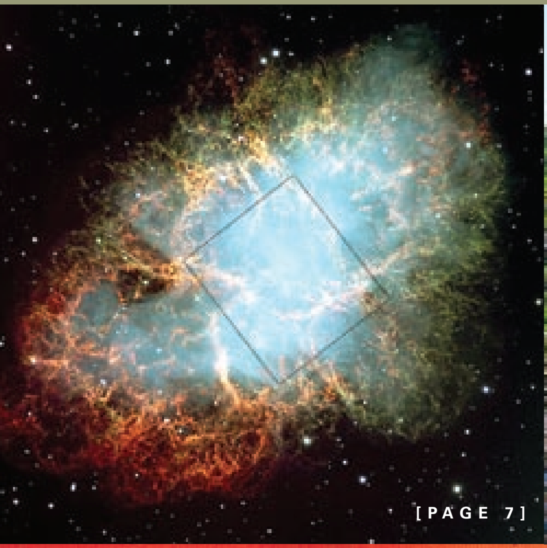
SPECTRA

THE NEWSLETTER OF THE CARNEGIE INSTITUTION (SUMMER 2002

Opening New Horizons for Scientific Research



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CASE/ FIRST LIGHT

Women in Science
How Carnegie Compares

Ninety-eight years ago—16 years before women won the right to vote—the fledgling Carnegie Institution awarded its first grant to a woman scientist. Her name was Nettie Stevens. Interestingly, Stevens, a biologist, studied gender differences. Her work revolutionized our notion of what determines sex by showing that the X and Y chromosomes are involved, changing conventional thinking that environment was the cause. Since that time, Carnegie has fostered the genius of a succession of extraordinary women—geneticists Barbara McClintock and Nina Fedoroff, embryologist Elizabeth Ramsey, archaeologist Anna Shepard, and astronomer Vera Rubin, to name a few.

In 2001, the National Research Council issued a report about women scientists and engineers in the workforce. It caught my eye, and I wondered how Carnegie compared with the national figures.

In 1995—the last year covered by the report—women Ph.D.s made up 21% of the science and engineering workforce. In the life sciences, 26% were women. I am pleased that the departments of both Plant Biology and Embryology are well ahead of this norm: 44% of the current Staff Members, Staff Associates, and adjunct staff at Plant Biology are women, while at Embryology, 33% of the Staff Members and Associates, and 55% of the fellows and postdoctoral associates are female. Excellent numbers.

Nationwide, there are proportionately fewer women in the physical sciences. They represented just 10.5% of the total in 1995. With the advent of the newest Staff Members at the Department of Terrestrial Magnetism (DTM), women now make up 14% of the senior staff there, but only about 7% at the Geophysical Laboratory (GL). Despite the latter figure, the future at GL is very promising—18% of our Carnegie fellows and postdocs there are female. It is the postdocs and fellows at the Observatories who also tell the tale of what the future holds in astronomy. Nationally, only 7.3% of working astronomers were women in 1995—a figure on a par with the senior Observatories staff. Today in Pasadena, however, 33% of the postdocs and fellows are female.

The gender balance in science is improving across the country, and especially at Carnegie. The encouraging trends we see at the institution are a tribute to the work of Maxine Singer and each of the department directors. But we shouldn't be too surprised with our standing. Since the beginning, we have supported extraordinary individuals, no matter who they are. We have frequently gone against convention to pursue this central mission; it is the foundation of all we do.

—**Tom Urban**
Chairman

Trustee News

The board of trustees met at the St. Regis Hotel in Washington, D.C., on May 2 and 3. In addition to the full board, the Finance, Employee Affairs, Development, and Nominating Committees met. The board elected three new trustees: Freeman H. Hrabowski III, president of the University of Maryland, Baltimore County; Hatim A. Tyabji, a pioneer in the wireless communications industry; and William K. Gayden, chairman and CEO of Merit Energy Company *(see story below)*. Kazuo Inamori, a trustee since 1990, became a trustee emeritus.

As part of the meetings, Gus Oemler, director of the Observatories, talked about the Observatories Enhancement Fund, and astronomer Alan Dressler gave an update on instrumentation for the Magellan telescopes. Bjørn Mysen of the Geophysical Lab discussed the latest plans to renovate the experiment building on the Broad Branch Road campus *(see page 11)*. Wes Huntress, director of the Geophysical Lab, highlighted the status of the high-pressure facility (HP-CAT) at Argonne National Laboratory, and Chris Field, director of Global Ecology, described the new building for the new department. At dinner Thursday evening, Sean Solomon, director of the Department of Terrestrial Magnetism, gave a presentation about the MESSENGER Mission to Mercury. Solomon is Principal Investigator for the project and discussed the science, engineering, and organizational challenges the mission presents. The meeting concluded on Friday with presentations from two new Staff Members—Zhi-Yong Wang from Plant Biology and Greg Asner from Global Ecology. Wang talked about his research on the plant hormone brassinolide. He is investigating how the hormone is involved in conveying information about a plant's environment—particularly light—to regulate its growth and development. Asner began his presentation with a summary of the field of global ecology. He then talked about what his lab does specifically, focusing on his work in the Amazon Basin, where his group is trying to link human activities to remotely sensed properties of plants. Asner uses satellite data and extensive fieldwork in his research *(see page 11)*.

The trustees passed the following resolution in recognition of Carnegie's centennial:

"That in this year of the centennial, the Board expresses its deepest appreciation and gratitude to the men and women of Carnegie science. Over the course of one hundred years, their passion for discovery, supreme ingenuity, and unyielding dedication to the truth have blazed a path of enlightenment that fulfills the dream of our founder: 'to encourage, in the broadest and most liberal manner, investigation, research, and discovery, and the application of knowledge to the improvement of mankind.'"

Telescopes for Biologists?

Alan Dressler, Staff Member at the Observatories, kicked off the grand finale to the centennial celebrations at the Carnegie Evening on May 3. His hour-long talk, "Telescopes for Biologists?" presented a succinct overview of the entire history of astronomy—including a lesson on optics—that provided the context for understanding what astronomers are doing now to decode the secrets of the universe and what new devices and research are planned for the future. Dressler discussed some of the big questions in astronomy today, including deciphering how galaxies were assembled at the farthest reaches of time, determining the composition of the earliest generation of stars, and finding and analyzing extrasolar planets. He also gave the audience a preview of the future, which will feature the Next Generation Space Telescope, enormous (20-meter-diameter and perhaps larger) land-based telescopes with adaptive optics systems, and NASA missions in the search for life. This last topic, Dressler predicted, is likely to dominate astronomy for decades to come. In particular, he explained how programs such as NASA's Terrestrial Planet Finder and Life Finder are linking a broad array of scientific disciplines to answer the centuries-old questions: Are we alone, and how did we get here? Dressler's talk provided a perfect overview for the discussions the following day at the All-Carnegie Symposium *(see page 6)*.

Alan Dressler at Carnegie Evening.

Carnegie Welcomes Three New Trustees

The board has approved the appointment of three new trustees: Freeman H. Hrabowski III, president of the University of Maryland, Baltimore County (UMBC); Hatim A. Tyabji, formerly chairman and CEO of Saraide, Inc.; and William K. Gayden, chairman and CEO of Merit Energy Company.

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Welcome

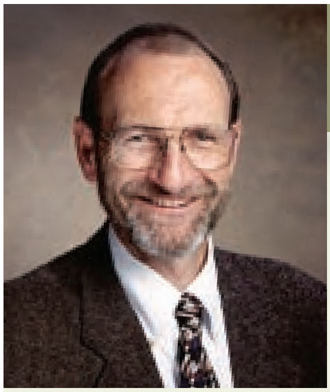
Freeman H.Hrabowski, a mathematician and educator, became president of the university in 1992. He graduated with highest honors in mathematics from Hampton Institute at the age of 19 and received his Ph.D. in educational statistics/administration from the University of Illinois at the age of 24. After 10 years as a professor, dean, and vice president at Coppin State College, he was recruited in 1987 to become vice provost at UMBC. Hrabowski has changed the face of the UMBC campus, transforming it from a school that mostly appealed to locals into a U.S. leader in producing African Americans who earn their Ph.D.s in engineering and science. This accomplishment has come in large part through his creation of the Meyerhoff Scholarship Program, which was established in 1989 to combat the shortage of African Americans in these technical fields. It was named for Baltimore philanthropists Robert and Jane Meyerhoff, who gave the school the initial endowment. The rigorous program started out targeting promising African American men. It now finances and trains about 50 mostly minority students a year, who come from all over the country to prepare for careers in science and engineering. The program is based on discipline, high expectations, intense mentoring by instructors and fellow students, learning what it means to work hard, and promoting the notion that "it's cool to be smart." Hrabowski is coauthor of the books *Beating the Odds: Raising Academically Successful African American Males* and *Overcoming the Odds: Raising Academically Successful African American Young Women.* He also serves on a broad range of boards in the public and private sectors.

Welcome

Hatim A. Tyabji, "a pioneer in the field of wireless data technology," came to the U.S. from India in 1967. He received his M.S. in electrical engineering from the State University of New York at Buffalo and an M.B.A in international business from Syracuse University. Tyabji's career began at Sperry Corporation, which is now Unisys. In 1986 he became president and CEO of VeriFone Inc., a leader in the electronic payments industry. The company was acquired by Hewlett-Packard in 1997, and in 1998 Tyabji became the founding chairman and CEO of Saraide, a San Francisco–based company devoted to marrying wireless communications and the Internet. He brokered a deal to sell Saraide to InfoSpace.com in 2000. Tyabji serves on a number of boards, including those of Ariba, Best Buy, eFunds, PubliCard, and SmartDisk. He is chairman of the board of the Datacard Group, a member of the Dean's Council at the State University of New York, and a member of the advisory board of the School of Business at Santa Clara University.

Welcome

William K. Gayden is the founder and CEO of Merit Energy Company, a private oil and gas development and production enterprise, in Dallas, Texas. He received a degree in finance from the University of Texas at Austin in 1964, then spent 20 years at Electronic Data Systems (EDS). He held many senior positions at EDS, including senior vice president of corporate development and president of EDS World Corporation. He was a member of the board of directors from 1972 until the company was sold to General Motors—a sale that he negotiated. Gayden went on to become president of Petrus Oil. After spending three years reorganizing and expanding its operations, he engineered its sale to Bridge Oil Limited. He founded Merit in 1989. Among his affiliations, Gayden is a director of Perot Systems Corporation, which is an international technology services provider. He also serves on the board of directors of Harte-Hanks and the King Ranch, Inc.

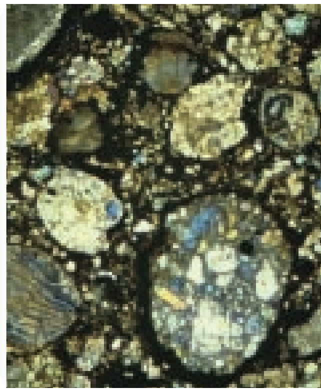


Christopher B. Field, new director of the Department of Global Ecology.

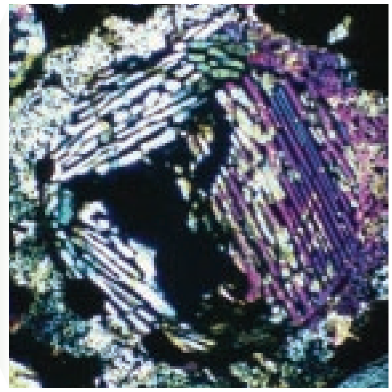
It's Official!

The trustees approved Christopher Field to be the first director of Carnegie's new Department of Global Ecology, effective July 1, 2002. Field, who has been serving as interim director of the department, has been with Carnegie since 1984, when he became a Staff Member at the Department of Plant Biology. A plant ecophysiologist, his research ranges in scale from observing the effects of individual plant species on the function of ecosystems to noting the effects of vegetation on global climate. Field has conducted fieldwork across the Americas, Asia, Africa, and Australia, in terrain encompassing rain forests and deserts. His research has two aspects—modeling plant responses to different ecosystem conditions, and experimentally observing what happens to plants under different conditions. The models he and colleagues have developed simulate ecosystem exchanges of carbon, water, and energy at the global scale. They use surface data on climate and soils, satellite data on vegetation type and canopy development, and functional generalizations from physiology and ecology. The information helps test hypotheses to understand the future status of terrestrial ecosystems, especially the responses to and influences on global change factors, such as an increase in atmospheric carbon dioxide. On the experimental side, he and his colleagues are currently using California grasslands as a model for understanding ecosystem responses to warming, increased atmospheric CO_2, increased nitrogen deposition, and altered precipitation.

The little lumps in this cross section of a chondrite—an unprocessed type of meteorite—are chondrules, which are less than 1 millimeter across.



The higher magnification of the chondrules in this image allows a crystal pattern, composed of blue and white crystals surrounded by a black circle, to be seen at lower right.



This is a close-up of a chondrule, less than a millimeter across. Olivine crystals appear as parallel bars. Fine-grained dust, collected after the chondrule formed, surrounds the chondrule.

(Images courtesy Harold C. Connolly, Jr.)

SHOCKING EXPERIENCE In Planetary Formation

Searching for Earths around other stars is one of the most urgent quests in science today. But to find out what conditions are necessary for these bodies to form, researchers must first solve the mystery of how our own Earth arose. Tiny, millimeter-size spheres of melted silicate rock called chondrules—the dominant constituent of meteorites—may hold the clue to this puzzle.

Steven Desch, a Carnegie Fellow at the Department of Terrestrial Magnetism and a member of NASA's Astrobiology Institute, with Harold C. Connolly, Jr., of CUNY-Kingsborough College, published a new model in the March issue of *Meteoritics and Planetary Science* that has made huge strides toward understanding chondrule formation and thus understanding what went on in our early solar system. It also helps answer a series of problems that have plagued theoreticians for years. The model determines how chondrules melted as they passed through shock waves in the solar nebula gas. They changed from fluffy dust to round, compact spheres, which altered their aerodynamic properties, allowing them to grow larger. Since this process would have occurred early in the solar nebula's evolution, the results are consistent with the common idea that chondrule formation was a prerequisite to the formation of planets.

"This model may be the key that unlocks the secrets of the meteorites," says Desch. "It is the first model detailed enough to be tested against the meteoritic data, and so far it has passed every test." Based on the evidence, scientists know that at the time of formation chondrules reached peak temperatures of 1800 to 2100 K for several minutes; that they almost melted completely; and that they cooled through crystallization temperatures of 1400 to 1800 K at rates slower than 100 K/hr, which kept them hot for hours. To prevent the loss of iron from the silicate melt, pressures had to be high—greater than 0.001 atmospheres—which is orders of magnitude higher than pressures expected in the nebula. A few percent of the chondrules stuck together while they were still hot and plastic. These "compound chondrules" tend to be more completely melted and to have cooled faster than the average chondrule.

Satisfying all of the known conditions simultaneously has been a challenge to theorists. A variety of mechanisms have been proposed over the years, but none of the ideas has been able to calculate cooling rates precisely enough to match what is known about meteorites.

The model proposed by Desch and Connolly exactly correlates the cooling rates of chondrules with physical conditions in the solar nebula and includes several previously ignored effects, such as dissociation of the hydrogen gas by the shock wave, the presence of dust, and especially a precise treatment of the transfer of radiation through the gas, dust, and chondrules. This transfer of radiation has to be calculated accurately, since the gas and chondrules cool only as fast as they can escape the intense infrared radiation coming from the shock front. With this effect included, typical cooling rates are 50 K/hr, which is exactly in line with what is known about the average chondrule. Moreover, Desch and Connolly predict a correlation with the density of chondrules: regions with more chondrules than average will produce chondrules that are more completely melted and cooled faster. This is because in dense regions radiation from the shock front cannot propagate as far before being absorbed, and therefore chondrules can escape the radiation from the shock front more rapidly. Compound chondrules are overwhelmingly produced in regions with high chondrule densities, so the extra heating and faster cooling of compound chondrules is easily explained by the model. Since the time a chondrule spends in a semimelted, plastic state is also calculated, even the frequency of compound chondrules can be determined— satisfying another key condition. Finally, shocks compress the gas to pressures orders of magnitude higher than the ambient pressure, which is another key requirement that has not been met before.

Desch and Connolly do not specify the source of the shock waves, but they do identify gravitational instabilities as a likely candidate, assuming the solar nebula protoplanetary disk was massive enough. And there are sound theoretical reasons for believing it was. Observations of other protoplanetary disks, in which planets are forming today, indicate that sufficiently massive disks may be common. If shock waves triggered by gravitational instabilities are taking place in other protoplanetary disks, then the odds of chondrules melting and planets forming—including Earths around other stars—are greatly increased.

The All-Carnegie Symposium

A Science Sampler

The last—and first—All Carnegie Symposium was in October 1994. It was a two-day event, entitled “From Galaxies to Genes: Evolutionary Processes.” Some 80 Carnegie scientists participated, and eight researchers made presentations. By contrast, the second institution-wide symposium, “Connecting the Earth’s Physical and Biological Components,” which took place this May 4, drew twice the crowd and featured 17 scheduled speakers. It was also the grand finale for the centennial celebrations. Staff Members, Staff Associates, and postdoctoral associates and fellows from all of the departments participated.

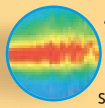
The scientific presentations were grouped into four sessions: Constructing the Earth; Energy and Materials for the Start of Life; The Evolving Planet; and The Continuity of Life. Four of the six department directors chaired the sessions, and the other two directors—Chris Field of Global Ecology and Allan Spradling of Embryology—gave talks. Summaries of the presentations follow.

Constructing the Earth

"I tell my wife that her fresh glass of water isn't so fresh. It has atoms in it that are 14 billion years old."

Andy McWilliam of the Observatories was the first speaker. His talk, "Stars and the Formation of the Elements," emphasized the fact that all of us—and all of life—contain products from the nuclear physics of massive stars that went supernova—the spectacular explosions that eject the elements found in the universe today. McWilliam provided an overview of the process of element recycling and synthesis that started with the Big Bang. The lightest elements—hydrogen, helium, lithium, beryllium, and boron—were produced by that event. Heavier elements such as silicon and carbon, which are the grist for planets and for life, came later via nuclear processing inside massive stars. McWilliam made it clear how important stars are to the creation of life when he said that the iron and calcium atoms in our bodies come from one million to tens of millions of supernova events.

Sleuthing solar systems through dust

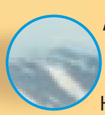


Alycia Weinberger, the newest member of the DTM research staff, looks for analogs to our early solar system by exploring the dusty disks surrounding young stars similar to our early Sun. She began her talk, "Young Stellar Disks as the Sites of Planetary Evolution," with a summary of the planetary formation process—from a collapsing protostar all the way to the construction of terrestrial planets. Young disks have lots of dust and gas encompassing and obscuring the central star. Fortunately, these particle shrouds radiate in the infrared (IR). Weinberger and colleagues image disks in the IR and pay particular attention to the structure they exhibit. The way a disk is sculpted can provide clues to the presence of planets. Weinberger used Beta Pictoris as one of her examples. She showed that the inner disk surrounding the star is warped, and suggested that this may have resulted from perturbations exerted by an orbiting object. In addition to analyzing disk structure, Weinberger looks at the chemistry of these disks at varying distances from the central star. This spectral analysis can reveal a lot. It tells researchers how materials are formed and distributed during early planet formation, and therefore how they came to be incorporated into young planets.

"Forty thousand tons of extraterrestrial material fall on Earth each year."

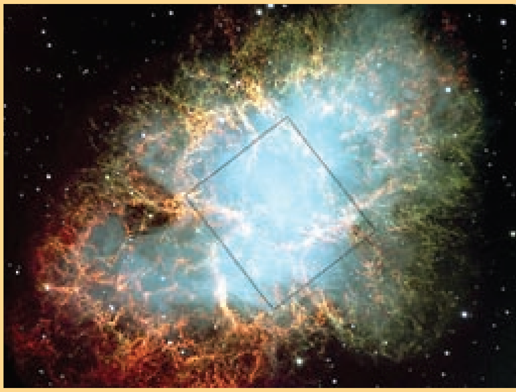
And this cosmic debris provides scientists, such as Conel Alexander of DTM, with a bounty of information about galactic and solar system formation and perhaps the origin of life. Alexander's talk, "Materials for Solar System Formation," focused on chondritic meteorites—the oldest and most abundant type of meteorites—and what they can tell us about early solar system evolution. Alexander began his presentation with a chondritic anatomy lesson, pointing out the constituents of the rocks that tell us about solar system formation, and of those that tell us about galactic evolution and the interstellar medium. He also talked about the role meteorites may have had in the origin of life. Analysis has shown that they contain more than 70 amino acids and three of the nucleic acids in RNA and DNA. Many amino acids are so-called chiral molecules, meaning that they come in two mirror-image forms, designated left- and right-handed. It is the left-handed forms that are almost exclusively present in living organisms and that are, in some instances, slightly more abundant in meteorites. With these objects constantly bombarding Earth, they may have ferried the precursors of life here. Alexander observed that "if they played a role in life in our solar system, then maybe they play a role in life elsewhere."

"The lead story on the evening news was that Hekla would erupt in 20 minutes."

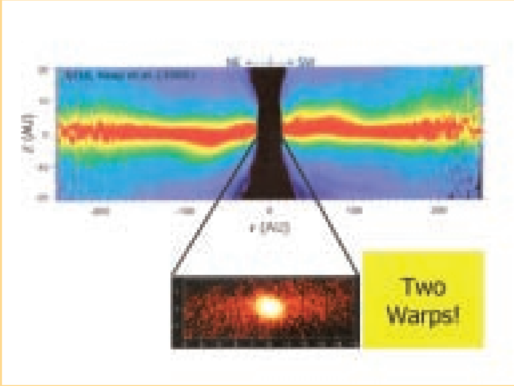


Alan Linde's talk, "Volcanic Activity," reflected how his work at DTM has shifted over the years from earthquakes to volcanoes. He provided a context for his presentation by reviewing Earth's plate tectonics and the worldwide distribution of earthquakes and volcanoes. He then described a device, called a strainmeter, developed years ago at DTM by Selwyn Sacks and colleagues to study earthquakes. Compared with displacement measuring techniques, such as GPS, strainmeters are able to detect smaller movements, perhaps as deep as 30 km below the surface. They have been installed in Iceland, Japan, California, and elsewhere. Linde provided vivid examples of how strainmeters work and what they can tell us about the interior by using examples of two active volcanoes—Oshima, in Japan, and Hekla, in Iceland. His Icelandic example compared an eruption in 1991 with one in 2000. The plots were remarkably similar, as the volcano went through virtually the same paces the second time around. This information allowed Linde's Icelandic collaborator to issue a warning to the area population just minutes before the volcano blew and just in time for the evening news. As Linde concluded, "Finding out how the physics of volcanoes work has a nice by-product—an early-warning system."

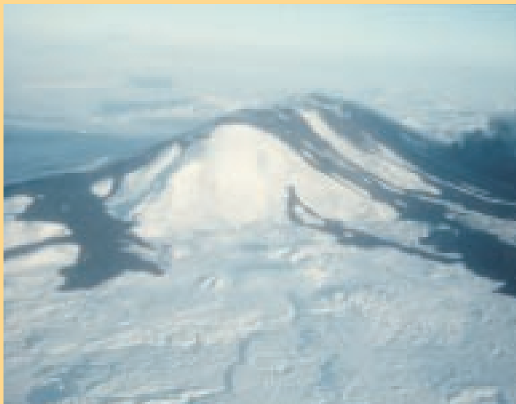
The elements in the universe today are a result of the nuclear processing in massive stars that explode as supernovas, explained Andrew McWilliam. The Crab Nebula, pictured here, is an example of a supernova remnant. *(Courtesy European Southern Observatory and the Space Telescope Science Institute.)*



The radiation-reflecting dust around the star Beta Pictoris exhibits warping, which, says Alycia Weinberger, may indicate the presence of planets. *(Courtesy Alycia Weinberger.)*

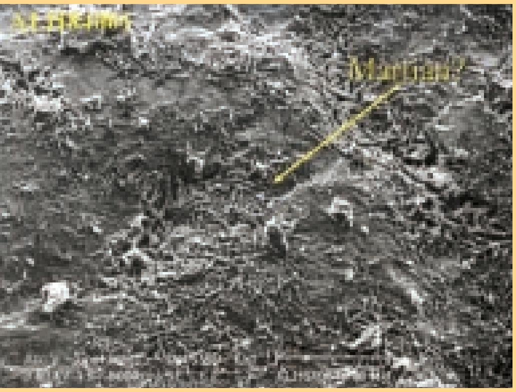


Alan Linde described techniques that detect earthquakes and volcanoes. He talked about the Hekla volcano in Iceland, shown here erupting in 1991. *(Courtesy Alan Linde.)*

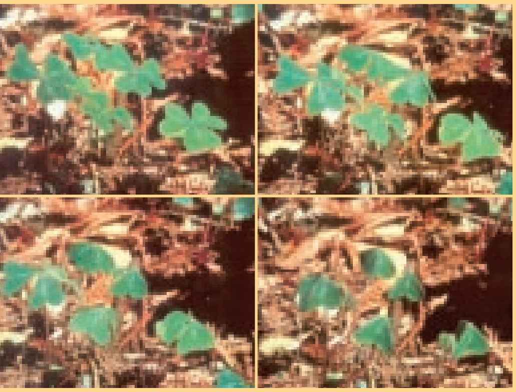


Energy and Materials for the Start of Life

George Cody described his work suggesting that base metals could have provided the catalyst needed in the emergence of life. *(Courtesy George Cody.)*



Andrew Steele discussed Martian meteorites, such as ALH84001, and how they are being analyzed to determine the source of their organics. *(Courtesy Andrew Steele.)*



Photosynthetic organisms change their light-harvesting machinery to adjust to different light conditions, said Arthur Grossman. Under high light, these *Oxalis* leaves bend to reduce the available surface area for light absorption. *(Courtesy Arthur Grossman.)*

"There is another way. It's heresy."

With the proliferation of extrasolar planet discoveries in recent years, increasing attention has been focused on how these systems came to be. Alan Boss, formation theorist at DTM, looked at the conventional beliefs on the topic and described his own theories with his talk, "Building the Solar System." The generally accepted model for giant planet formation is core accretion, in which comet-size particles "bang" together, eventually accreting into planetary cores. This model is very slow, so slow that it takes longer to grow a core than the lifetime of the nebular gas from which our solar system and giant planet atmospheres formed. To deal with this wrinkle and others, Boss described his disk instability model. It requires only about 1,000 years for the beginning of core formation—plenty of time for the gas to remain and be assimilated into atmospheres. Boss discussed the physics involved: small instabilities in the disk cause the gas and dust to break up, forming first spiral arms and then clumps, which could then turn into planets. He also explained how the gravitational effects from a newly formed Jupiter and Saturn could have sped up the formation of the terrestrial planets. Finally, he mentioned that the UV radiation process in the protoplanetary disk could have yielded the prebiotic chemistry leading to later life.

"I drew the short straw, so I have to talk about the origin of life."

George Cody of the Geophysical Lab described the work he has been doing on the emergence of protometabolism, before the advent of RNA. For life as we know it to emerge there has to be a viable route for elements such as carbon, nitrogen, and phosphorus to be metabolized by organisms. His presentation, "Carbon, Minerals, and the Origins of Life," began with a summary of when and where life arose on Earth. The oldest known crystal contains evidence that the planet was hospitable to life as early as 4.4 billion years ago. Other evidence suggests that hyperthermophilic organisms, such as those that live in high-temperature conditions at deep-sea vents, could have been the earliest life forms. Cody explained that for such creatures to arise, an emergence from a world of chemistry to one of biology would have had to take place and some kind of catalyst would have been required to promote sophisticated carbon and nitrogen fixation. His research in mineral catalysis under deep-sea conditions has shown that base metals, such as iron, nickel, and cobalt, which would have been readily available in the deep-sea environment, could have provided the catalyst needed in a protometabolism. He ended his talk with a caution that complex organic chemistry doesn't necessarily equal life.

Martians, Martians everywhere, or are they?

Andrew Steele, the newest Staff Member at GL, gave a lesson on detecting extraterrestrial life and recognizing frauds. His talk, "How to Spot a Martian," explored techniques that have been used to search for life on Martian meteorites, described their results, and predicted what the future holds in this area. Steele showed a spectacular array of images that made it clear that it isn't just the structure of fossil remains that can indicate the presence of microbial life. The biochemistry, chemistry, and context of the samples must be considered too. He pointed out that meteorites are subject to contamination by organisms on the Earth and described the five techniques that are used now to unravel what a sample contains. Of eight meteorites that have been analyzed, terrestrial organisms and organics have been found on all of them, including one bacterium that normally lives in the human eyebrow. Steele also discussed technical advances that are on the horizon, including technology developed for DNA analysis such as fluorescent probes and protein chips. He ended his talk by saying that meteorites will continue to be important sources of information, but that robotic missions to various celestial bodies and manned missions to Mars would significantly advance the search.

"Let there be light."

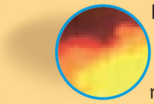
Maybe God created life and the creationists are right, said Arthur Grossman of Plant Biology as he introduced his talk, "The Diverse Responses of Photosynthetic Organisms to Light." As the audience blanched, he pointed out the simplicity and paradoxical nature of the entire seven-day affair and then eased into the serious part of the presentation. Grossman described the dual nature of light—its particle and wave properties—and then talked about its biological duality with respect to photosynthetic organisms. Plants need light for photosynthesis and carbon fixation, but too much can lead to death as a result of photo-oxidative processes. How then do plants regulate their light intake? Grossman described research on light energy use in cyanobacteria, green algae, and vascular plants. He presented some fascinating images from experiments that demonstrate how cyanobacteria move to and from light to regulate their light intake, and how they can optimize the light-collection machinery relative to the wavelengths of light in the environment. He also showed how plants can bend toward light under low light conditions and change leaf orientation and chloroplast position within cells under high light intensity to minimize light absorbance. But despite these strategies, plants may still absorb dangerous amounts of light energy. Grossman talked about how excess absorbed light energy can be efficiently dissipated as heat through a process that occurs within the light-harvesting structures themselves. He concluded by saying that specific photoreceptors and intracellular redox conditions supply the signals that allow photosynthetic organisms to acclimate to different light environments, and that morphological, physiological, biochemical, and biosynthetic changes must work in concert to cope with light's dual nature.

The Evolving Planet

"Life is tough."

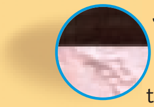
Ken Nealson, a geobiologist and the Cecil and Ida Green Senior Fellow, at GL, studies the Earth as a means of advancing the search for life on Mars. His talk, "Energy Flow: A Guide to Life Detection," focused on looking for life in and around rocks and understanding how energy is processed in a variety of living systems. This information can be used to develop biosignatures—chemical signals indicating the presence of life. Nealson pointed out that some life is nonconformist and shouldn't be overlooked when looking for life elsewhere. There are microbes, for instance, that eat and breathe rocks. They consume sulfides and iron, ammonia, and manganese, and breathe metal oxides. Nealson presented an energy scale of fuels and oxidants and ranked them in terms of their relative energy potential for life forms. As an example, organic carbon, which is necessary for most life on Earth, has lots of energy. He then gave two examples of the constituents of stratified lakes and basins to show what chemicals make the best biosignatures. Although oxygen topped the list, metals such as manganese and iron oxide are also important life indicators. Nealson closed with "Ken's Laws of Life Detection": Know your planet, use non-Earth-centric approaches, and keep an open mind.

What does the core of the Earth have to do with life on the surface?



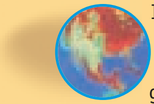
Erik Hauri of DTM explained just that with his talk, "The Mantle Convection Connection." He began his presentation describing the formation of the Earth. As particles from the early solar nebula accreted, the volatile elements—hydrogen, carbon, nitrogen, and sulfur—rose to the surface and partially escaped while the remaining elements formed the solid Earth. Heat generated by the early dynamic environment effectively melted the early Earth, making it an ocean of magma. After the Earth cooled and solidified, the remaining heat continued (and continues today) to escape from the planet, resulting in solid-state convection. Convection is a circulatory process resulting from temperature variations and gravity that brings magma to the surface, in the same way that steam escapes from boiling water. Volatile elements thus escape through volcanoes, oceanic hydrothermal vents, and hotspots. Although geochemists and geophysicists are able to determine much about the history of Earth from isotopic analysis and 3-D imaging techniques, Hauri said that the question of where life formed is still open. He speculated that if the original atmosphere on Earth was made by outgassing and was therefore tenuous, then life would probably have started in the oceans, where the elements originating from the interior were plentiful. If, however, the atmosphere formed from a late bombardment of comets and meteors, then it is possible that the ingredients necessary for life would have been available on the surface. In either case, the continual transport of carbon, nitrogen, and sulfur (all of which may be present in the Earth's core) out of the deep planet through volcanoes probably played a crucial role in allowing life to persist.

Living under pressure



James Scott, a microbiologist at GL, talked about the extraordinary experiments he and Anurag Sharma, a geochemist at the lab, conducted showing that everyday bacteria can live under pressure that is 16,000 times greater than that found at sea level—equivalent to 30 kilometers beneath the surface of the Earth. His talk, "The Effects of Pressure on Microbial Survival and Evolution," began with a discussion of organisms on Earth that are adapted to extreme environments, so-called extremophiles. He then described the subjects of his experiment—*E. coli,* found in the human gut, and *Shewanella oneidensis,* a metal-reducing bacterium found in lakes. In the absence of oxygen, these creatures metabolize formate. The scientists used the diamond-anvil cell from GL's high-pressure team to subject the bacteria to extreme pressures. As pressures increased, the two measured formate oxidation to see if the organisms were alive. After decompression, some 1% of the bacteria were still viable. The implications for the study are several: First, even common organisms can adapt to extreme conditions; second, there may be life in methane ice and water ice on other worlds; and finally, life can thrive, and may have originated, below the surface of this planet.

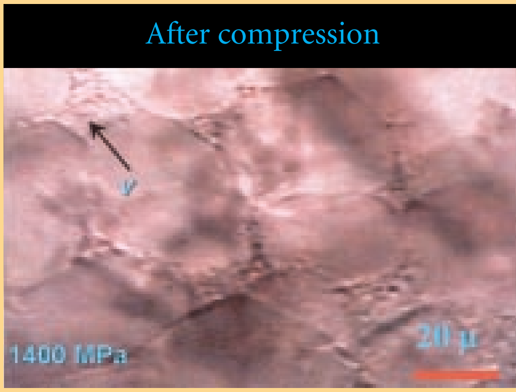
"Carbon is the poster child for global ecology."



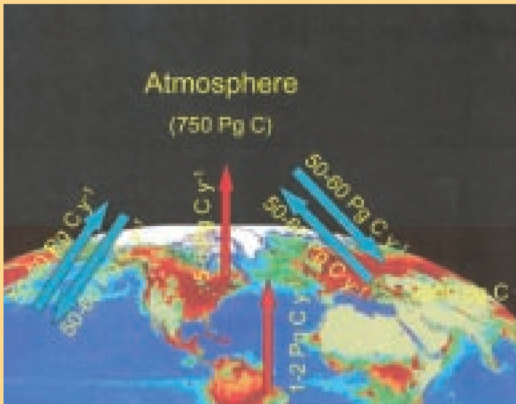
It is widely known that a variety of human-induced activities release carbon into the atmosphere. Carbon is the best-known heat-trapping greenhouse gas implicated in the overall warming of the planet. Chris Field, the new director of the Department of Global Ecology, gave the latest accounting of the global carbon cycle in his talk, "The Cycling of Carbon." He itemized the known man-made and natural sources of carbon and estimated what they contribute to overall emissions. He also described the natural mechanisms that trap carbon and take it out of circulation. By current accounts using new, bottom-up estimates (looking at the small scale and extrapolating to the bigger picture) Field said that carbon hasn't increased in the atmosphere as much as our release of it. One of the challenges to global ecology now is to figure out what happened to the rest and how storage or "sinks" on land an in the oceans will change in the future. To do this, global ecologists are using new techniques to better determine what all the man-made and natural carbon sources and sinks are and to understand the processes involved. One thing is clear, Field said. It is unlikely that unmanaged carbon sinks will increase dramatically, so it is even more important for people, industries, and countries to focus on limiting carbon emissions.

Convection has brought elements from the Earth's interior to the surface for millennia, as Erik Hauri explained. *(Courtesy Erik Hauri.)*

James Scott described experiments subjecting common bacteria to extreme pressures. *Shewanella*, shown here, moved to the areas between ice crystals during compression. *(Courtesy James Scott.)*

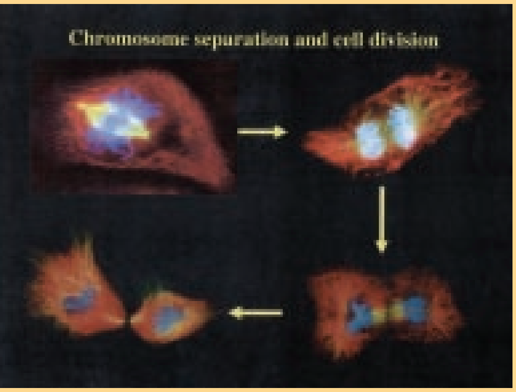


Chris Field talked about the global sources and sinks of carbon. This image shows emissions and sinks in petagrams—1 Pg is a billion metric tons. *(Courtesy Chris Field.)*



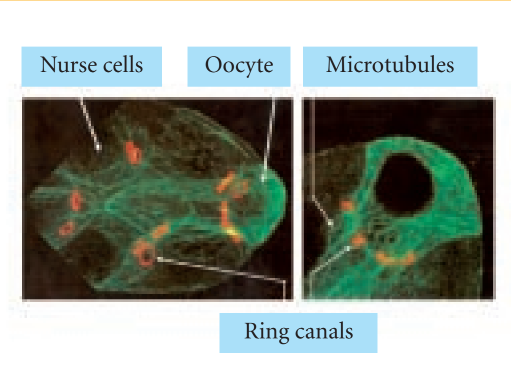
Marilyn Fogel *(left)*, Matthew Wooller *(middle)*, and colleague collect samples from the dwarf mangrove environment on an island in Belize for their biocomplexity study.

(Courtesy Marilyn Fogel.)



Yixian Zheng described the steps involved in cell division that ensure the proper duplication of cells. The spindle assembly *(yellow)* is seen in step one.

(Courtesy Yixian Zheng.)



Among his topics, Allan Spradling talked about how germ cells form into clusters called cysts, which support intercellular movement of cytoplasmic material and organelles through ringlike canals. Cysts may be responsible for removing damaged material from the old generation to keep the new germ cells damage-free.

(Courtesy Allan Spradling.)

"After my husband's beeper goes off he can go right back to sleep. I can't."

Jimo Borjigin, Staff Associate of the Department of Embryology, opened her presentation, "Light, Time, and the Rhythm of Life," with an outline of the natural rhythms that affect us all—the annual seasons, the lunar cycle, and the daily rhythm of light and dark. Borjigin's research focuses on the genetic processes that control the latter cycle, which is known as the circadian rhythm. A tiny part of the brain called the pineal gland is integral to our internal clocks. It works by regulating the hormone melatonin, which is only secreted at night. Under the stress of shift work, or of traveling to different time zones, the melatonin-production system must readjust. Borjigin demonstrated what happens during this readjustment by discussing some of her lab's experiments on rats. Surprisingly, she found that rats, like people, had very individual responses. She examined a six-hour readjustment and found that some animals stopped producing melatonin completely before adapting to the new time, while others had a smooth transition, with melatonin production gradually adjusting to the new circumstances. Borjigin will be investigating the genetic and/or biochemical basis for these and similar results.

Who eats whom?

Marilyn Fogel of GL talked about her work with Matthew Wooller in the mangrove swamps on an island in Belize. Their job is to sort out the complex relationships among the ecosystem components, primarily by using stable isotope analysis. Her presentation, "Biocomplexity of Cascades and Cycles," began with an explanation of the laws of biocomplexity. Biocomplexity is an interdisciplinary study to determine how an ecosystem works; it examines the macro world down to single cells. Fogel and Wooller's techniques are helping to integrate the different disciplines, reveal spatial and temporal complexities in the ecosystem, and identify links among plant and animal species. Among the many hypotheses they tested, they looked at whether the island's mangroves have an effect up the food chain. They analyzed the carbon and nitrogen isotopic ratios of two varieties of mangrove on the island and found that, indeed, there were differences. They are now examining what their results might mean. As the study continues, they will try to determine what their data tell them about who eats whom.

"After this talk, I hope you all see that a cell is as complex as the universe."

The adult human body produces millions of new cells each second, and each new one is the result of cell division. So why does this process not go awry more often? Yixian Zheng of the Department of Embryology looks at the genetic signals that ensure the proper duplication of chromosomes during cell division, as she explained in her talk, "Assuring the Production of New Cells." She started with a review of the parts of an animal cell and talked about their complex functions. Then, focusing on the nucleus where DNA is contained in the form of chromosomes, she described the steps involved in cell division. Zheng's lab concentrates on the biochemical signals activated during a particular time in the cell cycle when stringlike microtubules form a structure called the spindle. It is the spindle's job to pull the chromosomes into two new cells. The researchers also look at the centrosome, near the cell's nucleus, which is important for creating the microtubules. Zheng showed some spectacular images of real cells at different steps in the process and said that the chromosomes seem to produce a signal that tells the microtubules to grow toward them for spindle assembly. This essential step helps to ensure that segregation occurs without costly mistakes.

"On this planet there are no organisms, just cells."

Allan Spradling, director of Embryology and the last speaker, launched his talk, "Evolving and Manipulating Germ Cells," by likening different types of cells to individuals in social insect societies. Sophisticated biological mechanisms cause each cell "caste," such as skin, muscle, or blood, to do its particular job despite suffering damage and lacking any chance to reproduce. In contrast, germ cells, the "queens" of multicellular society, behave in ways that seem to preserve both their genes and their cytoplasm. A novel example of the latter may be the formation of germ cells into clusters called cysts. Cysts are intriguing because they support intercellular movement of cytoplasmic material and organelles, such as mitochondria—the cells' energy producer—through ringlike canals. Spradling said that cysts might be responsible for removing damaged material from the old generation to keep the new generation of germ cells damage-free and "young." He suggested that damaged material may be sent through the ring canals to cells that are fated to die, while the pristine material stays in cells that will become new eggs. Finally, Spradling reviewed the extensive germ line genetic engineering that has been carried out during the last 20 years in *Drosophila*. This technology, as embodied in the Carnegie/Baylor/BDGP Gene Disruption Project, has produced thousands of new strains useful for understanding biology and advancing medicine. Like previous types of domesticated animals, however, none were better adapted to life in the wild. The same amount of genetic modification of the human genome would require 5,000 to 10,000 years simply because of the differences in generation time, and Spradling predicted that such an effort would likewise fail to significantly enhance human capabilities. "We are not about to take control of human evolution using germ line genetic engineering; still less, create a new class of people," he stated.

Broad Branch Road Gets a New Look

Plans to transform the historic experiment building and annex on the Broad Branch Road campus into an attractive center for conferences, meetings, and social activities are well under way. The renovation, estimated to cost $2 million, will be funded as part of the institution's ongoing *Carnegie Campaign for Science.*

Most recently, the structure has been used for storage. The three-story main room has protective foot-thick walls, which were needed in past years to shield against experiments that used explosives. It will become a large, modern kitchen and eating area. A patio, for outdoor activities, will link the building to the Van DeGraff Generator tower.

The complex will also include a badly needed auditorium that will seat about 140 people. The current seminar room in the Abelson building seats only about 80. There will also be smaller meeting rooms and a gallery to display items that were on exhibit at the centennial exhibition.

"The history of the Department of Terrestrial Magnetism happened in those buildings," explained Staff Scientist Alan Boss, who is involved in the renovation planning. "Now it will be a showcase for the campus." The remodeling design is by architect Lynne Iadarola of Archeus Studio in Chevy Chase, Maryland. Weather permitting, demolition and construction will begin late this year or in early 2003. The project is scheduled for completion by the end of 2003. The current seminar room, kitchen, and dining areas in the Abelson building will become much-needed office and lab space.

This architectural rendering shows the renovated experiment building and annex on the Broad Branch Road campus, which is home to the Department of Terrestrial Magnetism and the Geophysical Laboratory.

Forensics, First Light, and Fresh Fields Foods

In celebration of Earth Day 2002, the Carnegie Academy for Science Education (CASE) and First Light staff and friends conducted an outdoor class in biology for customers of Fresh Fields/ Whole Foods Market on P Street in Washington, D.C. The April 20 event was a collaboration with the market, forensics experts from the FBI and George Washington University, and biologists from the Living Classroom. While kids and adults extracted visible amounts of DNA from fruit,* the forensics experts explained how the process is linked to human DNA analysis. Other activities included looking through microscopes to study flower anatomy and learning about the wildlife to be found in and along the Anacostia River.

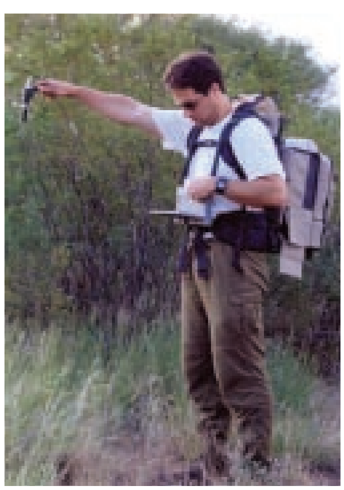
The event, which drew 300 people and featured a market-sponsored fund-raising barbecue for Carnegie's Saturday science school, was the most successful community outreach effort ever hosted by the P Street Fresh Fields. A measure of its success was the recruitment of four new students for the school. Fresh Fields and Carnegie look forward to making this an annual event.

A diverse crowd experiences hands-on science. These children are using microscopes to examine flower anatomy.

(See http://www.caseciw.org/first_light_case/horn/DNA/berrydna.pdf to find out how!)

First New Staff Member at Global Ecology

Greg Asner collects spectral information from an Argentinean grassland.



Greg Asner is the first new faculty member to join the Department of Global Ecology. A biogeochemist, Asner is interested in nutrient cycling in terrestrial ecosystems, especially those affected by human disturbances. Understanding the processes that regulate the availability of nitrogen for plants is one focus of his research. He uses novel approaches for analyzing satellite data, and has increased the scale of studying nitrogen cycling from individual plants to large regions. He also uses satellite data for quantifying the impacts of logging, monitoring shrub invasion in savanna ecosystems, and determining the chemical composition of forest canopies. His work combines mathematical modeling with field studies, which take him to Hawaii, Texas, Argentina, and the Amazon Basin.

Asner's undergraduate training was in engineering. He received a Ph.D. in biology from the University of Colorado. He was a postdoc in the Department of Geological and Environmental Sciences at Stanford. Prior to joining Carnegie, he was an assistant professor in the Department of Geological Sciences at the University of Colorado.

IN Brief

Trustees

Trustee **Richard Meserve**, chairman of the Nuclear Regulatory Commission, was elected to the American Philosophical Society in Apr.

Administration

The Apr. newsletter of the American Society of Biochemistry and Molecular Biology featured an article by Carnegie president, **Maxine Singer**, entitled "Scientific and Medical Aspects of Human Reproductive Cloning," about the National Academy recommendation to ban human cloning. On Apr. 15 Singer gave a talk, "Scientists and Schools," at U. Maryland, Baltimore County.

—

Greg Taylor, CASE and First Light coordinator, was an invited speaker at the Potomac Regional Education Partnership (PREP) meetings June 12. His talk focused on his experiences with technology in the classroom.

Embryology

Don Brown presented a talk at Rockefeller U., "Centennial Symposium on Cell Biology."

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Joanne Hama (Ph.D. 2001, Mount Sinai School of Medicine, NYU) has begun her postdoctoral work in the Brown lab, studying limb development in amphibian metamorphosis.

—

Joe Gall was appointed to the editorial board of *Proceedings of the National Academy of Sciences*. In Mar. he presented the Second Billingham Lecture in the Cell Biology Department at U. Texas Southwestern Medical Center in Dallas. In Apr., he received an honorary doctorate in medical sciences from Charles U. in Prague.

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Marnie Halpern joined the Marine Biological Laboratories Alumni Relations Advisory Board. In Jan., she became a managing editor for the journal *Mechanisms of Development*. Halpern and Sally Moody (George Washington U.) organized the Mid-Atlantic Regional Developmental Biology Meeting, held at Carnegie's P Street building Apr. 19-20. Several Embryology researchers, including **Erika Matunis, Rachel Brewster, Christian Broesamle, Daniela Drummond-Barbosa, Josh Gamse, Alex Schreiber**, and **Judy Yanowitz**, presented their work.

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Anne Lynn Langloh joined Terence Murphy's lab as a special investigator to study how centrosome duplication is regulated in *Drosophila*.

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Jim Wilhelm spoke at the 43rd Annual *Drosophila* Research Conference in San Diego on the localization and translational control of *oskar* mRNA.

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Vince Klink (Ph.D. 2001, U. Maryland) started his postdoctoral work in the Zheng lab studying mitotic spindle assembly.

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Sudeep George (Ph.D. 2002, Division of Biochemical Sciences, National Chemical Laboratory, Pune, India) has begun his postdoctoral work in the Zheng lab looking at the regulation of microtubule assembly.

Observatories

The Observatories welcome **Nancy Davis**, regional director for external affairs. **Silvia Hutchison** joined the administration in May.

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Miguel Roth gave a talk at the National Science Teachers Association meeting in San Diego Mar. 27-30 on the accelerated expansion of the universe and the new generation of giant telescopes. More than 400 teachers attended the presentation.

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In Mar. **George Preston** addressed three senior classes at John Muir High School in Pasadena during Futures Day. He talked about the rewarding careers offered by the search for origins of the chemical elements, stars, planets, and life in the universe.

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Alan Dressler gave an invited talk, "The Landscape of U.S. Astronomy in 2015," at an Apr. 2-5 meeting, "Hubble Space Telescope's Science Legacy," at U. Chicago.

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❶ **Wendy Freedman** gave colloquia at the Institute for Astronomy in Princeton, at Stanford U., and at SLAC in Feb., and at DTM in Mar. She also gave an invited talk at the Moriond cosmology workshop in France in Mar.

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Instrument scientist **Bruce Bigelow** and **Alan Dressler** were interviewed this spring for *Search for Solutions*, a National Science Teachers Association video that will be made available free of charge to middle and high school science teachers.

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John Mulchaey served as an editor for the recently published conference proceedings *Extragalactic Gas at Low Redshift*, based on a workshop held at the Observatories Apr. 4-6, 2001, in celebration of **Ray Weymann's** contributions to astronomy.

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Andy McWilliam gave an invited talk at the "Stellar Abundances and Nucleosynthesis" conference in Seattle Mar. 27-29. He also attended the Pasadena meeting of the U.S. Gemini Scientific Advisory Committee, of which he is a member, on Mar. 22 and 23. McWilliam was appointed a U.S. representative to the Gemini Science Committee and attended its meeting in Vancouver Apr. 7-9.

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Luis Ho visited the Academia Sinica to serve on the Ten-Year Planning Committee for the development of astronomy in Taiwan.

—

Donald Lynden-Bell (Institute of Astronomy, Cambridge) arrived in Jan. for three months as a Scientific Visitor. During his residence, he presented two talks, "Why Disks Collimate Jets" and "What Newton Knew and We Don't"; visited the Mt. Wilson Observatory; and celebrated his 67th birthday with friends from the Observatories and Caltech. He also gave an invited talk, "Why Disks Make Jets," at the Rubin Symposium at

IMACS Sees First Light!

The main structure of the Inamori Magellan Areal Camera and Spectrograph (IMACS) arrived at the Observatories on Santa Barbara Street on March 13. The instrument, which will be installed on the Walter Baade telescope, is named after Trustee Emeritus Kazuo Inamori. It is a high-resolution spectrograph with a very large field of view, allowing astronomers to study hundreds of faint objects simultaneously. Alan Dressler, Principal Investigator for the project, Bruce Bigelow, and Greg Burley reported first light for the instrument on May 15 at 9:30 p.m. PDT. A slit mask with 0.5-arc-second hole was imaged through the field lens, collimator, imaging mirror, and long camera. IMACS will become the backbone of major survey programs. In the left image, Bruce Bigelow (right) and Christoph Birk are ready to install the long camera barrel. Right, Bigelow and Tyson Hare handle the field lens before installation.

➊ The Feb. 2002, *Astronomy & Geophysics* published **Wendy Freedman's** George Darwin Lecture, "The Expansion Rate of the Universe." She was also quoted in the Mar. 18, *Aviation Week and Space Technology* about the uses of the "revived" Nicmos camera on the Hubble Space Telescope. In addition, the May 4 *Science News* mentioned Freedman in an article about using the cooling rates of white dwarf stars as a new means for estimating the age of the universe.

Carnegie's P Street building in Washington, DC, on Jan. 11; at the Observatories on Jan. 22; and at UC-Santa Cruz on Jan. 30. On Apr. 4 he presented a talk on exact optics at UCLA.

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Stephen Helsdon is a new postdoc working with John Mulchaey. He completed his degree at U. Birmingham and will be working on data taken with NASA's Chandra X-ray Observatory.

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Albert E. Whitford, former director of UC's Lick Observatory and a postdoc at the Mt. Wilson Observatory decades ago, died at age 96 on Mar. 28.

Plant Biology

Kathy Barton has been gradually staffing her new lab. Postdoc **Pablo Jenik,** from Barton's former lab at U. Wisconsin, arrived in Oct. In Dec. **Khar-Wai Lye** started as the lab technician. **Rachael Huntley** arrived in Jan. from Cambridge U. as a postdoctoral fellow, and Visiting Investigator **Ning Bao** arrived from U. Wisconsin to continue his research.

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The Ehrhardt lab welcomed a new lab technician from Stanford U., **Dorianne Allen.**

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Sue Rhee's TAIR lab has a number of additions. **Jill Tacklind** is the new webmaster and has been working on updating the department's Web pages since Dec. **Suparna Mundodi** finished her project in Shauna Somerville's lab and joined the TAIR group as a curator. **Tanya Berardini** began her position as a curator in Jan., and in Mar. **Alan Chou** arrived as a postdoctoral associate. **Peifen Zhang** arrived in Apr. as a new curator.

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New arrivals in Chris Somerville's lab are **Heather Youngs** and **Erin Osborne.** Youngs arrived from the Oregon Graduate Institute in Dec. as a postdoctoral associate. Osborne arrived from UC-Santa Cruz in Mar. as a lab technician.

Aden Habteab joined the Somerville lab as a laboratory assistant in Apr.

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The department welcomed **Susan Cortinas** back in Feb. when she accepted the administrative assistant position. In Oct. **Miguela Osbual** started as the department's new receptionist.

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Gert-Jan de Boer left the Somerville lab in Jan. to start his new position at the Swammerdam Institute for Life Sciences in Amsterdam.

—

The TAIR lab bade farewell to **Mark Lambrecht,** who left to accept a postdoc position at Catholic U. of Leuven, Belgium.

—

John Christie left the Briggs lab on Apr. 8 to start a prestigious five-year fellowship at the Royal Society. He has chosen to go to U. Glasgow. **Michael Blatt,** a former graduate student who completed his Ph.D. with Winslow Briggs in 1980, was recently appointed the Regius Professor of Botany at U. Glasgow.

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Postdoctoral fellow **Koji Sakamoto** will leave the Briggs lab on May 1 to join the laboratory of Prof. Ken-Ichiro Shimizaki at U. Kyushu.

—

Damares Monte ended her stay in the Somerville lab to return to Brazil for her position at EMBRAPA. **Jeremy Gollub** left Shauna Somerville's lab in Dec. for a programmer position with the Stanford Microarray Database at Stanford, and **Mira Kaloper** left for a programmer position with the Yeast Database (SGD) at Stanford.

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Rejane Guimaraes left Shauna Somerville's lab in Jan. to start her new job at Oregon State.

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Miguel Ribas-Carbo left the Berry lab in Dec. for the Universitat de les Illes Balears, Spain.

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On Feb. 23 **Winslow Briggs** was an invited speaker at the Conference on Ecological Consequences of Artificial Night Lighting, held with the Urban Wildlands Group, at UCLA. The title of his presentation was "Plant Photoreceptors." On Feb. 25 Briggs gave a seminar, "Phototropins: A New Family of Plant Photoreceptors," also at UCLA. He was the keynote speaker on Mar. 9 at the Plant Biology Symposium held at U. Mass.-Amherst, speaking on "Phototropins: A New Family of Plant Photoreceptors." On Mar. 27 he was an invited speaker, presenting the same seminar on phototropins, at a symposium organized by graduate students, "Sensing and Signaling: Molecular Responses to the Environment," at U. Washington-Seattle.

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Stewart Gillmor successfully defended his Ph.D. thesis at Stanford and in May will move to CIMMYT near Mexico City for postdoctoral studies on apomixis.

Global Ecology

The Field lab has had a number of new arrivals. **Jeff Dukes** (Stanford) began his position as a postdoctoral fellow in Feb. **Todd Tobeck** arrived from Cal. State U. as a laboratory and field technician. Also new to the lab are predoctoral student **Thuriane Mahe** from **France** and three new field assistants, **Jennifer Ayers, Helen Fields,** and **Vivian Schoung,** who will assist with the seasonal harvesting at the Jasper Ridge research site.

—

Greg Asner has been traveling extensively. His research takes him to the Brazilian Amazon, where his lab is studying the effects of land use and climate on biochemistry, soil chemistry, and the forest canopy. He also gave an invited presentation on the state of advanced remote sensing techniques for vegetation studies at NASA headquarters.

—

Lab technician **Amanda Warner** arrived from U. Colorado in Dec. to help organize and set up Asner's new lab. Postdoc **Jeff Hicke** arrived from U. Colorado in Feb. to continue his research with Asner.

Geophysical Laboratory

Wes Huntress was selected by the American Institute of Aeronautics and Astronautics to receive the Dryden Lectureship in Research, to be awarded at the Aerospace Sciences Meeting and Exhibit in Reno, NE, in Jan. 2003.

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Robert Hazen has been appointed to the editorial board of *Astrobiology*. His article, "Life's Rocky Start" (*Scientific American,* Apr. 2001) was selected for inclusion in the anthology *The Best American Science Writing, 2001*, published by Houghton Mifflin. Hazen also presented lectures on minerals and the origin of life at NASA Goddard; Princeton; RPI; and U. Wyoming. In addition, he presented a lecture on scientific ethics at UC-Santa Cruz, where he has a joint research project with David Deamer on the prebiotic synthesis of

The Latest on HP-CAT

The HP-CAT team made successful radiation tests on beamline enclosures ID-A and ID-B in early April, and started installing instrumentation shortly after that. The experiment setup installation for enclosure ID-B is scheduled for June. Various commissioning experiments within the sector will continue through November, after which time large mirrors will be installed. The BM beamline should be fully commissioned by April 2003. This picture shows the Advanced Photon Source floor coordinators, radiation crew, and HP-CAT staff members after the successful radiation testing of enclosures ID-A and ID-B. Carnegie members include Daniel Errandonea (standing left), Eric Rod (standing right) and Daniel Haüsermann (sitting in front of Rod). The formal dedication for the project is scheduled for July 26, 2002.

See http://www.hpcat.aps.anl.gov for the latest.

membrane-forming molecules.

—

Wes Huntress, James Scott, Andrew Steele, Jan Toporski, and Hazen attended the Second Astrobiology Science Conference at NASA Ames Research Center, Moffett Field, CA, Apr. 7-11.

—

Ronald Cohen was elected a fellow of the American Geophysical Union. The honor will be conferred at the fall meeting. Cohen ran the workshop on fundamental physics of ferroelectrics Feb. 3-6 in DC. He has organized all of these workshops since 1990. This year there were about 90 participants. Cohen also attended the invitation-only ONR Workshop on Ferroelectric Semiconductor Interfaces in Kona, Hawaii. The small, diverse group met to discuss the next generation of semiconductor devices, which will use ferroelectrics as gates, optical and X-ray sensors, capacitors, memory elements, and potentially as key elements in "quantum computers." These quantum machines will be able to perform some computations within a second, which with today's technology would take billions of years using all the computers on Earth. Ferroelectrics used as nonlinear optics devices will also eventually replace many of the electronic components in optical fiber communications. A key element in the growth of this field is the ability to design materials at the atomic level, laying down one layer of atoms at a time in commercially viable processes.

—

In Mar. **Bjørn Mysen** presented the keynote lecture, "Physics and Chemistry of Melts and Glasses," at EMPG IX in Zurich. Also in Mar., Mysen gave an invited lecture at Saint-Gobain Recherche, Paris, titled "Physical Chemical Properties and Structure of Silicate Glass and Melts at 1 Atm."

—

Ho-Kwang (Dave) Mao gave an invited talk, "High Pressure—A New Dimension in Physical Science," at the James Franck Institute Colloquium, U. Chicago, on Jan. 8. He also presented an invited talk, "Absolute Pressure-Temperature-Density Determinations of Mantle Minerals," at the Superplume Workshop, Tokyo 2002, Jan. 28-31, Tokyo Institute of Technology. On Feb. 22 he presented a seminar, "Understanding the Earth Core," at the Dept. of Geophysical Sciences, U. Chicago; from Apr. 27 to Apr. 30 he attended the National Academy of Sciences annual meeting in Washington, DC; on May 8 he presented a seminar, "High Pressure—A New Dimension in Physical Sciences," at Daresbury Laboratory, UK; and on May 22 he presented an invited talk, "High Pressure Science in the New Century," at World-Famous Scientists Forum of Nanjing University, Nankang, China.

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Aaron J. Celestian, a graduate student at SUNY-Stony Brook who, with Prof. John Parise, has been studying how zeolite structures change as a function of pressure, has been appointed a Visiting Investigator. He is working with Charlie Prewitt and Przemek Dera. Celestian will perform high-pressure diffraction experiments using diamond-anvil cells on selected zeolite crystals.

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Yang Ding (Johns Hopkins) has been appointed a postdoctoral associate and will begin his fellowship June 1. Ding has successfully carried out excellent in-depth studies in crystallography and petrography using state-of-the-art TEM and ELINE equipment.

—

Sung Keun Lee (Ph.D. candidate, Stanford) has been appointed a Carnegie postdoctoral fellow beginning July 1. He will use GL's arsenal of spectroscopic techniques with quantum mechanical calculations to address the complete structure complexities of amorphous and crystalline silicate materials to characterize the structures of these materials; to describe physico-chemical properties; and to apply that knowledge to equilibrium processes in inorganic and organic materials relevant to rock-forming materials and those of materials science.

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Jung-Fu Lin (Ph.D. candidate, U. Chicago) has been appointed a postdoctoral fellow beginning July 1. Lin's main area of research is minerals physics. He has an excellent background in diamond-anvil research including high-pressure devices (laser-heated diamond-anvil cell, externally heated diamond- anvil cell, and large-volume press) to study the pressure-temperature-composition phase diagrams and thermodynamic properties of Fe-Si and Fe-Ni alloys relevant to the Earth's core.

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Giles "Jake" Maule (Ph.D. Imperial College, London), has been appointed a postdoctoral associate and is working with Andrew Steele on developing microarrays for spaceflight. This is a collaborative effort between Carnegie, the Johnson Space Center, and Montana State.

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Shuhei Ono (Ph.D. in Geochemistry, Penn State) has been appointed a research associate and will be working with Doug Rumble on the sulfur isotope geochemistry of Earth's atmosphere.

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Marcelo Sepliarsky (Ph.D., U. Rosario, Argentina), has been appointed a postdoctoral associate and is working with Ron Cohen on ferroelectric solid solutions PMN-PT and PZN-PT, using a potential model Sepliarsky has developed.

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Heather Watson, Dept. of Earth and Environmental Sciences, RPI, has been appointed a predoctoral fellow beginning July 1. She will be working with Yingwei Fei studying the siderophile element diffusion in the Fe-Ni system at high pressure and temperature, using the multianvil high-pressure apparatus.

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Chih-Shiue Yan (U. Alabama, Birmingham) has been appointed a postdoctoral associate beginning in Apr. Yan has been working on the CVD large anvil project. A proposal to develop this technology, titled "Development of the Next Generation Megabar High-Pressure Cells: A COMPRES Grand Challenge," has been funded by the NSF Instrumentation and Facilities Program.

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Yukihiro Yoshimura (Ph.D., U. Ritsumeikan, Kusatsu, Japan) has been appointed a Visiting Investigator and will be working with Dave Mao, Rus Hemley, and others in the high-pressure group when he arrives in Aug. He will work on aqueous systems and ices using GL's spectroscopic and synchrotron diffraction techniques, in collaboration with the National Defense Academy of Japan.

Terrestrial Magnetism

Paul Butler, with Geoff Marcy (UC-Berkeley) and Steve Vogt (UC-Santa Cruz), are the recipients of the 2002 Beatrice M. Tinsley Award from the American Astronomical Society for their "pioneering work in characterizing planetary systems orbiting distant stars." In Apr. Butler participated in the physics and astronomy colloquia at U. Calgary and delivered the American Astronomical Society Centennial lecture at the Calgary Science Centre. Both Butler and **Alan Boss** were featured in *U.S. News and World Report's* "Mysteries of Science" edition.

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Alan Linde was named a fellow of the American Geophysical Union at a ceremony at the Spring AGU Meeting in May. Linde visited Hokkaido U. in Apr. to give a seminar and to work with former DTM postdoctoral fellow **Tetsuo**

❷ Carnegie Fellow **Eugenio Rivera** arrived in late Feb. after completing his Ph.D. at SUNY-Stony Brook.

GL scientist **Russell Hemley** is shown to the right of DTM's **Louis Brown,** who introduced him at the Jan. DTM/GL centennial lecture. Hemley's lecture, "Turning Gases into Metals: The New Alchemy," was attended by neighbors of the Broad Branch Road campus. **Larry Nittler** (DTM), **Marilyn Fogel** (GL), and **David James** (DTM) spoke in succeeding months. The series concluded in May, when **John Frantz** (GL) discussed "The Diet of Seafloor Bacteria: Investigations of Deep-Sea Hydrothermal Fluids using the Submersible ALVIN."

Takanami on data from borehole strainmeters installed in Hokkaido. He also took a field trip to the volcano Showa-Shinzan with **Hiromu Okada**, a DTM predoctoral fellow from 1972 to 1973, and he delivered a seminar at Tohoku U. during a two-day visit hosted by former DTM postdoctoral fellow **Akira Hasegawa.**

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In Feb. **Paul Silver** was elected president of the Seismology Section of the American Geophysical Union. He was elected to the board of directors of UNAVCO, Inc.—a consortium of more than 30 universities doing research in geodesy—at its Mar. meeting in Colorado Springs. That month Silver also delivered a seminar at U. Michigan, where he collaborated with Prof. **Carolina Lithgow-Bertelloni,** a former DTM postdoctoral fellow.

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In Feb. **Vera Rubin** presented the Thomas Edison Lecture at the Naval Research Laboratory. She also participated on a panel at the Smithsonian Institution on "Cosmological Mysteries: Physics in the 21st Century" with Sir Martin Rees, Cambridge U., and Nobel Laureate Joseph Taylor, Princeton U., to celebrate 50 years of Nobel Prizes. In Mar. Rubin delivered a popular lecture in the U. Maryland Distinguished Lecturer Series.

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❷ Carnegie Fellow **Eugenio Rivera** arrived in late Feb. after completing his Ph.D. in physics and astronomy at SUNY-Stony Brook. Rivera's thesis involved modeling scenarios for the progenitors of the Earth and the Moon. He and Jack Lissauer have also modeled the dynamics of the three planets in the Upsilon Andromedae system (discovered by Butler, Marcy, and colleagues) to address the question of the origin of the orbital eccentricities of the outer two planets. At DTM Rivera will look at the role of gas and dust in early planet evolution and the mechanisms for achieving orbital commensurabilities and other resonances.

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William White, a professor in the Dept. of Earth and Atmospheric Sciences at Cornell U., was appointed a Merle A. Tuve Senior Fellow for the spring semester. White's interests include isotope and trace element geochemistry and the dynamics and evolution of the Earth's mantle. He delivered the Tuve Lecture on "Pb Isotopes and Models of Earth Structure and Evolution" in Apr. White was a predoctoral fellow at DTM from 1974 to 1975 and a postdoctoral fellow from 1977 to 1979.

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Satoshi Inaba was honored at a going-away party in late Mar. before returning to Japan to become a research fellow at the Japan Society for the Promotion of Science at the Tokyo Institute of Technology. At DTM he worked with George Wetherill on new models and algorithms for calculating the formation of terrestrial, gas giant, and extraterrestrial planets.

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Predoctoral fellow **Gregory Waite,** a geophysics student at U. Utah, visited DTM this winter to work on data collected from a broadband seismic experiment designed to investigate the nature of the Yellowstone hotspot. He worked with Derek Schutt on analyzing split shear waves to investigate the pattern of seismic anisotropy and mantle flow near the hotspot.

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Darrell Hyde, a graduate student from Memorial U. of Newfoundland, left DTM in early May after a three-month stay with the geochemistry group. He worked with Steve Shirey on the Re-Os and platinum-group element geochemistry of gold-bearing banded iron formation from the Churchill Province of the Canadian Shield.

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Predoctoral fellow **Ofra Klein BenDavid** returned to the Institute of Earth Sciences, Hebrew U., after visiting DTM in Feb. While at DTM she worked with Erik Hauri, using the ion-microprobe to study the C and N isotopes and N abundances in inclusion-bearing diamonds to establish links between the chemistry of fluids and the chemistry of the diamonds in which they are hosted.

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Conel Alexander, Larry Nittler, Sean Solomon, and postdoctoral fellows **Steven Desch, Andrew Dombard, Steven Hauck, Nader Haghighipour,** and **Sujoy Mukhopadhyay** gave papers at the Lunar and Planetary Science Conference in Houston in Mar.

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Alan Boss spoke about magnetic fields and multiple protostar formation at the American Astronomical Society meeting, held in Jan. in Washington, DC, where he also participated in a press conference about adaptive optics searches for protoplanets. In Feb. he lectured on finding and forming planetary systems at the Smithsonian Institution's program, "The Life Story of the Universe." He reviewed models of triggered and magnetic star formation at the Workshop on Galactic Star Formation across the Stellar Mass Spectrum, held in La Serena, Chile, in Mar. Boss and **Nader Haghighipour** attended the Second Astrobiology Science Conference, held in Apr. at NASA Ames Research Center. Boss spoke on the implications for prebiotic chemistry of rapid ice giant planet formation, basing his remarks on a paper he coauthored with **George Wetherill** and Haghighipour. Haghighipour and Boss also presented a poster on migration of solids in a nebular disk due to pressure gradient and drag forces. Boss also wrote an article for the May-June *Mercury* magazine about the formation of gas giants, and his work was described in the March 6, 2002, *New Scientist*.

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Larry Nittler gave a colloquium on galactic chemical evolution at Case Western Reserve U. in Feb., as well as a presentation in Apr. on meteorite hunting in Antarctica to a third-grade class in Elmira, NY, via a teleconference.

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Sean Solomon served as a member of the Scientific Advisory Board to the Max Planck Institute for Chemistry (Mainz, Germany) in Feb. and as a member of an international expert committee for the Canada Foundation for Innovation in Mar. He delivered a seminar on seismic imaging of mantle plumes at U. Chicago in Apr.

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In Mar. **Alycia Weinberger** was a panelist at the Workshop on Future Far-IR and Submillimeter Astronomy at U. Maryland. Her article on dusty circumstellar disks, "Perspective," appeared in *Science* in Mar. In Apr. she was an invited speaker at the Gillett Symposium in Tucson on Vega-type disks. Her work on Beta Pictoris was featured in the Apr. issue of *Sky & Telescope* and on astronomy.com and cnn.com. She was also quoted extensively in the May 4, *Science News* cover story, "Dusty Disks May Reveal Hidden Worlds."

DTM/GL

Visiting Investigator **V. Rama Murthy** returned to DTM/GL in Feb. from U. Minnesota, where he is the Institute of Technology Distinguished Professor in the Dept. of Geology and Geophysics. He plans to continue his experiments in the high-pressure lab of GL's Yingwei Fei to determine the solubility of potassium in Fe-FeS melts and to explore the possibility for significant radiogenic heat production in the Earth's core due to ^{40}K decay. Such an additional heat source in the core has important implications for the geomagnetic dynamo, the age of the inner core, and the dynamics of the mantle.

A Gift of Cosmic Importance

Scott E. Forbush

Scott E. Forbush, a Staff Member at the Carnegie Institution's Department of Terrestrial Magnetism (DTM) for 42 years and the discoverer of the "Forbush effect" of cosmic rays, died in 1984. But because of his generosity and that of his widow, Julie, who died last year, a new generation of scientists will directly benefit from his fascination with the universe.

The institution recently received more than $80,000 from the trust of Julie Forbush. Two years before Dr. Forbush's death, he and Mrs. Forbush established a fellowship in geophysics at DTM with a donation of $36,000. Thanks to careful investment, that fund (which is part of the institution's endowment) is now valued at about $150,000. The latest gift will be directed to *The Carnegie Campaign for Science.*

Early in his career, Forbush was a researcher aboard the ship *Carnegie*, which traveled around the world mapping the Earth's magnetic field. In 1937 he discovered the so-called Forbush effect, a decrease in the intensity of cosmic rays bombarding the Earth resulting from the magnetic effects created by major solar flares. Over the years Forbush received several awards, among them the Charles Chree Medal and Prize and the John Adam Fleming Medal. He was a member of the National Academy of Sciences.

Capital Science Lectures 2002-2003

The speakers for next season's Capital Science Lectures are listed below. All lectures are on Tuesday evenings at 6:30 p.m. at the Carnegie building, 1530 P Street, NW, Washington, D.C. ***Schedule subject to change.***

October 22, 2002:	**John McKinney**, Rockefeller University, *Combating tuberculosis*
November 19, 2002:	**Marilyn Fogel**, Carnegie Institution, *Coevolution of biology and geology*
December 3, 2002:	**Irving Weissman**, Stanford University, *Stem cells*
February 11, 2003:	**Eric Lander**, Whitehead Institute and Massachusetts Institute of Technology, *The human genome*
March 25, 2003:	**Kip Thorne**, California Institute of Technology, *Gravity*
April 8, 2003:	**Sally and Bennett Shaywitz**, Yale University, *Learning mathematics and reading*
April 22, 2003:	**Peter Grant**, Princeton University, *Evolution*
May 27, 2003:	**Jennifer Doudna**, Yale University, Howard Hughes Medical Institute Investigator, *RNA catalysis*
Washington Premieres:	Carnegie will host two Washington, D.C., documentary premieres. A Norwegian documentary about Wilhelm Bjerknes and the Bergen School of Meteorology will be shown at 6:30 p.m on Monday, December 9, 2002. A South African documentary on African astronomy entitled *Cosmic Africa* will be shown at 6:30 p.m. on January 16, 2003. Both films will be shown in the Root Auditorium.

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