mission from before launch through completion. The group of educators will work with the AAAS and NASA to develop activities that correspond to the events of the mission. Teacher training, student experiments, new curricula, museum participation, and even a televison documentary are planned to be part of the program. Although the events of the mission are years away, Chuck James, director of curriculum and instruction for CASE and the First Light science school, and the CASE staff are already thinking about specific ways to integrate both programs into the MESSENGER mission.

James and staff are considering a simulation project for students that would occur before launch. The objective would be to compare the challenges of a mission to Mars with a mission to Mercury. Another prelaunch idea is to have students from different schools put together pieces of the orbiter model to learn how the instruments will be used to collect information about Mercury. Once MESSENGER orbits the planet, teachers and students will monitor the mission via real-time data viewed on the Internet. Sean Solomon will serve as the program's mentor.

Shake, rattle, and roll

Three kilometers beneath the sea

For the first time, scientists have installed geophysical observatories beneath the ocean floor. This August, researchers from Carnegie's Department of Terrestrial Magnetism (DTM), the Japan Marine Science and Technology Center (JAMSTEC), and the University of Tokyo successfully placed two separate packages of instruments 1 kilometer below the Pacific Ocean floor in waters 2 kilometers deep. Each package contains a strainmeter, a tiltmeter, and 2 seismometers. The sites, about 150 kilometers east of Japan, are 10 to 15 kilometers above the Japan Trench subduction zone–an area where the Pacific Plate is sliding under the Eurasian Plate, and an active earthquake region.

Selwyn Sacks (DTM) and Kiyoshi Suyehiro (JAMSTEC) are the chief scientists for this Ocean Drilling Program project. Other DTM staff on board the drilling ship were Alan Linde, Ben Pandit, Nelson McWhorter, and Mike Acierno. Participating scientists from the University of Tokyo included Eiichiro Araki and Masanao Shinohara. Technical support for instrument installation was provided by staff members of the Ocean Drilling Program.

Although other seismometers have been installed on the ocean bottom, this is the first time such packages of instrumentation have been buried beneath the seafloor. The Japan Trench was chosen because it is one of the world's most active earthquake zones. It has some of the largest recorded quakes, greater than 7.0 on the Richter scale. Despite the large magnitude of the earthquakes, the energy they release accounts only for about 25% to 30% of the slip occurring on the subduction interface. This means that 70% to 75% of the energy is being released and absorbed in a manner other than by large-magnitude earthquakes. By placing sensitive instruments literally on top of the subduction zone, scientists will have a better opportunity to find out where this missing energy is being dissipated.

The depth of the instruments will allow for extremely precise measurements of the tilt of the rocks, the tiny movements of strain, and any seismic activity. The two instrument locations are about 26 nautical miles apart.

Some members of the project team from left to right: Ben Pandit, Alan Linde, Eiichiro Araki, Masanao Shinohara (seated), Kiyoshi Suyehiro, Nelson McWhorter, and Selwyn Sacks.

One of the two is located on an extremely seismically active segment of the Japan Trench and the other is located on an aseismic, or seismically quiet, part of the trench. The team hopes that by studying the two extremes of tectonic activity along one trench they will be able to gather information about what is happening to the unaccounted-for seismic energy.

Both instrument packages can stand alone. Each has its own battery, but it is hoped that within 2 years the team will be able to connect the packages to a nearby ocean-bottom cable. This would eliminate the need for and maintenance of the battery packs and provide a valuable warning tool for imminent quakes. The nearby cable has copper wiring for power and fiber optics for real-time data transmission. Real-time data would be used for earthquake warnings. Scientists would be alerted the instant an earthquake occurred in the trench, and could immediately warn populated areas. Even 20 seconds, about the time it normally takes for earthquake waves to travel to land-based seismographs, may make a difference and spare lives (by stopping Japan's fast trains, for example).

This is the first time in 70 years that DTM has had a large group at sea. Since the magnetic-measuring ship the *Carnegie* sank in the South Pacific in 1929, the department's research activities have been primarily land based.

Plant Biology Shares NSF Grant for Plant Genome Research

The National Science Foundation has awarded a five-year, $5.3 million grant to The *Arabidopsis thaliana* Information Resource (TAIR) project, a joint venture of Carnegie's Department of Plant Biology and the National Center for Genome Resources (NCGR) in Santa Fe.

By the end of next year, scientists will know the entire genetic makeup of the *Arabidopsis thaliana* plant, a mustard that is closely related to many food plants and is used as a model for all aspects of plant biology. Availability of comprehensive genomic data about this species–the first for which the complete DNA sequence will be known–is a significant step toward understanding the biology of all plants and improving agriculturally important crops such as corn, soybeans, and rice.

The NSF grant will support a new, public database called TAIR, which will contain all the information generated by the *Arabidopsis* genome project and all published experimental data about the plant. There is a direct link between most, if not all, genes of the model plant and those of about 250,000 other plant species. However, *Arabidopsis* is easier to study. It has a highly compact genome, about a third as much DNA as rice, with relatively little repetitive DNA. Thus, more is known about the function of *Arabidopsis* genes than of those of any other plant. TAIR will allow researchers to compare the DNA sequences of other plants with the sequences of genes whose functions are known in *Arabidopsis* and thereby determine what role the genes in other plants may play. This in turn will hasten understanding of how to exploit plant genetics to increase productivity, bolster resistance to disease, and optimize other desirable traits in the hundred or so commercially important species.

Chris Somerville, director of Plant Biology and a principal investigator on the grant, said, "We will be developing a comprehensive database of *Arabidopsis* data with broad applications. Because the value of *Arabidopsis* is its utility in understanding other plants, our goal is to build a structure that permits us to link information about *Arabidopsis* to all other plants, and vice versa."

TAIR will contain information about the *Arabidopsis* research community; DNA sequence and map data; allele, phenotype, and stock data; gene, protein, and transcript data; experimental data from the literature; as well as images and references. "With the explosion of genomic data and the diversity of data types and methods, biologists are in need of new ways of obtaining and analyzing data. TAIR will address this critical need by providing integrated and value-added data in an industry-standard database environment," said Sue Rhee, director of TAIR.

Geophysical Lab Part of New Consortium in High-Pressure Research

New advances in fields as diverse as materials science, planetary science, and high technology are on the horizon with the formation of a new Collaborative Access Team (CAT) for high-pressure (HP) research at the third-generation Advanced Photon Source (APS) in Illinois. Member organizations of the newly formed HP-CAT include Carnegie's Geophysical Laboratory, the Lawrence Livermore National Laboratory, and the University of Nevada, Las Vegas. Ho-Kwang (Dave) Mao of the Geophysical Laboratory is director of the team.

The new HP-CAT team participants and APS will pool $15 million over the next five years to develop, construct, and operate one sector at the facility for high-pressure studies. Collaborative Access Teams allow various organizations to pool their resources to advance basic research more effectively.

The APS is a giant ring-shaped accelerator two-thirds of a mile around. It can produce x-ray beams one trillion times brighter than those of conventional x-ray machines. It allows scientists to see what happens to materials at the atomic level.

Materials put under extreme pressures and varying temperatures will be analyzed with three to four x-ray beam lines dedicated to x-ray spectroscopy and diffraction analyses. The first experiments are planned for year three of the project. New physical and chemical phenomena will be observed at the new facility as materials undergo transitions from one state to another under different pressure and temperature scenarios. Many unexpected transitions are likely. Scientists will be able to mimic conditions in planetary interiors like those of Earth and the gas giant Jupiter. Other experiments could lead to an entirely new class of synthetic materials and usher in a new era for condensed-matter physics, which is an important science to the field of high technology.

Carnegie Education Gets a Boost

In July, a $450,000 grant was awarded to CASE and First Light, the two innovative, imaginative, and successful science education programs at Carnegie. The grant is part of $12.7 million distributed by the Howard Hughes Medical Institute (HHMI). Thirty-five research institutions were recipients. The money is targeted to help develop partnerships between local schools and highly trained researchers from the same communities. Details can be obtained from the Hughes Web site, www.HHMI.org/preview/precollege99.

The old problem of new parts

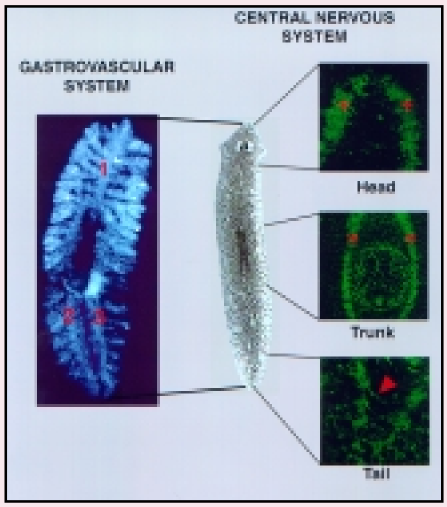
Planarians at Embryology

The specimens came from an abandoned trash-filled fountain in Barcelona and now live on two pounds of beef liver a year. They are planarians, or flatworms, the model organism used by Alejandro Sánchez Alvarado and Phil Newmark at the Department of Embryology in Baltimore. The Sánchez Alvarado lab investigates the molecular components of regeneration, and for this purpose planarians are ideal.

The problem of understanding regeneration has been around for over 250 years. All creatures regenerate to some degree. Wounds heal in most if not all organisms, and others, such as the zebrafish and the mouse, can regenerate actual body parts–in these cases, the tail fins and the liver respectively. But the flatworm can duplicate itself entirely, and it does so quickly. Cut one in half, and in four to five days two individuals result. It doesn't matter if the flatworm is cut vertically or horizontally. However, the location of the piece on the body does determine the identity and the rate at which the missing part is formed. A piece from near the head, for instance, regenerates a head faster than does a piece from near the tail. Why this happens is unknown and is called the "problem of polarity." Another unknown is the minimum number of cells required to regenerate a whole new individual. Although these unresolved questions are just the tip of the iceberg of the mysteries that face the lab, a lot of ground has been covered in the two and a half years since Carnegie scientists began investigating planarian regeneration.

Why planarians?

Sánchez Alvarado started his regeneration work at Carnegie as a postdoc in Don Brown's lab five years ago, studying tadpoles. Two and a half years later, as a staff associate, he changed to planarians because he wanted a simpler organism to study. Sánchez Alvarado decided on the cartoonlike, cross-eyed flatworm because it fit his criteria perfectly: its 15 to 20 millimeter body is composed of the three fundamental cell layers, ectoderm, mesoderm, and endoderm; regeneration is part of the animal's life cycle; it's not difficult or expensive to raise; and it promised to be amenable to molecular manipulations. Phil Newmark's work has been key to the rapid progress of research at the lab. He realized, while doing part of his postdoctoral training in Spain, that the flatworm *Schmidtea mediterranea* was a suitable species for molecular studies. Unlike most other known species the flatworm is a stable diploid, and has a relatively small genome which streamlines gene isolation, identification, and function.



The image on the left, produced by feeding the animal fluorescent latex beads, shows the branching of the gut. On the right, the nervous system is seen. Two cerebral ganglia are located at the red crosses on top. The nerve cords are shown in the trunk. The red triangle in the tail indicates the location of commissural neurons, which connect the cords along the entire axis (Phil Newmark).

Planarians offer other unique advantages for the study of developmental processes. For example, individuals of several species of freshwater flatworms (including those studied in the Sánchez Alvarado lab) can be either sexual and asexual. The sexually reproducing variety is a hermaphrodite–each individual has both male and female reproductive organs. However, the way in which the embryo develops–its embryogenesis–has not been extensively studied. The asexual variety reproduces exclusively by fission; each individual splits in half. This planarian thus relies on regeneration to reproduce. Since both types have to reproduce to continue the species, an investigation of how genes are used for regeneration in one and for embryogenesis in the other will provide unique insights into the mechanisms underlying both regeneration and sexual reproduction.

Planarian anatomy

The flatworm is bilaterally symmetrical. It moves by muscle and glides on cilia. It has a brain that is a collection of neurons forming right and left ganglia. Nerve chords emerging from each of these ganglia travel parallel down the length of the body. There are two readily noticeable structures in these animals: eyelike photoreceptors, which sit on top of the ganglia, and a muscular pharynx that functions as a mechanism for both eating and excreting. Flatworms lack a body cavity; because of this the gut is highly branched to distribute food throughout. Interestingly, and a trait that the Sánchez Alvarado lab will exploit, one piece of the animal does not regenerate–the tip of its head, in front of the photoreceptors.

Despite the marvels of this Disney-like character, there are only three places in the world where the regenerative properties of flatworms are being investigated at the molecular level–in Baltimore at the Sánchez-Alvarado laboratory, in Japan at Kiyokazu Agata's laboratory, and in Spain.

Deciphering planarian regeneration

Researchers at the Sánchez Alvarado laboratory are working in three areas to attack the planarian regeneration problem: They are identifying the genes involved in regeneration; they are developing ways, or assays, to determine the genes' specific functions; and they are trying to understand what regulates the

The head of the planarian *S. mediterranea* is shown during regeneration.

division of stem cells–cells that are initially undifferentiated but that can divide into other cell types.

Identifying the genes

To identify the genes in question, the lab has used the "gene screen" methodology, devised in Don Brown's laboratory, to detect differences in gene expression–the manifestation of a gene's activity. Close to thirty different genes activated during the early stages of flatworm regeneration have been isolated and identified by the gene screen. The exact functions of many of these genes are unknown and are under investigation.

One strategy the lab is pursuing to determine gene function is to place the newly isolated genes in the context of other, better understood genes and genetic pathways. To accomplish this, Sánchez Alvarado is collaborating with colleagues at the Himeji Institute of Technology in Hyogo, Japan, where Dr. Kiyokazu Agata's laboratory has been researching planarians for nearly ten years. The Japanese laboratory began its studies by searching for genes in planarians that have been shown in the scientific literature to play key roles in the developmental processes of animals as varied as the mouse, *C. elegans* a nematode, and the fruit fly *Drosophila.* The search turned up several homologs–the planarian versions of the mouse, *C. elegans,* and *Drosophila* genes. Among these were the hox genes, which are known to have similar functions in the body-plan specification of all animals where these genes have been described. The Sánchez Alvarado lab is expanding on this work by trying to determine if genetic relationships do or do not exist between the genes isolated by the Carnegie researchers and those identified by Dr. Agata's laboratory.

Developing assays

Once the genes are identified, the scientists have to be able to watch what happens to the cells they control to understand the nuances of genetic function. To do this markers are used. Antibodies are used as markers because they react specifically to different types of cells. Sofia Robb, an undergraduate intern from the University of Maryland, Baltimore County, has been screening antibodies that react to specific cells in other animals to see if they work on planarian cells. Thus far she has found about thirty that cross-react with a variety of cell types in the planarian. A fluorescent additive is combined with the antibody so that the cells under investigation can be viewed microscopically.

Still, cell marking in planarians has been a stumbling block to studying regeneration in the species for more than three decades. Particularly difficult has been developing a way to see the undifferentiated cells called neoblasts. These are stem cells that migrate to the site in need of repair and become the new type of cell. But Phil Newmark (whom Sánchez Alvarado met serendipitously at a developmental biology meeting England and eventually lured to Carnegie) discovered the key to specifically marking planarian stem cells. This revelation came to him during a sleep-deprived period soon after his son was born. Rather than bathing the creatures with a marker, he found that he could successfully feed it to them under certain conditions.

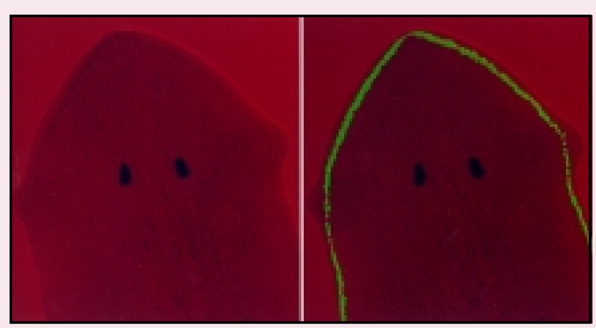
The meat of the matter–neoblasts

The third area under investigation, and the meat of the matter, is to understand what goes on in the planarian neoblast cells during regeneration. The primary focus of current neoblast research is to identify the point in time when the neoblast "decides" to become another type of cell. Several genes are suspected to be involved. Three specific ones under study are transcription factors (genes that control the expression of other genes) that regulate aspects of the central nervous system. They were isolated by the Japanese group and specify cell fate. Their role is to activate other genes that then "tell" the neoblasts to become neurons. The scientists believe that it is likely that these transcription factors are at work when the neoblast is first "told" to become a neuron. They suspect that other fate-specifying genes involved in the transformation of a neoblast to a neuron will stop working in the absence of these transcription factors. To see if this is the case, the scientists inactivate each of the genes individually and see how the neoblasts react. Through a painstaking process of elimination the scientists hope to discover the first moment of the transformation process from one cell type into another.

Reflections on regeneration

The regeneration work on planarians being carried out at the Department of Embryology is addressing one of the oldest long-standing problems in biology. Despite the fact that the problem has been investigated for over two centuries, little is known about why some animals regenerate missing body parts and others cannot. Sánchez Alvarado reflects, "We hope that by molecularly dissecting planarian regeneration we will be able to uncover the permissive or inhibitory factors operating behind regenerative abilities. Obviously, we wish to answer many questions. Yet, to my way of thinking, perhaps the most intriguing of all is, why does regeneration occur at all, and why when it manifests itself it does so in some but not all metazoans?"

An experiment conducted by Sofia Robb shows monoclonal antibodies reacting with an intermediate filament protein along the border of the animal's head (right).



EMBRYOLOGY

On April 15, **Don Brown** became the proud grandfather of twins, Donald and Emily.

Ying Liu, previously from NIH, where she worked with Dr. Yoshi Yamada, has joined Chen-Ming Fan's lab to study the development of the cerebellum and dentate gyrus. She received her Ph.D. in Japan.

Joe Gall presented the keynote address at a workshop sponsored by the European Molecular Biology Organization entitled "Functional Organization of the Cell Nucleus." The workshop was held in Prague August 9-12. At that meeting Gall received the J. E. Purkinje Honorary Medal for Merit in the Biological Sciences, awarded by the Academy of Sciences of the Czech Republic. Purkinje was an important 19th-century Czech biologist who is

Planarian researchers at Embryology are shown above. From left, **Réjeanne Juste**, Dr. Kiyokazu Agata (Himeji Institute of Technology, Japan), **Alejandro Sánchez Alvarado**, and **Phil Newmark**.

best known for his discovery of the Purkinje neurons in the cerebellum and the Purkinje fibers in the heart.

In June **Marnie Halpern** coorganized the 60th anniversary meeting of the Society of Developmental Biology held at the University of Virginia. She was the session chair and speaker for the Gordon Conference on Developmental Biology. Halpern spent July and August in the laboratory of Nicole LeDouarin at the CNRS Institute for Cellular and Molecular Embryology in France. The visit was supported by a short-term fellowship from the Human Frontier Science Program.

Undergraduates **Liisa Hantsoo** and **Janeen Mangalit**, from Johns Hopkins, received support from the NSF REU program for summer research. Princeton undergraduate **Eric Olsen** also returned to Carnegie for his third summer of research.

Ryan Stermer joined the Halpern laboratory in June as an animal care technician.

Postdoctoral fellow **Bob Skibbens** has left for a faculty position at Lehigh University.

Terence Murphy joined the Department of Embryology in August as a staff associate. Terence was a graduate student with Gary Karpen at the Salk Institute in San Diego, where he conducted studies on the mechanism of chromosome inheritance in *Drosophila*. For his graduate work, Terence recently received the Larry Sandler Award at the 40th Annual Drosophila Research Conference in Bellevue, Washington. Terence will continue his studies of chromosome inheritance at the Carnegie Institution, focusing on epigenetic aspects of centromere function.

Alejandro Sánchez Alvarado was awarded the Marcus Singer Medal for research in regeneration at the Midwest Society for Developmental Biology in Urbana, IL, in May. He has also been asked to serve by editor in chief, Dr. William A. Haseltine, on the editorial board of the new journal *Regenerative Medicine.*

TERRESTRIAL MAGNETISM

Paul Butler joined the staff at DTM in August. Paul moved from Sydney, Australia, where he was a staff astronomer at the Anglo-Australian Observatory. Prior to that, he was a postdoc at Berkeley and at San Francisco State University. Along with his collaborator Geoff Marcy, Paul has discovered two-thirds of the known extrasolar planets, including the only known system of multiple planets orbiting a Sun-like star.

Stephen Richardson (U. Cape Town) arrived in September to spend three months working with Steve Shirey and Rick

Paul Butler, standing in front of Keck I (the world's largest telescope) on the extinct volcano Mauna Kea on the Big Island, Hawaii. (Photo by Andrew Perala/ W. M. Keck Observatory.)

Carlson on Re-Os studies of eclogite and peridotite xenoliths from South Africa and on sulfide diamond inclusions.

Rodger Hart (South African Council for Geosciences) arrived in September to spend a month working with Rick Carlson on Re-Os analyses of rocks from two large meteorite-impact structures in southern Africa.

Vera Rubin attended the dedication of the Gemini North telescope on Mauna Kea, HI, in June.

Sean Solomon delivered an invited paper at the 5th International Conference on Mars, held at Caltech in July.

In May, **Paul Rydelek**, a DTM visiting investigator and former postdoctoral fellow, was awarded the Distinguished Research Award in Natural Sciences by the University of Memphis.

The annual Goldschmidt Conference held in August in Cambridge, MA, was attended by **Rick Carlson**, **Monica Handler**, **Erik Hauri**, **Phil Janney**, **Aaron Pietruszka**, and **Steve Shirey.**

David James and **Randy Kuehnel** spent two weeks in Kimberley, South Africa, in late June and early July. They completed the final pullout of portable Carnegie and PASSCAL seismograph systems from the Southern Africa Seismic Experiment, thus ending the "active" phase of the project. Almost half a terabyte of broadband seismic data were collected during the course of the deployment, making it the largest portable broadband experiment ever conducted.

In June, **Alan Boss** reviewed work on binary star formation in magnetic clouds at the Star Formation 1999 conference at Nagoya University, Japan. Boss gave a public lecture about the new extrasolar planets during the Spanish government's commemoration of the 30th anniversary of the first Apollo lunar landing, at the headquarters of the Consejo Superior de Investigaciones Científicas in Madrid, in July. In August, Boss spoke about rapid gas giant planet formation at the Bioastronomy 1999 conference on the Kohala coast of Hawaii. Boss also organized and chaired the Gordon Research Conference on the Origins of Solar Systems held at New England College in June. Boss, **Ken Chick**, **Satoshi Inaba**, **Harri Vanhala**, and **George Wetherill** presented posters on their work, while **Steve Kortenkamp** gave a talk on terrestrial planet formation.

François Schweizer is shown with the galaxy paperweight presented to him at his farewell party on August 26. A scientific staff member at DTM since 1981, he has transferred to the Carnegie Observatories, where he will continue his work in observational astrophysics, the structure and evolution of galaxies, and the cosmic distance scale. To the left are **Charles Prewitt**, **Daniel Kelson**, and **Sue Schmidt**. To the right is **Conel Alexander**.

DTM Fellow **Philip Janney** (right) works with geochemist Laure Dosso, of IFREMER, in July aboard the research vessel *L'Atalante* to describe and prepare lavas dredged from submarine volcanoes for chemical analysis.

Patrick McGovern, postdoctoral associate, joined an aerial and ground-based tour of the Channeled Scabland region, a potential analog for flood-sculpted terrains on Mars. The excursion was a prelude to the Mars Orbiter Laser Altimeter (MOLA) team

Shown from left are DTM summer research interns **Kirsten Brandt** (Earlham Coll.), **Patrick Kelly** (Sidwell Friends High School), **Lan-Anh Ngoc Nguyen** (U. North Carolina), **Kisha Steele** (Howard U.), **Kaisa Mueller** (U. Missouri, Columbia), **Caleb Fassett** (Williams Coll.), and **Jacob Bauer** (Spring Hill Coll.), who presented the results of their research on August 11.

meeting; also attending the team meeting was DTM director **Sean Solomon**, a MOLA coinvestigator.

In August, **Jay Brandes** returned to his position as assistant professor at the Marine Science Institute of the University of Texas at Austin, after spending July at DTM/GL as an adjunct investigator in the Astrobiology Institute.

Stephen Gao, an adjunct investigator at DTM in June and July, has taken up his new position as assistant professor in the Department of Geology at Kansas State University. While at DTM, he continued his work on the structure of the mantle beneath southern Africa and the documentation of strain transients in western North America.

Visiting investigators recently at DTM include **Julie Morris** (Washington U.), **Graham Pearson** (U. Durham); **Yuji Sano** (Hiroshima U.), **Douglas Toomey** (U. Oregon), and **Elisabeth Widom** (Miami U.). The department also hosted short-term visits by **Matthias Barth** (Harvard U.), **James Farquhar** (Scripps Institution of Oceanography), **Gordon Irvine** (U. Durham), and **Jacek Stankiewicz** (U. Cape Town).

Oliver Lang Kortenkamp was born to DTM postdoctoral associate **Steve Kortenkamp** and his wife, Jane Morrison, on August 29. Oliver weighed 7 pounds 15 ounces and was 20.5 inches long.

GEOPHYSICAL LABORATORY

Robert Hazen was appointed to the American Geophysical Union's Panel on Teaching Evolution. Hazen appeared as commentator for ABC Australian TV on the subject of the evolution-creation debate, which is now focused on events in Kansas.

GL scientists **Badro**, **Cohen**, **Eremets**, **Goncharov**, **Hausermann**, **Hazen**, **Hemley**, **Hu**, **Mao**, **Merkel**, **Shieh**, **Shu**, and **Struzhkin** presented papers at the 17th meeting of AIRAPT, the international society for high-pressure research. Numerous former GL postdocs were also in attendance.

Wes Huntress has been appointed a Member for Section 1 (Basic Sciences) of the International Academy of Astronautics. Dr. Huntress has also been appointed to the National Academy's Commission on Physical Sciences, Mathematics, and Applications.

Jürgen Konzett, having completed his postdoctoral position at GL, has returned to the Institut für Mineralogie und Petrographie, Universität Innsbruck, Austria.

Sebastien Merkel, predoctoral associate, has returned to the École Normale Supérieure de Lyon, France, to finish his studies for his doctoral degree. Mr. Merkel will conduct part of his Ph.D. research at GL under joint supervision with ENS. Dr. Hemley will be his supervisor at GL.

Mark Teece, former postdoctoral fellow, has taken a position at the State University of New York, College of Environmental Science and Forestry. Dr. Teece will be an assistant professor of environmental chemistry, teaching chemistry and undertaking research in the area of stable isotope environmental biogeochemistry.

Oguz Gulseren, postdoctoral research associate who was working with Dr. Cohen and others on materials under high-pressure and dynamic shock conditions, has taken a position at the NIST Center for Neutron Research.

Sergey Stolbov is now a postdoctoral research associate at the lab, and will be working with Ronald Cohen on electromechanical coupling in ferroelectric solid solutions.

Anurag Sharma has been appointed a postdoctoral research associate. He will be working with Drs. Hazen, Cody, and Hemley, and others in GL's proposed development and application of the hydrothermal diamond-anvil cell (HDAC) to the problem of high-P/T organic synthesis.

James Henry Scott has taken a position as a postdoctoral research associate. Dr. Scott will be working on isotopic studies and microbial metabolism with Drs. Fogel and Cody.

Prof. **Altaf H. Carim**, visiting investigator who spent his sabbatical at GL working with Charles Prewitt and others, has returned to the Department of Materials Science and Engineering at Penn State University.

In July, **George Cody** presented a paper on hydrothermal organic chemistry relevant to the origin of life at the International Society Symposium on the Origin of Life. In August, Cody presented an invited paper on soft x-ray spectromicroscopy at the X-ray Microscopy Conference held in Berkeley, CA.

Rus Hemley gave an invited lecture at a DOE workshop, "High-Pressure Research," on June 12. He also gave an invited lecture at the Adriatico Research Conference entitled "The liquid state of matter," at the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy. Rus coorganized a workshop, "Frontiers in High-Pressure Materials Physics," at the Centre Européen de Calcul Atomique et Moléculaire, in Lyon, France.

Sonali Mukherjee has been appointed a postdoctoral research associate at GL. She will be working with Ronald Cohen on equations of state and rheology of materials at high pressure.

Oliver Tschauner has been appointed a postdoctoral fellow at GL. He will be working with Drs. Mao and Hemley in applying laser-heated diamond-anvil cell techniques to study transport properties and crystal-melt element partitioning at lower-mantle conditions.

OBSERVATORIES

Jason Prochaska gave talks first in Marseille, France, at the "Clustering at High Redshift" conference on July 1, and then at a UC Santa Cruz workshop on galaxy formation. The title was "Probing the damped Lyman alpha systems to study galaxy formation."

Patrick McCarthy has been appointed to a NASA oversight committee for the next-generation near-infrared camera on the Hubble Space Telescope. He recently gave colloquia at UC Santa Barbara, the University of Michigan, UC San Diego, and UCLA entitled "Near-infrared observations of distant galaxies from orbit."

In June, **Rebecca Bernstein** gave a talk at a conference, "The Hy-redshift Universe," in honor of Hy Spinrad's birthday. Her talk was entitled "The first detections of the optical extragalactic background light." Rebecca has also accepted a faculty position at the University of Michigan. She will start there in September 2001.

François Schweizer is now in residence at the Observatories. He was welcomed with his family at a lunch for new employees at the Observatories on September 2.

Judy Rosenau is the new Magellan Project assistant. Also, new Imacs engineer **Tyson Hare**, data analyst **Jennifer Wilson**, postdoctoral associate, **Swara Ravindranath**, and Carnegie Fellow **Jennifer Johnson** arrived on September 1.

Alan Dressler hosted a National Academy of Sciences O/IR panel of the Astronomy and Astrophysics Survey Committee for the National Research Council at the Observatories in Pasadena on July 20 and 21. This is part of the decadal review of Astronomy for Advice for government. He and **Wendy Freedman** are both members of this review committee. Alan was also presented with the NASA public service medal at the 3rd NGST Science and Technology Meeting at the September 15 meeting in Washington, D.C. The medal was presented for his contribution in creating the Origins program at NASA.

Joan Gantz (above), Observatories librarian for many years, retired on June 30. A retirement party was held in the library on June 25.

Miguel Roth participated in Atacama Large Millimeter Array's (ALMA) two-day cost review of the array in Charlottesville, VA, this July.

In Brief...

PLANT BIOLOGY

Chris Somerville gave a plenary lecture at the International Botanical Congress in St. Louis on August 2 entitled "New genomic tools for research in plant cell biology."

Postdoc **Matthias Rillig** of Chris Field's lab departed June 30 to take up an assistant professorship at the University of Montana.

Olle Björkman, who retired from the department on July 1, was the guest of honor at a symposium to review recent progress in some of the fields where his research has had an impact. The symposium, held in California's wine country August 28-30, was attended by nearly fifty of Björkman's friends, students, and colleagues, as pictured below.

Public Forums on the Meaning of Science

P Street will be the site of the newly initiated "Reflections on Science: Public Forums on the Meaning of Science" series. Presented by the Carnegie Institution of Washington and Virginia Tech's Science and Technology Studies Program, these free public forums are intended to encourage discussion between the audiences and the presenters. All forums begin at 6:30 p.m.

February 8, 2000 *The Challenge of Human Genetic Testing* with Doris Zallen and Maxine Singer

March 7, 2000 *Technology and Discovery in Astronomy* with Joe Pitt and Alan Boss

April 4, 2000 *On the Origins of Life* with Bob Hazen and Chris Cosans

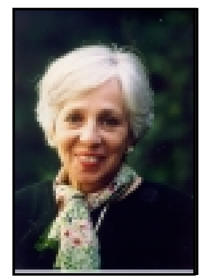
For more information, visit <www.nvgc.vt.edu/sts>

TRUSTEES

Richard Meserve was nominated by President Clinton to be chairman of the Nuclear Regulatory Commission. The nomination was confirmed in October. Meserve currently chairs a NAS committee that is evaluating scientific openness at DOE weapons laboratories in light of the current espionage concerns. He has also served as chairman of a task force of the Secretary of Energy Advisory Board that prepared and submitted an evaluation of DOE's fusion energy program.

Bruce Ferguson received the 1999 Harvard Business School Alumni Achievement Award at a ceremony in June.

On August 18, 1999, the *Washington Post* ran a piece in its Op-Ed section about the Kansas Board of Education's decision to allow local schools to eliminate the subject of evolution from the science curriculum. The writer was Maxine Singer. Excerpts from her editorial, entitled "Believing Is Not Understanding," follow.



"...The decision is comparable to leaving the U.S. Constitution out of civics lessons. Evolution is the framework that makes sense of the whole natural world..."

"...The goal of science education should be an understanding of the theory of evolution; the students can decide whether or not to believe it. Understanding is different from believing...."

"...It is foolhardy to accept creationist arguments as part of scientific discussions. Their purpose is to arrive at a conclusion consistent with religious faith. Science approaches questions the other way around. Even a theory as well supported as evolution could, in principle, be replaced by new and compelling evidence. Here is the most profound difference between belief based on faith and understanding based on science. The first is unassailable, the second inherently tentative...."

ADMINISTRATION

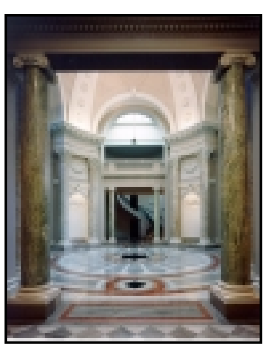
Maxine Singer will speak at the Weizmann Institute of Science's Jubilee Science Symposium, in honor of its 50th anniversary, in November.

Michael Pimenov arrived in August as the new endowment manager.

Margaret Charles left Carnegie after six and a half years. She is now a professional career counselor with the Health Resources and Services Administration.

The Science with the Atacama Large Millimeter Array (ALMA) conference will be held at the administration building from October 7-8. **Alan Boss** will be one of the featured speakers.

The P Street administration building received the Historic Resources award from the D.C. chapter of the American Institute of Architects.



. . . . MAGELLAN UPDATE. . . .

The Magellan I mirror is currently scheduled to leave Tucson the first week of November. It should arrive in Chile around November 28, 1999, and reach its final destination of Las Campanas a day later.