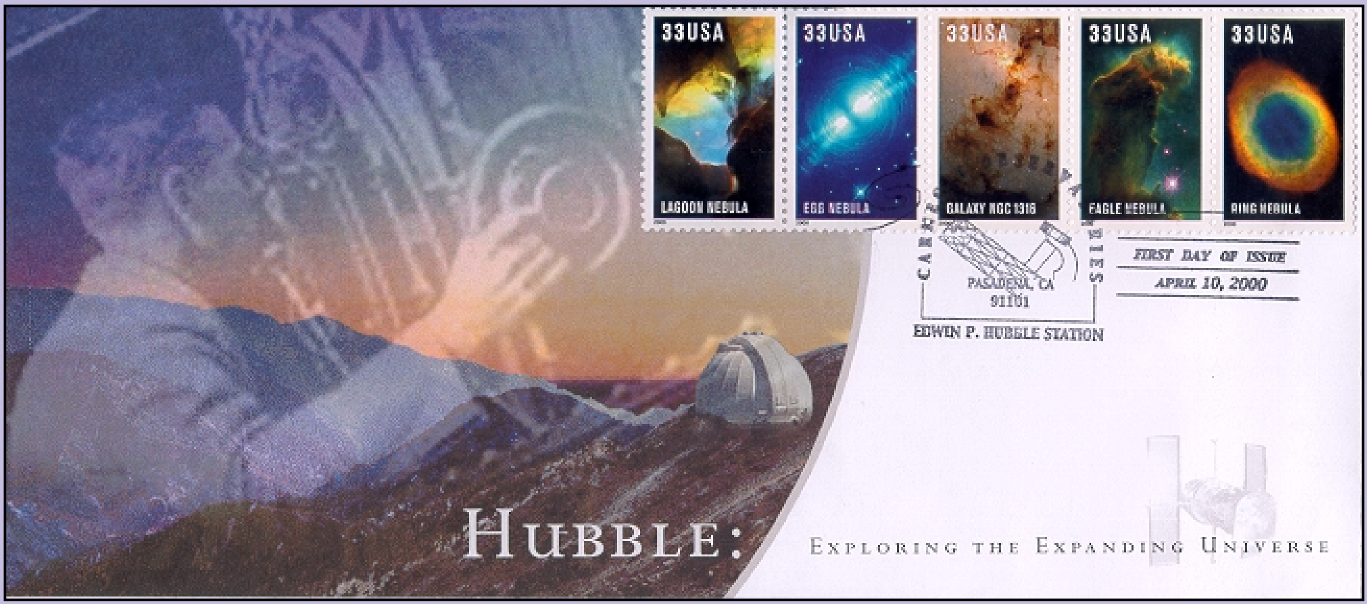
SPECTRA

Summer 2000

THE NEWSLETTER OF THE CARNEGIE INSTITUTION

Extending the Frontiers of Science



Above is the Carnegie Observatories' official first-day envelope and cancellation for the Edwin P. Hubble commemorative stamps. The envelope features the young Hubble at the 100-inch Mount Wilson telescope.

INSIDE:

LETTER FROM THE CHAIRMAN


Tom Urban

Carnegie has been in the business of science for almost one hundred years. When we reflect on our history, we have to ask, "What have we accomplished?"

For almost a century we have provided the world with countless discoveries and innovations—from Barbara McClintock's genetic breakthroughs to Hubble's discovery of our place in the universe. These examples and others have profoundly influenced everyday lives. Carnegie's recent achievements in areas such as genetics, planetary and earth science, and astronomy illustrate how our institution continues to make society better.

In March, the *Drosophila* genome was officially sequenced. Embryology's director, Allan Spradling, and former Staff Member Gerald Rubin were pivotal in initiating this work, which began almost a decade ago. The project has yielded 177 genetic counterparts for genes that are linked to human diseases. This means that as scientists learn more about gene function in the fruit fly, they will learn more about curing illnesses in people.

Genetic research on the model organism *Chlamydomonas reinhardtii* at Plant Biology is a similar case. Art Grossman's career-long work with this single-celled alga is revealing important insights into how plants acclimate to different environmental conditions. The payoff? Researchers will be able to develop food crops that can grow in a broader range of climates and keep up with the needs of the world's growing population.

Scientists from three Carnegie departments—Terrestrial Magnetism, Plant Biology, and the Geophysical Lab—continue to help us understand more about the Earth. DTM's director, Sean Solomon, for instance, unravels the mysteries of our sister planets, providing insights into Earth's evolution. Chris Field and Joe Berry at Plant Biology investigate the human role in environmental change on our own planet. At GL, Marilyn Fogel studies biological and geological processes in the Earth's past and present environments. Ultimately all of this work will help to improve the planet's long-term habitability.

Our fundamental understanding of matter, energy, and the principles on which the universe operates is enhanced with research at the Observatories. Wendy Freedman's role in determining the expansion rate of the universe, and Luis Ho's investigations into black holes are examples. Practical results aside, what could be more important?

None of the science we do today was envisioned a hundred years ago. Nor can we imagine what the next hundred years will be like. But we do know that Carnegie's achievements today and tomorrow will continue to provide the foundations on which future generations will build to improve the world that they inherit from us.

Tom Urban

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New Members Join the Board

Former Embryology Staff Member Steven McKnight was elected to the board of trustees at the May meeting in Washington, D.C. McKnight joins Daniel Belin as the newest Carnegie board members. Daniel Belin, who was elected to the board in December, is a founding partner of the Los Angeles law firm Belin Rawlings & Badal. He is a trustee of the Ahmanson Foundation, the Samuel H. Kress Foundation, and serves on a variety of other boards and visiting committees.

Steven McKnight has been affiliated with Carnegie for many years. He came to the Department of Embryology as a staff associate in 1979 and left as a Staff Member in 1992 to cofound Tularik, Inc. At present, he is the chairman of the Department of Biochemistry at UT Southwestern Medical Center. He holds the Sam G. Winstead and F. Andrew Bell Distinguished Chair, and the Distinguished Chair in Basic Biomedical Research.

Signatures of Life—Carnegie Evening 2000

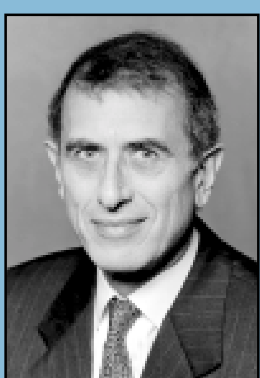
Marilyn Fogel, a Staff Member at the Geophysical Lab, was this year's Carnegie Evening speaker. Her visually appealing, fast-moving lecture was sprinkled with stories about what it is really like to collect data in the field. Fogel discussed her work detecting "signatures of life" on Earth and explained how her methods can be applied to the search for life on extraterrestrial bodies.

Fogel's research blends the fields of biology, chemistry, and geology. She described how she uses isotopes of carbon, oxygen, and nitrogen to understand the biological and geological processes in Earth's past and present environments. She presented several examples to illustrate how she applies her techniques to trace phenomena as varied as the nature of the first microorganisms on our planet, and the landscape and climate of ancient Australia. Fogel also talked about how she anticipates analyzing samples, such as those from future missions to Mars, to hunt for evidence of life elsewhere.

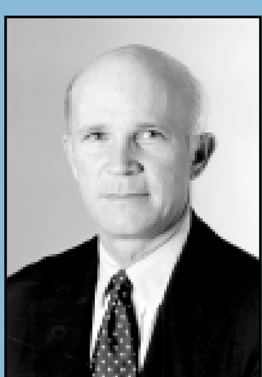
Left: Trustee Tom Cori and Marilyn Fogel enjoy a moment after the lecture.

Right: More than 350 guests filled the administration building for Carnegie Evening on May 4.

Below: After a day of board business, trustees Richard Meserve (left), Robert Goelet (middle), and Tom Cori (right) get a chance to relax.



Daniel Belin



Steven McKnight

May 2000, Board of Trustees: First row, from left: Michael Gellert, Tom Urban (chairman), Maxine Singer (president), Suzanne Nora Johnson, David Swensen. Second row: Sandra Faber, Sidney J. Weinberg, Jr., Tom Cori, Burton McMurtry, Philip Abelson, Gary Ernst. Third row: John Diebold, Bruce Ferguson, David Greenewalt (secretary), Robert Goelet, Jaylee Mead, John Crawford, Christopher Stone, James Ebert, William Rutter, Frank Press. Not pictured: Euan Baird, Daniel Belin, William Coleman, Jr., William Golden, William Hearst III, Kazuo Inamori, Gerald Laubach, Steven McKnight, John Macomber, Richard Meserve, and William I. M. Turner, Jr. (vice chairman).

Honoring Hubble

Carnegie astronomer Edwin P. Hubble revolutionized our concept of the universe, compelled Einstein to revise his Theory of Relativity, and is the man for whom the Hubble Space Telescope is named. The U. S. Postal Service honored the man and the telescope on April 10 by issuing five commemorative stamps. Two first-day-of-issue ceremonies were held: one on the Observatories' campus in Pasadena, California, where Hubble was a staff member from 1919 until his death in 1953, and the other at the NASA Goddard Space Flight Center in Greenbelt, Maryland.

Robert Mysel, postmaster of Pasadena, presided over the California ceremony, which was attended by more than 200 guests, six TV stations, two radio stations, and several newspaper reporters. Gus Oemler, director of the Observatories, welcomed the audience. Speaking about about Hubble's life and accomplishments, he said, "Edwin Hubble is recognized as the greatest astronomer since Galileo and is certainly the most influential astronomer that this nation has produced." Oemler, Allan Sandage, and Steven Hawley, an astronomer and astronaut from the NASA Johnson Space Flight Center, then unveiled the stamps.

Allan Sandage took the podium next. He referred to the Observatories as "the best-kept secret in Pasadena," and said that the fantastic discoveries on Mount Wilson "made this city the world center of astronomy for most of the past century." Pointing to the Observatories' buildings, he continued, "It was in those offices, constructed in 1912 in the middle of farmland, citrus groves, and vineyards that the foundations of the grand picture of cosmology originated."

The parallel celebration, at NASA Goddard Space Flight Center, was also cohosted by the U.S. Postal Service. Carnegie president Maxine Singer, NASA director Daniel Goldin, and Space Telescope Science Institute director Steve Beckwith unveiled the stamps. In a talk later that day at Goddard, Carnegie's Alan Dressler noted that "the HST is continuing Edwin Hubble's own work of measuring the expansion rate of the universe."

It's "thumbs up" for the formal unveiling of the Hubble stamps in Pasadena. Astronaut Steven Hawley (left), Observatories' director Gus Oemler, and Edwin Hubble's successor Allan Sandage (right) participate in the ceremony. Photo: Courtesy Michael Jones, U.S. Postal Service.

The East Coast event for the first day of issue was held at NASA Goddard Space Flight Center in Maryland. From left to right: NASA administrator Daniel Goldin, Carnegie president Maxine Singer, and Postmaster General William Henderson.

One Little Cell with Lots to Tell

To understand how plants acclimate to a changing environment, Arthur Grossman studies simple, single-celled algae—a group of organisms he has investigated throughout his career. Researchers in Grossman's lab at the Department of Plant Biology are trying to identify the genes and understand genetic processes that allow plants to sense and react to their dynamic environment. They are particularly interested in the details of how plants respond to different nutrient levels and light conditions. This research has important implications for agriculture: developing an understanding of how plants acclimate to different light and nutrient conditions will help researchers engineer crops to prosper in a broader range of environments. It is also helping to build a body of knowledge on the evolution of biological processes in plants.

The mustard plant *Arabidopsis* is one of the model organisms that researchers in the Grossman lab have used, but increasingly the investigators have focused on algae. They primarily examine the green alga *Chlamydomonas reinhardtii*, and a variety of "blue-green algae," more properly called cyanobacteria. Cyanobacteria are actually photosynthetic bacteria that contain all of the machinery necessary for photosynthesis; much of this machinery is similar to that of vascular plants.

Why algae?

Although algae are the simplest of plants, green algae, such as *Chlamydomonas reinhardtii,* contain all of the same pigments in essentially the same proportions as vascular plants, their more complicated cousins. In fact, green algae are thought to be the evolutionary precursors to vascular plants. Chlamy, as this alga is affectionately called, is ideal for nutritional and photosynthetic studies because it is simple and cheap to grow; it can be grown photosynthetically in the light, or in the dark by feeding it on acetate (a fixed carbon source that can serve as its energy supply); at 10 microns it is large enough to see microscopically; it reproduces quickly; it can be stored for long periods; and it is a haploid organism with each cell containing a single copy of the nuclear genome. This last characteristic makes it good for generating mutants and for performing classical genetic analyses.

Chlamy is a single-celled organism that can be maintained in culture under highly defined conditions. It is therefore better for certain types of studies than vascular plants because the analyses are not complicated by multiple tissue types, such as roots and shoots, that are exposed to different environments. Furthermore, Chlamy can grow by feeding directly on a fixed carbon source without light, whereas vascular plants need photosynthetic carbon fixation to survive. Because of this feature, it is much easier to create viable mutants that affect photosynthetic processes in the alga.

Important parts

There are several critical, functionally distinct compartments in plant cells. Among them is the nucleus, which is the control center of the cell; the mitochondrion, where energy is extracted from food in a process called respiration; and the chloroplast, where the plant absorbs and converts the energy from the sun to glucose for nourishment. These compartments all have their own genomes. Genes that have been isolated and characterized can be introduced into any of these three compartments in Chlamy. As in vascular plants, integration of genes into the Chlamy nuclear genome is random, which means that the introduced genes cannot be inserted into a consistent location on the chromosomes. However, Chlamy is unique with respect to vascular plants in that genes can be readily integrated into both the mitochondrial and the chloroplast genomes. The integration of DNA into the chloroplast genome, where much of the machinery for photosynthesis is encoded, is by homologous recombination. Researchers can therefore replace an existing gene on the chloroplast genome with one that has been altered or mutated in vitro. The phenotype, or observable characteristics of the strain for which a chloroplast gene has been altered, provides important clues concerning the function of that gene in the alga (for example, elimination or modification of any of a number of chloroplast genes alters the ability of the organism to perform photosynthesis). Chlamy is also ideal for classical genetic crosses; it takes only 10 to 14 days to perform a cross and to characterize the phenotypes of the progeny. In *Arabidopsis* the same analysis can take months.

Arthur Grossman is shown here in his lab.

Markers help locate genes

Many mutations of Chlamy's nuclear genome have been obtained by treating the organism with chemicals or UV light. This treatment generates small changes in the genome that are not easy to locate. However, there are now a number of both physical and genetic markers on the Chlamy genome that are enabling researchers to find and identify the mutated gene sequences. The markers are of several types. They can be individual genes associated with a particular observable characteristic or phenotype, physical features associated with a DNA sequence, or both. The markers are located at specific locations on the Chlamy chromosomes and are powerful landmarks for mapping a gene to a unique region of the chromosome and for identifying lesions in genes that cause particular mutant phenotypes.

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The Photosynthesis Engine

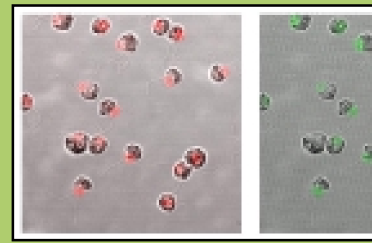
Chlamy has served as the classic model for studies of photosynthesis, a process primarily performed within chloroplasts. Chlorophyll, the pervasive green pigment in plants, as well as the orange and yellow pigmented carotenoids, are located in this organelle. Most of the chlorophylls and carotenoids are associated in structures called light-harvesting complexes. These structures consist of subunits of proteins, molecules of chlorophyll, and molecules of carotenoids that are all embedded in a lipid matrix. The pigments in these light-harvesting complexes absorb or trap certain wavelengths of light and transfer that light, or excitation energy, to specialized chlorophyll molecules in the photosynthetic reaction centers; these reaction centers are the foci for the primary photochemistry that drives photosynthesis. The energized chlorophylls within these centers pass high-energy electrons to acceptor molecules. This initiates a series of reduction (the gain of an electron) and oxidation (the loss of an electron) reactions that eventually lead to the production of sugars that fuel metabolic processes in plants and, ultimately, the animals that eat them. The carotenoids associated with the light-harvesting complexes are also extremely important for the dissipation of excitation energy when the plant is absorbing more than it can use for photosynthesis. (The absorption of excess light energy by plants can lead to the production of potentially toxic reactive oxygen species.)

Finding out what a gene does

The process to determine what a gene does can be tedious. Sometimes a gene's function can be inferred from the similarity it has to genes in other organisms that have already been characterized. However, to begin to understand the activity encoded by a gene and the precise biological process in which that activity functions, it is critical to generate mutations and compare mutated organisms with wild-type, or normal, organisms. This analysis may reveal differences between the mutants with respect to morphology, development, or various biochemical processes.

Getting DNA into a single-celled alga

There are three main methods of introducing DNA into cyanobacteria and green algae, and they are all used in the Grossman lab: glass bead transformation, electroporation, and the biolistic procedure. Glass bead transformation works well for a strain of Chlamy that lacks a cell wall. The algal cells are submerged in a solution containing the DNA and finely ground glass beads. The suspension is vigorously mixed with a device called a vortex for 30 seconds. The glass beads apparently abrade the cells and generate transient gaps in the cell membrane through which the DNA can enter. In electroporation, the algae are submerged in a low-salt solution containing the DNA. An electrical current is discharged that opens the cytoplasmic membranes of the cell, allowing the DNA to permeate. This procedure has been used with both Chlamy and cyanobacteria. The biolistic procedure involves bombarding the algae with micropellets coated with DNA. All of these methods can be used both to generate mutants and to identify genes that have been altered in the mutant strains.



These images show what happens during phosphorus starvation in *Chlamydomonas*. To monitor the level of the protein Psr1—a regulator of some of the responses to phosphorus starvation—the researchers quantified and localized Psr1 after the cells were exposed to different conditions. The red fluorescence indicates the presence of DNA and marks the nucleus (left) of phosphorus-starved cells. The presence of Psr1 in these same nuclei was determined by an

Making mutants

In some organisms, including many cyanobacteria, it is relatively easy to generate mutants by "knockout" strategies. The generation of knockout mutations involves the specific replacement of the original, normal copy of the gene with a copy that has been altered and no longer performs its normal function. In many cases a specially engineered drug-resistant cassette, for example one resistant to spectinomycin, can be placed into the middle of an isolated gene of interest. The gene disrupted by the cassette can be introduced into wild-type cyanobacterial cells, where it will exchange with the normal copy of the gene. Strains harboring the interrupted version of the gene are readily identified as being drug resistant because they don't die in the presence of spectinomycin. Since the normal function of the gene has also been inactivated in these strains, the scientists analyze the mutated organism for features that differ from those of wild-type cells.

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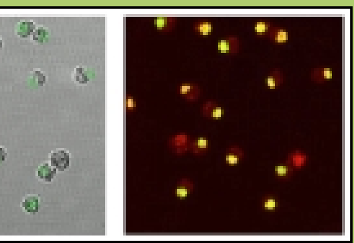


immunological stain and is indicated by green fluorescence (middle). The yellow represents an overlap of Psr1 fluorescence (green) with fluorescence from nuclei (red) (right). These results show that Psr1 is a protein that specifically localizes to the nucleus. When similar experiments were performed with cells that were not starved for phosphorus, very little Psr1 was observed. The level of the Psr1 protein goes up at least 10 fold during phosphorus deprivation.

Responding to starvation

Grossman wants to understand what genes and processes are active in photosynthetic organisms that allow them to sense nutrient levels and acclimate to nutrient-deficient conditions. When cyanobacteria are starved for a specific nutrient, the organism synthesizes systems to help scavenge for the limiting nutrient more efficiently. The organism also undergoes a more general response: cells stop growing, the light-harvesting complex is degraded, and photosynthetic electron transport shuts down. It is essential that the cell eliminate most photosynthetic electron transport during nutrient limitation. If the system were not shut down, it would produce reactive oxygen species, which could burn up the cell. The redox state of the cell would also increase, which could adversely affect metabolic control. With the degradation of the light-harvesting complex during nutrient limitation, the cells look yellow or bleached instead of blue-green.

Locating the starvation-response genes

To understand the details of what happens during nutrient starvation, the scientists first mutated normal cells with a chemical mutagen. This created random base changes in the genomic DNA, generating populations of mutant cells. The mutants were screened for those that specifically looked blue-green following nutrient limitation, indicating they were unable to degrade their light-harvesting complex. The single base changes often caused by the chemical mutagens are too small to find easily, so the scientists identified the mutated genes by a process called complementation. In this process, the researchers placed a library of pieces of genomic DNA from normal cells into a plasmid vector (a carrier molecule containing a genetic marker) and then introduced the material into the mutant strains. The plasmid, plus normal cyanobacterial DNA, recombines into specific locations in the genomic DNA. The researchers visually identified those strains that exhibited normal bleaching during nutrient limitation, and then isolated and characterized the genes of interest by locating the plasmid marker in the genome.

How the genes function

In this manner, the researchers identified four genes involved in modifying the photosynthetic apparatus during nutrient stress. Two of the genes isolated encode proteins that are directly involved in the destruction of phycobilisomes—the major light-harvesting complex of cyanobacteria. The remaining two genes encode regulatory proteins that have been designated NblR (nonbleaching regulator) and NblS (for nonbleaching sensor). NblR is a DNA-binding protein and is critical for activating specific genes that encode proteins that function in phycobilisome degradation during nutrient limitation. It also controls other cellular processes that are critical for the survival of cells during nutrient limitation. The NblS protein appears to regulate the activity of NblR and is hypothesized to be the molecule that integrates information provided by a variety of environmental signals; it tunes cellular metabolism and growth to the information provided by environmental signals. Interestingly, NblS contains a domain that binds a pigment called a flavin. The flavin can serve as a redox molecule that can both accept and donate electrons; it can also absorb blue and UV-A light. During all nutrient stress conditions the redox state of the cell is elevated and NblS may be able to quantify cellular redox through the bound flavin. The redox state of the flavin may then modulate the activity of a group of transcription factors—genes that control the expression of other genes—that are involved in regulating metabolic processes. NblS also appears to control a number of genes whose activity is controlled by the light environment. Many of the genes encoding proteins of the photosynthetic apparatus are controlled by blue/UV-A light (which is often a signal for high light in the environment). The blue/UV-A light signal appears to be communicated to the transcriptional apparatus of the cell through NblS. Therefore, NblS functions as a global cell regulator that uses the redox state and the light environment as an indicator of the cell's potential for growth and then tunes photosynthesis and probably other metabolic processes accordingly.

These studies in Grossman's lab raise a lot of questions about how a variety of environmental cues are fused into a single cue that is represented by redox and, possibly, the level of reactive oxygen radicals in the cell. This work also suggests that redox components involved in electron transfer reactions have evolved into both regulatory molecules and photoreceptors.

continued on page 11

It's In!

April 30, 2000

Dear colleagues:

I'm pleased to announce that the Magellan I 6.5-meter primary mirror has been successfully installed in the mirror cell. The procedure took place on Wednesday and Thursday of last week in the Magellan coatings facility (the "auxiliary" building).

The installation team consisted of Magellan Project and LCO staff assisted by Steve Warner from the University of Arizona. Nineteen people were involved, including the safety officer and the photographer. Before starting, a detailed procedure was reviewed and discussed ahead of time with the team.

The lift started at 7:30 Thursday morning. First, Warner dressed out the one defect in the back surface found earlier by Frank Perez. The mirror was picked off the shipping frame with the vacuum lift fixture. Once the mirror was in the air there was no stopping until it was in the cell.

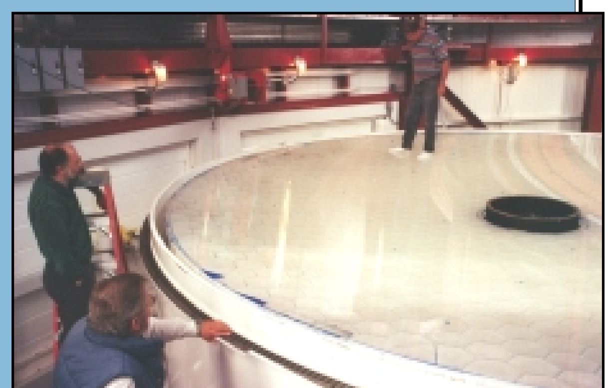
An inspection with the mirror raised revealed no additional defects in areas that were inaccessible when the mirror was in the shipping container. Once the mirror was raised, the shipping frame was rolled out of the way, and the telescope cell was positioned below the mirror. The process of lowering the mirror into the cell was tedious but was accomplished without major drama, as the Chileans say. The bolts that hold the mirror in the telescope were installed, and the mirror was set down on the static supports. The lift fixture was detached at 4:00 p.m., completing the installation.

The mirror is suspended over the mirror cell as Matt Johns (left) and Frank Perez (on the ladder) look on.

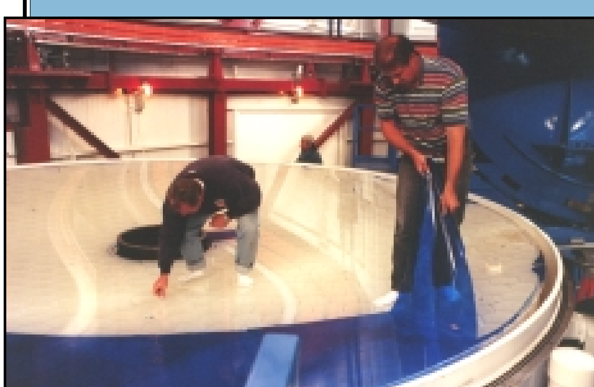
On Friday, the primary mirror and cell were driven into the enclosure and installed in the telescope along with the tertiary mirror assembly. We had some minor difficulty attaching the tertiary support base but in the end we prevailed. The mirror is now safely installed in the telescope and is protected by the mirror covers.

The primary mirror will be tested initially without its aluminum coating. The reflection off the bare glass will be enough to see bright objects. When the aluminizing chamber is ready later this summer the mirror will be taken out of the telescope and coated in its cell. At that time we will install the primary mirror thermal-control system.

The crew is currently engaged in installing and aligning the primary mirror supports. This work will take much of May to complete. During this time the secondary mirror will be reinstalled in the telescope and the telescope optical support structure will be balanced. The secondary and tertiary mirrors were aluminized previously. The initial alignment of the optics will be accomplished with alignment telescopes and fixtures specially designed for this purpose.



Magellan Project scientist Steve Shectman (left) and Las Campanas director Miguel Roth (bottom) assist as Frank Perez takes the final bits of coating off the surface.



Steve Warner (left) from the University of Arizona Steward Mirror Lab and Carnegie's Frank Perez take off the protective coating that has shielded the glass since it left Arizona.

There is still a tremendous amount of work left to be done to make the telescope truly ready for observing, but this last week marked a major milestone in that process.

On behalf of the Magellan team,

Matt Johns, *Magellan Project Manager*

Fruit Fly Genome Sequencing Project Has Deep Roots at Carnegie

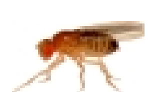
The completed sequence of the *Drosophila* genome was published in the March 24, 2000, issue of *Science.* The fruit fly has about 13,600 genes, 99% of which now have been mapped. Two of the players on the team of scientists and engineers who decoded the genome are Embryology's director (and Howard Hughes Medical Institute [HHMI] investigator) Allan Spradling and former Embryology Staff Member Gerald Rubin. Rubin, now at the University of California-Berkeley, is vice president of HHMI and leader of the genome project. Nine years ago, the pair launched the sequencing as one component of the *Drosophila* genome effort. But their history as collaborators goes back even further.

In 1981, Spradling and Rubin (then both Staff Members at the Department of Embryology) made a groundbreaking discovery—a new method of gene transfer. They showed that an external gene could be successfully inserted and expressed in the fruit fly's germ cells—cells that give rise to gametes. Spradling and Rubin's experiments used transposable elements: the phenomena discovered by Carnegie geneticist Barbara McClintock, in which genes seem to jump within or between chromosomes. They used this feature to "ferry" sequences of DNA called P-elements into embryos. This method allowed scientists to study genes of complex multicellular organisms directly for the first time. Spradling and Rubin's P-element experiments also spawned the creation of transgenic flies and the unprecedented manipulation of the *Drosophila* genome, which opened the door to the development of a new, powerful gene-manipulation technology.

Now that the structures of the genes have been mapped, the genome project will concentrate on determining how the genes function. Indispensable tools in this task are fly strains bearing a mutation in just one of the genes. In 1988, Spradling's group developed a way to generate particularly useful mutants using P-elements. By creating strains containing only one P-element at a random site, the group could study the effects on the fly caused by disrupting just one easily recognizable place in the genome (usually affecting only one gene). The genome project adopted this method from the outset, and the project has already mutated more than a thousand different genes.

Now that the sequencing is complete, the Spradling and Rubin groups, with several additional collaborators, plan to redouble their efforts on the gene-disruption project. They expect their work to be nearly finished within three years.

Image courtesy of Carolina Biological Supply Company



Algae at the Desert Lab?

The Department of Plant Biology has a long history of research into photosynthesis using algae as a model organism. In 1916, Staff Member Herman Spoehr began Carnegie's first systematic study of photosynthesis, using a cactus as his model organism. But by the 1930s, algae, particularly the green algae *Chlorella,* was widely employed. The Desert Laboratory used *Chlorella* for research because it grows rapidly and easily, and tolerates variation in conditions such as light and temperature.

Research Associate Robert Emerson initiated a study in 1937 to determine how much light is really needed in the photosynthetic process. He embarked on a three-year study using *Chlorella,* which yielded significant results. Emerson noted that by illuminating the plant first with blue, then with red light, and then with blue and red light simultaneously, there was a severe drop in photosynthetic efficiency at the far-red wavelengths. He determined that the photosynthetic rate in far-red light could be enhanced by supplemental light from shorter wavelengths—a phenomenon later called the Emerson enhancement effect. This seemed to suggest that two separate pigment systems were at work, absorbing light preferentially at different wavelengths. This discovery was an important step to the later recognition of two distinct photoreactions in plant photosynthesis.

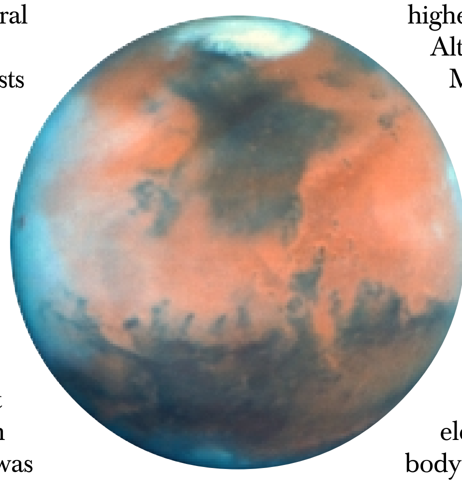
An offshoot of the photosynthesis research at the department occurred in the late 1940s and early 1950s with experimental studies of *Chlorella* as a food source. In Japan at this time, scientists were also studying the possibility of using algae as food, and Carnegie hosted visiting investigators to collaborate on the venture. The goal of this program was to enhance the protein content of algae by manipulating environmental factors. In 1951, the department purposefully stopped experiments on the nature of photosynthesis to concentrate on the technical development of algal cultures for food. CIW and the Carnegie Corporation paid a contracting firm to build and operate a *Chlorella*-producing pilot plant in Massachusetts. However, the operation was troubled by contamination in the algae growth tanks and was soon abandoned.

Chlorella is no longer used as a model organism for photosynthesis because it does not reproduce sexually and therefore isn't appropriate for today's advanced genetic research.

New evidence suggests there may have been more water on Mars than was previously thought

Gravity measurements from the Mars Global Surveyor (MGS) indicate that more water may have flowed on the Red Planet than was previously thought. Sean C. Solomon, director of DTM, and former DTM postdoctoral associates Patrick McGovern and Catherine Johnson are members of a team of geophysicists who conducted a study on the internal structure of Mars. The results are published in the March 10, 2000, issue of *Science.*

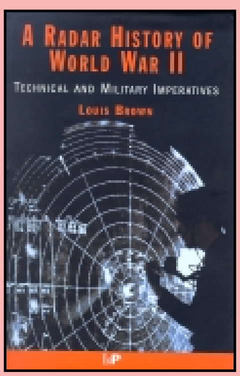
The team used the MGS satellite, orbiting the planet since 1997, to map the structure of the crust and upper mantle. As the surveyor orbits Mars, its speed varies because the difference in surface density affects the planet's gravitational tug on the craft. This speed variation creates an apparent shift in the frequency of the radio transmission back to Earth—a Doppler shift—which in turn was used to infer the subsurface density.



The scientists found low-density regions that appear to be a series of sediment-filled elongated channels, similar to ancient riverbeds on Earth. These Martian channels lead from the higher southern regions to the vast northern lowlands. Although scientists have known about channels on Mars for years, they didn't realize how large they were until they probed below the surface with the surveyor. The size of the subsurface structures—more than 200 km wide, thousands of km long, and 1 to 3 km deep—suggests that at one time in the past Mars may have had enough water to fill the lowland region with an ocean. If so, the water that carved the channels may have carried substantial sediments that over millions of years completely buried those portions of the fluvial record at the lowest elevations. These observations add to the growing body of evidence that early in its history Mars was much more similar to the Earth than it is today.

Image courtesy of NASA

New Reading

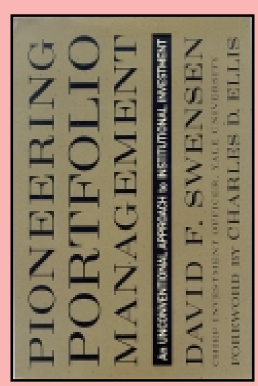


Louis Brown, *A Radar History of World War II: Technical and Military Imperatives* (Bristol and Philadelphia: Institute of Physics Publishing), 1999, 563 pp.

To prove the truth of the old adage about World War II, "The bomb may have ended the war but radar won it," Louis Brown, Emeritus Staff Member at the Department of Terrestrial Magnetism, wrote *A Radar History of World War II: Technical and Military Imperatives.* Brown began this work because he himself wanted to read a book about the development of radar, but found that there were none. He was "struck by the absence of a comprehensive and international history of radar, of the kind that has appeared many times about the atomic bomb." Brown's book interweaves a history of the technologies necessary for radar development with a description of the international theaters of war and the personalities of the scientists and engineers involved. To illustrate the link between war and science, he looks at military campaigns from the aspect of their use of radar. The book's introduction alerts the reader to the technical sections so that one can choose to enjoy the story with or without the technical details. As a result, the book will appeal to the technically-savvy and the layperson alike.

David F. Swensen, *Pioneering Portfolio Management: An Unconventional Approach to Institutional Investment* (New York: The Free Press), 2000, 366 pp.

Carnegie Institution trustee David Swensen is the author of a new book, *Pioneering Portfolio Management: An Unconventional Approach to Institutional Investment.* Swensen, chair of Carnegie's board of trustees Finance Committee, draws on his 15 years of experience as Yale University's chief investment officer to discuss investment strategies. "Establishing and maintaining an unconventional investment portfolio carries a wide range of risks," he notes. With this in mind, he explains how to successfully design and implement alternative investment policies for institutions and universities.



One Little Cell...

continued from page 7

Sensing light

Photosynthetic, aquatic organisms have to compete for light because of cloud cover, pollution, shade, and the absorption of certain wavelengths by the water column. To be successful light harvesters, many of these organisms sense their light environment and adjust to varying light conditions. Grossman's lab has identified a photoreceptor, as well as signal transduction elements, in cyanobacteria that tells the organism what wavelengths of light are available to use. The cells respond to the signal by adjusting the composition of the pigment-proteins in their light-harvesting structures to best absorb available wavelengths. The photoreceptor they identified is a protein kinase (an enzyme involved in transferring a phosphate to another protein, which may alter the activity of that protein) with a chromophore-binding site that is similar to that of the phytochromes. Phytochromes are photoreceptors of vascular plants that regulate a variety of physiological processes. This work has important implications with respect to the evolution of photoreceptors and the way in which phytochrome translates a light signal into the modulation of the cells' biochemical activities.

What happens with too much light

Other studies in the Grossman lab address the potential toxic effects of light. Although light is necessary for photosynthesis, too much of it can lead to the production of reactive oxygen species, which can damage many processes in the cell and result in death. During midday in California a plant may be absorbing five to 10 times the amount of light that can be used for photosynthesis. For a number of years, Olle Björkman's laboratory at Plant Biology examined the ways in which plants dissipate this excess absorbed light energy. An oxygenated carotenoid pigment called zeaxanthin appears to be involved in eliminating this excess excitation energy as heat. The synthesis of zeaxanthin is elevated in high light through the operation of the xanthophyll cycle—a cycle in which the carotenoid pigment xanthophyll violaxanthin is converted to other such pigments, antheraxanthin and zeaxanthin. Although zeaxanthin seems to be involved in the energy dissipation, the scientists do not know its exact mode of action.

Recently, researchers examined the problem of energy dissipation in plants at the molecular level by generating mutants of both *Chlamydomonas* and *Arabidopsis* that were unable to dissipate excess absorbed light energy. The scientists used a new screen involving video imaging of the colonies to identify mutants defective in energy dissipation. The results confirmed that the xanthophyll cycle and zeaxanthin were critical for the dissipation of excess absorbed energy, and suggested that other processes and other carotenoids might be involved. The investigators also identified a protein component of the energy-dissipating apparatus that is designated PsbS. This protein is thought to be an evolutionary precursor of the light-harvesting proteins of plants. These results suggest that energy dissipation within the photosynthetic apparatus arose prior to the establishment of large light-harvesting complexes.

In cyanobacteria, there are small polypeptides related to the light-harvesting proteins of vascular plants, which are critical for survival in high light. These proteins, called HliA (<u>h</u>igh <u>l</u>ight <u>i</u>nduced), are synthesized at high levels when the cells are exposed to high light or to blue or UV-A light. The HliA proteins appear to bind pigment molecules and associate into macromolecular complexes that are integral to the photosynthetic membranes. The exact role of the HliA proteins in high-light survival is not known, although they may be involved in energy dissipation or in binding chlorophyll molecules and facilitating their integration into protein complexes of the photosynthetic apparatus.

Understanding how and why they move

Cyanobacteria move in the water and in films on the surface of rocks to chase the best light and nutrient conditions. Grossman wants to understand what generates the forces required for this movement, define environmental factors that control motility, and identify the molecules responsible for linking light and nutrient cues to motor function. Normal cyanobacteria move toward a unidirectional light source. Recent work in the Grossman laboratory has demonstrated that this movement depends on hair-like structures called pili that are distributed over the surface of cyanobacteria. Both the motility of cyanobacteria and the pili are shown on page 12. The Grossman laboratory has generated over 300 mutant cyanobacteria that are either non-motile, do not respond to a unidirectional light source, or move backward with respect to the unidirectional light source. By analyzing these mutants, the researchers have identified molecules that are involved in several processes including the biosynthesis of pili, the generation of cell surface architecture, the regulation of motor function, and the sensing of light cues. One molecule that appears to be critical for forward movement contains a domain that is similar to the chromophore-binding domain of phytochrome; it may function in orienting the cells with respect to the unidirectional light source.

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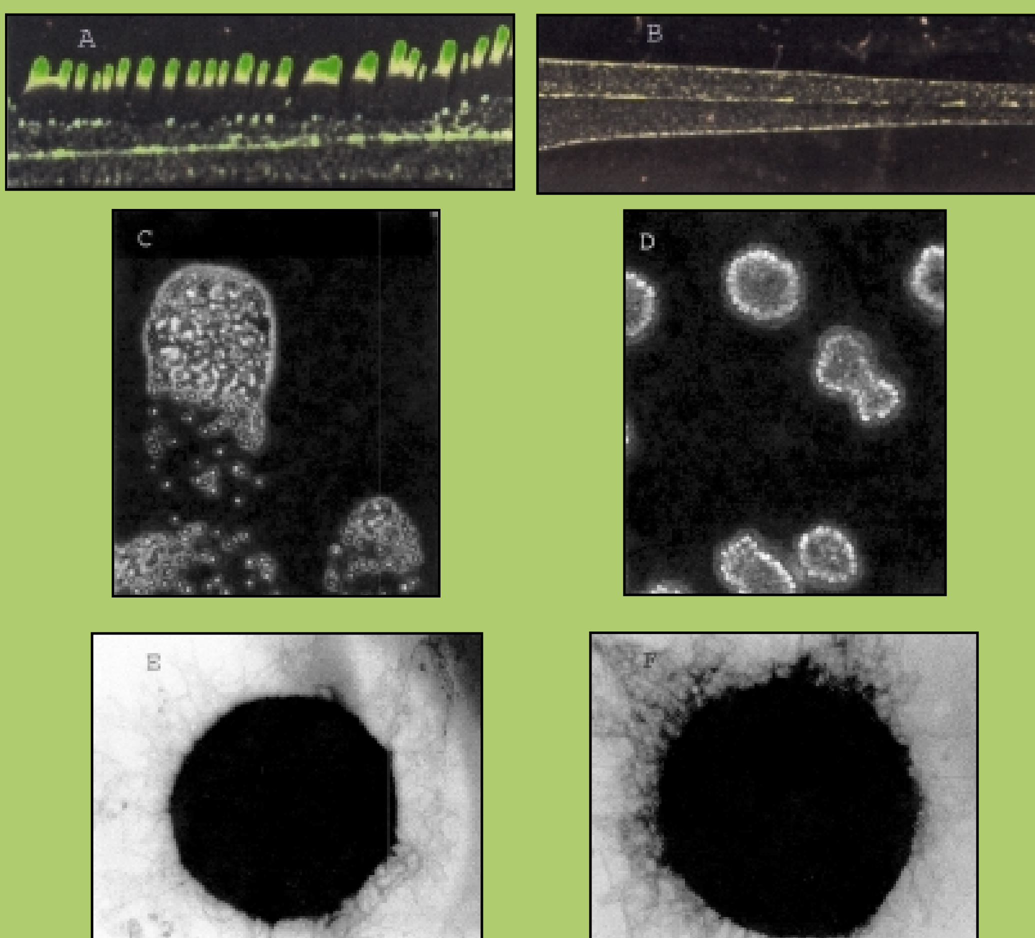
Chlamy's genome and NSF

Chlamydomonas is studied in more than a hundred labs worldwide. Because this alga is an ideal model organism for understanding photosynthetic mechanisms and the ways in which organisms acclimate to their light and nutrient environments, NSF funded the first phase of the *Chlamydomonas* Genome Project in November of 1999. Art Grossman is the principal investigator. The $3.3-million project includes the sequencing of cDNAs, using high density DNA microarrays to examine global gene expression in *Chlamydomonas* under a number of different environmental conditions and in certain mutant strains, analyzing the function of every gene on the chloroplast genome, and developing a database that is accessible to the international scientific community. In addition, the project will generate hundreds to thousands of physical markers that will be placed on the *Chlamydomonas* genome. These markers will allow for the efficient map-based cloning of genes, which in turn will enable researchers to efficiently probe the function and regulation of gene products. Genomic work performed under the auspices of the *Chlamydomonas* Genome Project will generate knowledge to fill the evolutionary gap that separates simple prokaryotic cyanobacteria and the more complex vascular plants like *Arabidopsis* and rice. It will deepen our understanding of the evolution of both specific genes and biological processes, providing strong insights into how we may tailor these processes to specific environmental conditions.



These images show how normal and a non-motile, mutant cyanobacterium react to a unidirectional light source. For the normal cyanobacterium, groups of cells aggregate into finger-like projections that move toward the light (A). The mutant strain shows no movement (B). At higher magnification (~125x) of the normal cyanobacterium, individual cells in a single finger-like projection appear to aggregate at the tip of the projection (C). The mutant cyanobacterium (D), on the other hand, makes tight, non-spreading colonies. At even higher magnification (25,750x) in which individual cells are viewed, the normal cell (E) exhibits thin and thick pili on the cell surface; these structures generate the forces that allow the cyanobacterium to move. The non-motile mutant (F) has an over abundance of the thick pili on the surface of the cell, which in some way prevents it from moving.

In Brief...

TRUSTEES

John Diebold's entrepreneurial project completed a case study of New York's Silicon Alley.

ADMINISTRATION

On April 30, **Maxine Singer** was inducted into the Washington, D.C. Hall of Fame for "outstanding scientific accomplishments and deep concern for the societal responsibility of scientists in Washington, D.C." At Bryn Mawr College, also in April, she delivered the 1999-2000 Rothenberg Lecture in Biology and Public Policy entitled "Catching Up." She delivered the 2000 Dael L. Wolfle Lecture at U. Washington–Daniel J. Evans School of Public Affairs entitled "Science and the Public: Playing Catch-Up." On May 11 she was the keynote speaker for the Whitehead Institute's Policy Symposium dinner and delivered a talk on "Genes and Greens." On May 21 she was a speaker at Yale University's Graduate School of Arts and Sciences Commencement Convocation. Her speech was entitled "Challenges Facing the Newly Elite."

OBSERVATORIES

François Schweizer attended an AURA Observatories Council meeting in La Serena, during which council members were shown the Gemini South 8-m telescope under construction on Cerro Pachon. He took the opportunity to also visit Las Campanas and see firsthand the rapid progress on Magellan I and II. He helped organize the ESO/CTIO/LCO International Workshop, "Stars, Gas and Dust in Galaxies," held in La Serena in March and the conference "Gas and Galaxy Evolution" in honor of the 20th anniversary of the VLA, held in Socorro, N.M., in May 2000.

In April, **Wendy Freedman** gave an invited review at a meeting at the Space Telescope Science Institute and at the Johnson Space Center. She also gave colloquia at Stanford, Berkeley, and Cornell, and sat on the Caltech Visiting Committee for Math, Physics, and Astronomy, a committee chaired by Carnegie trustee emeritus **Charles Townes**. Carnegie trustee **Sandra Faber** was also a member of the committee. On April 17, she presented the Mathematical and Physical Sciences Distinguished Lecture in Astronomy at the National Science Foundation, entitled "Determination of the Hubble Constant, for better or worse." Wendy has been elected a Fellow of the American Academy of Arts and Sciences.

Embryology's Yixian Zheng won a nationwide competition to be appointed a Howard Hughes Medical Institute Investigator.

In March, **Steve Shectman** presented a paper summarizing the present status of the Magellan Project at the conference "Astronomical Telescopes and Instrumentation 2000," held in Munich, Germany.

Jason Prochaska attended the SPIE conference in Munich and gave an invited talk on chemical abundances in the damped Lyalpha systems.

Andrew McWilliam gave talks on the chemical composition of the galactic bulge and Sagittarius dwarf galaxy at Ohio State U. and at U. Washington.

Hubble Fellow **Scott Trager's** topic was "The timescale of galaxy formation: the stellar evidence" in invited lectures at the Institute for Theoretical Physics, UC-Santa Barbara, U. Hawaii, U. Texas-Austin, and UC-Irvine.

EMBRYOLOGY

In April, **Don Brown** chaired the International Advisory Board to the Wellcome/CRC Institute in Cambridge, U.K.

Marnie Halpern coorganized the Cold Spring Harbor zebrafish meeting held in April 2000. The front page of the March 15 *Baltimore Sun* featured an article about the Halpern lab.

Doug Koshland was elected to membership in the American Academy of Arts and Sciences.

Shikha Laloraya has taken a job as an assistant professor in the Department of Biochemistry, Indian Institute of Science, Bangalore, India.

On April 29, **Sofia Robb**, a research assistant in the Sánchez Alvarado lab, married Tom Turlington.

Alejandro Sánchez Alvarado and Brigitte Galiot cochaired the session on metazoan regeneration at the Society of Developmental Biology's 59th annual meeting in Boulder, Colo., in June 2000. He also was an invited speaker at the IX International Symposium on the Biology of Turbellarians in Barcelona, Spain, in June.

On Thursday May 4, Daniel Barbosa Fraker was born to **Daniela Drummond-Barbosa** and Russell Norton Fraker.

Postdoctoral fellow **Nicole Grieder** has returned to the Biozentrum in Basel, Switzerland, where she will continue her studies of *Drosophila* oogenesis.

PLANT BIOLOGY

Winslow Briggs presented a seminar, "Phototropin: a photoreceptor kinase mediating phototropism in higher plants," at the Stazione Zoologica, Naples, and at the universities of Rome, Lausanne, and Geneva. Winslow coorganized and spoke at the Gordon-sponsored Meeting on Photoreceptors and Signal Transduction held in Il Ciocco, Italy, April 30-May 5.

In January, **Chris Somerville** participated in a workshop at the Salk Institute to draft a 10-year plan for goals in plant genome research. The National Science Foundation has incorporated the document, entitled "The 2010 Plan," into its long-term research funding plan. Transcripts of Chris Somerville's lecture entitled "The scientific basis of plant genetic engineering," presented at a January symposium in The Hague and organized by U.S. Ambassador Cynthia Schneider on behalf of the State Department, can be found at http://www.usemb.nl/bioproc.htm. In February, Chris presented a talk at Cornell U. entitled "The next phase of the plant genome project." In March, Chris presented the Lemieux Lecture, "Genetic dissection of plant lipid metabolism," at U. Alberta. In April, he presented the Thornton-Masa Lecture, "The case for GMOs," at Colorado State U. Finally, in May Chris presented a seminar entitled "The rubber problem" at the Defense Research Agency in Washington, D.C.

In April, **Arthur Grossman** presented two seminars at Indiana U.: "Integration of environmental signals in the acclimation of cyanobacteria" and "The control of phosphorus deprivation responses in *Chlamydomonas reinhardtii*." **Devaki Bhaya** also presented a seminar at Indiana, "One small step: motility in cyanobacteria." On April 17, Art gave a seminar at Paradigm Genetics, hosted by former staff member **Neil Hoffman**.

In February, **Art Grossman** was granted U.S. Patent #6,027,900 for "Methods and tools for transformation of eukaryotic algae." Art was also awarded a $21,000 NSF bi-national grant (with Daniel Vaulot in Roscoff, France) for his proposal, "Analysis of

On May 9, the department hosted a meeting of the Bay Area Biosystematics Working group, organized by Brent Mischler (UC-Berkeley) and Chris Somerville. In a brief overview, Brent explained that this meeting, started in the 1930s, has its historical roots with Carnegie's taxonomists and geneticists during the time of Clausen, Keck, and Hiesey.

gene expression during acclimation of cyanobacteria to stress conditions."

Jo-Man Wang, a technician in Shauna's lab, and Yeu-Shyr Wu welcomed their son, Aaron, born April 11.

In March, **Sarah Fisher** joined the Somerville labs as a lab technician.

Anne Krapp and **Catherine Mueller**, Visiting Researchers from U. Heidelberg, arrived for a month's stay in March to collaborate with **Wolf Scheible**.

Mark Stitt (U. Heidelberg) arrived in March for a five-month sabbatical to work with Chris Somerville.

Rogene Gillmor is working in the Somerville lab as a volunteer.

Chris Henderson joined The Arabidopsis Information Resource group (TAIR) in March as an assistant programmer.

Trevor Swartz (UC-Santa Cruz) joined the Briggs lab as a postdoctoral research associate to do spectroscopic studies on phototropin.

In April, **Warren Nott** joined the Field lab as a lab assistant, and **Isabell Buttron** (U. Freiburg) joined the Ehrhardt lab as a visiting researcher.

Margaret Olney will be an assistant professor in the biology department at Colorado College this fall. Margaret will finish the summer at the Briggs lab to wrap up her thesis work.

Gundolf Kohlmaier, a visiting researcher in Chris Field's lab, left in February to return to U. Frankfurt.

George Wetherill was the recipient of the J. Lawrence Smith Medal and Prize of the National Academy of Sciences, awarded at the May meeting. The award recognizes recent original and meritorious investigations in meteoritics.

Ken Keegstra left after spending a three-month sabbatical with Shauna Somerville. **Pam Green** left after spending a six-week sabbatical.

TERRESTRIAL MAGNETISM

Sean Solomon was elected a member of the National Academy of Sciences on May 2 at the 137th annual meeting of the academy. Election to membership recognizes "distinguished and continuing achievements in original research." He was one of 60 new members chosen.

Former DTM research staff member **Albrecht Hofmann** was inducted as a Foreign Associate at the NAS meeting. Dr. Hofmann, one of 15 Foreign Associates elected to the academy last year, is director of the Max Planck Institute for Chemistry in Mainz, Germany.

Erik Hauri received the James B. Macelwane Medal from the American Geophysical Union at the Spring AGU Meeting. The medal "recognizes significant contributions to the geophysical sciences by an outstanding young scientist (less than 36 years of age)."

In April, **Selwyn Sacks** and **Alan Linde** visited the Montserrat Volcano Observatory with Barry Voight (Penn State). The objective was to determine the feasibility of initiating a collaborative program in which a small array of borehole strainmeters and seismometers would be installed on the island.

Vera Rubin visited the U. Illinois and Arizona State U. astronomy departments this spring, where she presented colloquia and visited with groups of faculty, students, and women in science. Former DTM postdoctoral fellows **Linda Stryker** and **David Burstein** are now at ASU, where Burstein is currently president of the university senate. In April, Rubin addressed the National Science Teachers Association in Orlando on the subject "Connecting to the Universe." Penn State-Lehigh Valley campus science faculty has named their academic award, to be presented annually, the Vera C. Rubin Award for Excellence. Rubin was the keynote speaker and presented the first award to astronomy student Kevin Gordon.

In March, **Alan Boss** delivered the George C. Benson Memorial Lecture, "Extrasolar planets," at Miami U. (Oxford, Ohio). In April, Boss reviewed the role of magnetic fields in fragmentation at the IAU Symposium 200: The Formation of Binary Stars, held in Potsdam, Germany. Boss described science goals for NASA's Terrestrial Planet Finder (TPF) at the Ball Aerospace/TPF Science Team Meeting, held at the Space Telescope Science Institute in Baltimore.

Sean Solomon chaired the External Advisory Committee for Geology and Geophysics at Rice U. in March, and the Earth and Environmental Sciences Directorate Review Committee at Lawrence Livermore National Laboratory in April. In May he delivered the first lecture in the Discoveries of the 20th Century series at the Smithsonian Institution in celebration of the 50th anniversary of the National Science Foundation. He also gave invited papers at the General Assembly of the European Geophysical Society in April and at the Fourth Conference on the Low-Cost Planetary Missions of the International Academy of Astronautics in May.

DTM attendees at the Lunar and Planetary Science Conference in Houston in March included **Alan Boss**, **Erik Hauri**, **Sean Solomon**, **George Wetherill**, and postdoctoral fellows **Satoshi Inaba**, **Stephen Kortenkamp**, and **Harri Vanhala**.

Alan Boss, **Sean Solomon**, **George Wetherill**, and postdoctoral fellow **Kenneth Chick** attended the First Annual Astrobiology conference, held at NASA Ames, Moffett Field, in April.

Paul Silver gave an invited talk at the annual meeting of the Seismological Society of America meeting in San Diego.

On March 29, **Paul Butler**, Geoffrey Marcy (UC-Berkeley), and Steven Vogt (UC-Santa Cruz) announced the first two sub-Saturn mass extrasolar planets at a NASA press conference. **Alan Boss** also spoke at the event. The story was carried in the *New York Times*, the *Washington Post*, *Science News*, and on CNN. The discovery paper for this work has been accepted by the *Astrophysical Journal Letters*. On April 21, Butler, Marcy, and Vogt announced planets around two metal-rich stars.

In March, **Paul Butler** gave the annual invited popular talk at the New York Center for Studies on the Origins of Life. In April, he gave the astronomy colloquium at U. Virginia and a plenary talk at the American Physical Society annual meeting. In May, he gave astronomy colloquia at the CIW Observatories and the Space Telescope Science Institute.

Jon Aurnou, a geophysical fluid dynamicist who received his Ph.D. from Johns Hopkins U., was appointed a postdoctoral associate in April.

Jocelyn Bell Burnell was the Merle A. Tuve Senior Fellow at DTM for the month of May. A radio astronomer and professor of physics at the Open University, England, she is best known as the discoverer of the first radio pulsars, subsequently shown to be rapidly rotating neutron stars. Dr. Bell Burnell visited DTM the week of May 8. She gave the DTM seminar and participated in a number of discussions with staff and postdocs during her stay.

Visiting Investigator **Suzan van der Lee** arrived in May for a month to work with David James and Paul Silver on upper-mantle structure under South

Shown (from left) on May 3 at a Broad Branch Road reception honoring Sean Solomon on his election to the National Academy of Sciences are NAS members Albrecht Hofmann and Carnegie's Ho-kwang Mao, George Wetherill, Solomon, Vera Rubin, Hatten Yoder, Maxine Singer, and Francis Boyd.

America and southern Africa. A former DTM postdoctoral fellow, she is now on the faculty at the Institut für Geophysik, Zurich.

Predoctoral Fellow **Sue Webb**, from the U. Witwatersrand, arrived in April for a two-month visit. She is continuing work begun last year with David James on combining southern African gravity, magnetic, and seismic data sets as part of the Southern Africa Seismic Experiment.

LeAnn Nicole Bartholomew was born on May 12 to machinist-instrument maker **Richard Bartholomew** and his wife**,** Loretta.

DTM/GL

Library Assistant **Merri Wolf** was elected to the board of directors of the Interlibrary Users Association in March. The Association is a 50-member cooperative organization of specialized libraries in the National Capital area.

Two rare 17th-century star charts were presented to the DTM-GL library by **Vera Rubin** in February. Prepared by the astronomer Johannes Hevelius of Danzig in 1686, the charts are prized for their beautifully engraved figures of the constellations and their elaborate corner decorations. Rubin also donated a biography of Hevelius containing a bibliography of his published works.

GEOPHYSICAL LABORATORY

In April, participants in the National Junior Science and Humanities Symposium visited

The DTM/GL library's 1914-era reading room was renovated this winter. Among the features of the renovation are furniture appropriate to the period, and historic artifacts. The space serves as a pleasant setting for quiet study and small meetings of researchers from both departments.

the Broad Branch campus. **Constance Bertka**, **Steve Shirey** (DTM), and **Hattten Yoder** led the students on a tour of the facilities and spoke with them about preparing for a career in science.

George Cody presented invited talks at Penn State on biogeochemistry at nanoscales using soft x-ray microscopy, and at George Washington U. on geochemical roots of life. He also presented a poster at the Astrobiology Conference at the NASA Ames Research Center.

Gözen Erten (Georgetown U. Medical Center) has been appointed a Visiting Investigator. Dr. Ertem will conduct research with Bob Hazen on the selectivity of asymmetric crystalline minerals towards chirality in biological oligimers.

Wes Huntress has been elected to the board of directors of the Association of Universities for Research in Astronomy, Inc. (AURA) for a three-year term, effective July 1, 2000, through June 30, 2003. In April, Wes received the Federal Design Achievement Award for the Mars Pathfinder Mission. This award is given in recognition of contribution to excellence in design for the federal government. He has also been elected an academician in the International Academy of Astronautics and delivered the inaugural address, "Discoveries: a basis for new challenges," to the academy on May 9 in Washington, D.C.

Wes Huntress has been teaching a graduate-level course on astrochemistry at the BBR campus. The course examines chemical evolution from atoms in the interstellar radiation field to complex organic molecules and aggregates in the early solar system.

Wes Huntress and **Marilyn Fogel** were hosts to the Workshop on Life Detection, held April 25-26 at Carnegie's administration building. The workshop was sponsored by the National Research Council and responds to NASA's request for a comprehensive and interactive workshop that updates new techniques for detecting extraterrestrial organisms and their biosignatures. A dinner party was held at GL on April 25; many of the attendees toured the lab afterwards.

Robert Hazen was the Humana Distinguished Visiting Professor at Centre College in Danville, Ky., where he presented a series of five lectures on aspects of the origin and evolution of life. He presented two keynote lectures at a symposium at McPherson College, Kans., on evolution and creationism. Hazen also presented seminars on minerals and the origin of life at Stanford U., U. Connecticut, the Learning in Retirement Institute of George Mason U., and jointly to Carnegie's Department of Embryology and Johns Hopkins U.

Russell Hemley gave talks at Ohio State U., the Center for Solid State Sciences (Arizona State U.), UC-Santa Cruz, and at the Max-Planck Institute, Stuttgart. Hemley also attended a meeting at the Institute for Study of the Earth's Interior in Misasa, Japan. In March, he gave an invited talk at the Physical Chemistry at High Pressure Symposium of the American Chemical Society. He was the co-convenor of the High Pressure Neutron Scattering Workshop, Argonne National Laboratory, in April. In May, he gave an invited talk at the Verkin Institute 40th-anniversary meeting in Kharkov, Ukraine.

Charles Prewitt attended the Experimental Mineralogy, Petrology, and Geochemistry Conference in Bergamo, Italy, and presented an invited paper, "Crystal chemistry of Ca/Sr metasilicates and metagermanates."

As a graduate of U. Chicago, **Hatten Yoder** received their Professional Achievement Award for his distinguished record of professional accomplishments and leadership, which have reflected credit upon the university and its alumni.

GL's **Matthew Wooller** and **Marilyn Fogel**, former fellows **Sue Ziegler** (U. Arkansas) and **Mark Teece** (SUNY-ESF), and Visiting Investigators **Noreen Tuross** (Smithsonian Inst.) and **Diane O'Brien** (Stanford U.) presented papers on various aspects of ecological research at the 2nd Isotopes in Ecology Meeting held in Braunschweig, Germany. All of their research was conducted on GL's new isotope mass spectrometer.

Doug Rumble's recent Visiting Investigators are Hide Masago (Tokyo Inst. Technology), David Gorges (U. Lausanne), Uwe Wiechert (ETH-Zurich), and Being Change (Chinese Academy of Geological Sciences, Beijing).

In April, **Jie Li, Yingwei Fei,** and **Bill Minarik** journeyed to Kobe, Japan, to use the Spring-8 synchrotron facility. They were joined there by former GL researchers **Kei Hirose** and **Mike Walter**. The team managed to complete 10 successful multianvil runs in a row within four 24-hour days. After the experiments, they were hosted at the home of Mike, **Pru Foster** (formerly at DTM), and their son Dakota. Pru also works at Okayama U.

Yangzhang Ma and his wife Fengru Wu welcomed Darwin Bolun to their family, born March 31.

David James (center), with technician Pat Ryan (left) and professor Douglas Toomey (right) (U. Oregon), examine seismic field data aboard the fishing boat, *Golondrina,* in the Galapagos Islands. Ryan, James, Toomey, and Kristen James (photographer) spent three weeks in the Galapagos in late March and early April servicing the 10 Carnegie broadband portable stations of the IGUANA Seismic Project in the Galapagos Islands. The project, of which professor Toomey is PI, is a joint venture between the U. of Oregon and DTM.

In Brief...

Capital Science Lecture Series 2000-2001

The speakers for next season's Capital Science Lecture Series are listed below. All lectures are on Tuesday evenings starting at 6:30 p.m. at the Carnegie Building, 1530 P St., N.W., Washington, D.C.

October 3, 2000
Kenneth Nealson
California Institute of Technology
Early life microbiology

October 24, 2000
R. Paul Butler
Department of Terrestrial Magnetism
Extrasolar planets

November 28, 2000
Sallie Watson Chisholm
Massachusetts Institute of Technology
Phytoplankton and global change

January 30, 2001
Neta A. Bahcall
Princeton University
Cosmology

February 27, 2001
Cindy Lee Van Dover
The College of William & Mary
Hydrothermal vent biology

March 20, 2001
William T. Newsome
Howard Hughes Medical Institute and Stanford University Medical Center
Neuronal plasticity

April 17, 2001
S. George Philander
Princeton University
Why global warming is controversial

* Schedule subject to change

Photo by Anice Hoachlander

Centennial News

Planning for the Carnegie Centennial Exhibition is well under way. This show, which will celebrate a century of Carnegie science by displaying a range of images and objects from the institution's past, will be installed on the second floor of the administration building from December 2001 through May 2002. It will be open to the public as well as to invited groups.

We are planning a number of programs and lectures to accompany this exhibition. While attracting visitors to the show, these events will also provide opportunities to explore in greater depth various issues relating to Carnegie science–past, present, and future.

YOU CAN HELP! Are you aware of any academic or professional meetings scheduled to be held in D.C. during the time of the exhibition? We are eager to communicate with a range of audiences, including those without–as well as those with–scientific training. If you know of such a group, please contact Margee Hazen at mhazen@pst.ciw.edu.

Carnegie Now a Triple-A Institution

In April, Moody's upgraded Carnegie's long-term debt rating from Aa1 to Aaa. Only six other not-for-profits and 15 universities and colleges have attained this same high rating. The institution's unrestricted financial resources are more than 10 times greater than the debt, "a level surpassed by few organizations even in the Aaa category," says Moody's. Other reasons the rating was upgraded include insulation from the student market and other economic risks, and manageable future borrowing plans. Moody's sees a bright future for the institution, expecting it to continue "its powerful financial position indefinitely."

Carnegie to Bring the New Science of Astrobiology to Classrooms Worldwide

As a part of NASA's Astrobiology Institute, CASE will launch an interactive educational Web site dedicated to the new science of astrobiology–the study of how life originated and thrives on Earth and how we may find it elsewhere. The site is geared to elementary and middle school teachers and students. The content, which will appear on the site over the next two years, will be based on three themes drawn from astrobiology. The first theme will focus on Earth's environments and chemistry and will lead Web surfers to the second theme–life in space. The third theme will use the information from the other two segments to determine what components and conditions are really needed for life to arise and thrive anywhere. The Web site will be available later this summer at www.ciw.edu/leaf.

Where to Watch Plants at Work

David Ehrhardt at Plant Biology has unveiled a unique Web site where the dynamic processes in live plant cells can be viewed with the aid of time-lapse imagery. This imaging is made possible by introducing a green fluorescent gene from a jelly-fish into *Arabidopsis thaliana* and viewing the results with confocal microscopy. To see the images of plants at work on the evolving site, go to http://deepgreen.stanford.edu.