2005-2006 YEAR BOOK

The President's Report

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CARNEGIE INSTITUTION

OF WASHINGTON

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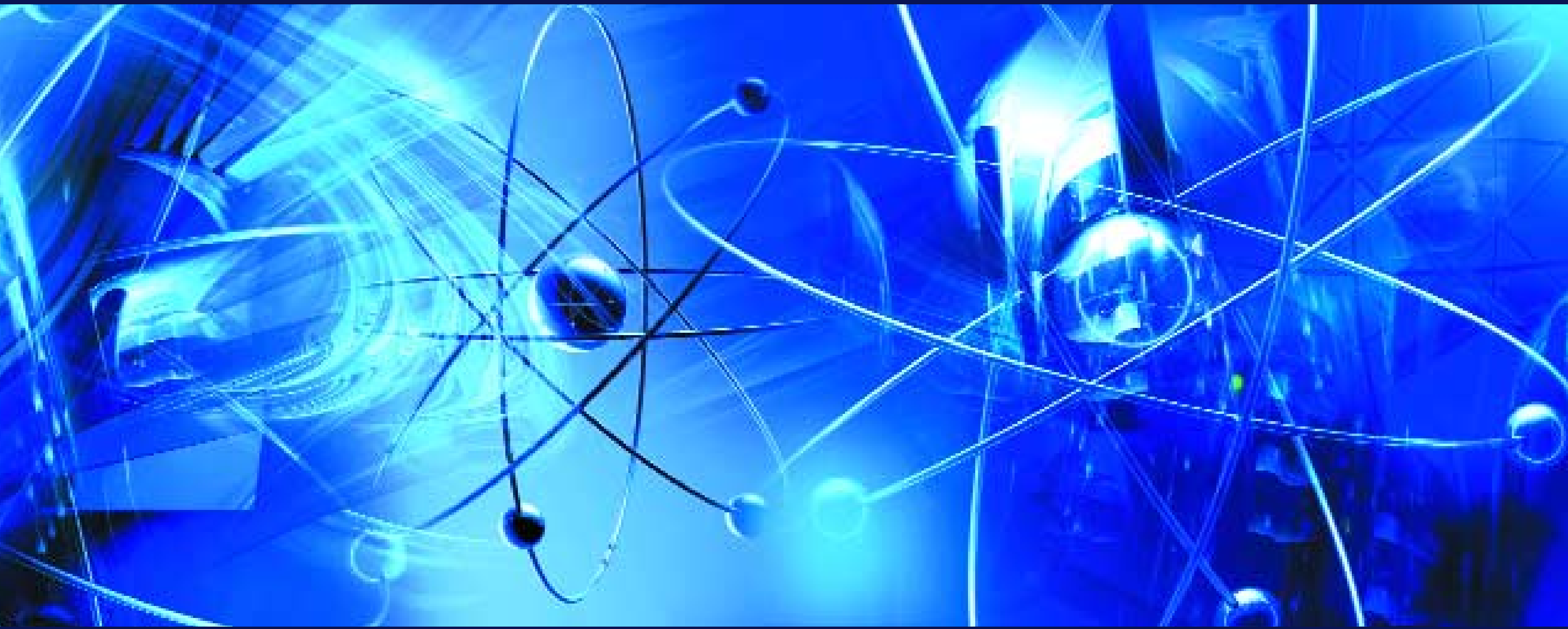
ABOUT CARNEGIE

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

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

CARNEGIE INSTITUTION



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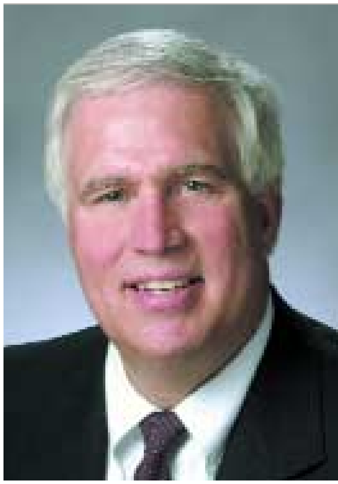


Carnegie president
Richard A. Meserve
(Image courtesy Jim Johnson.)

Two thousand six was a banner year for Carnegie. Three of our scientists were awarded major prizes and our scientific staff published prolifically in many prestigious journals, as is shown elsewhere in this Year Book. The institution also raised its profile in the popular media, as several of our scientists were regularly sought for comment on such matters as the planetary status of Pluto or the looming threat of global warming. Although this small institution has always been disproportionately influential, this past year will likely be remembered as a landmark for acknowledgment of our accomplishments.

Our Exceptional Scientists

Andrew Fire, now at Stanford University, spent 17 years in Carnegie's Department of Embryology. This year he shared the Nobel Prize in Physiology or Medicine with his colleague Craig Mello of the University of Massachusetts for work that he performed at Carnegie on RNA interference (RNAi). Although Andy received some modest NIH grants during his time at Carnegie, most of his Nobel-winning work was funded by Carnegie's endowment. His achievements are a ringing endorsement of the Carnegie philosophy of finding and supporting exceptional individuals.

Arabidopsis thaliana is the most widely used model plant for genetic studies. Plant Biology director Christopher Somerville was a pioneering advocate for its use.

Embryology's Joe Gall uses the extremely large lampbrush chromosomes from egg cells of the frog *Xenopus* in much of his work. A fluorescent antibody produces the glow in this lampbrush.
(Image courtesy Joseph Gall.)

One type of RNA is the messenger that transfers genetic information stored in DNA to the protein factories that implement the genetic instructions. Andy and Craig discovered a means to regulate gene expression by inactivating the capacity of this RNA to transmit genetic information. The technique has great significance because it enables the study of the function of a gene by adding a specific nucleic acid that turns off gene expression. This means that scientists can learn about gene function without first creating a mutant with the gene removed or inactivated. The new approach also expands functional genetic studies beyond a few model organisms for which methods of removing or disabling genes were well developed.

It also turns out that RNAi is a primitive control system with evolutionary significance. It may play a role in development by directing genes to turn on or off at various stages. And although RNAi was discovered just a few years ago, medical therapies employing it are already in clinical trials. In short, this fundamental advance promises to have paradigm-shifting impact.

Christopher Somerville, the director of Carnegie's Department of Plant Biology, shared the Balzan Prize in plant molecular genetics with Elliot Meyerowitz of Caltech. Chris was an early advocate of the use of *Arabidopsis*, a relative of the mustard plant, as a model organism for the study of molecular genetics. He also played an important role in the sequencing of the plant's genome. The department now houses The Arabidopsis Information Resource (TAIR), an open-source repository of genetic information about this plant. With about 12 million page hits per year, TAIR is perhaps the most extensively used biological database in the world.

Arabidopsis has become the genetic workhorse of plant biology, taking on the same role that the fruit fly and the mouse play for animal biology. Chris has helped to shape the very direction of his discipline as a result of his vision regarding this plant. He has also made fundamental contributions to the understanding of carbon dioxide fixation by photosynthesis, of lipid metabolism in plants, and, more recently, of the synthesis of cell walls using lignin and cellulose. The latter is critically important because of the role that biofuels are likely to play in humankind's response to the threat of climate change.

Joseph Gall, a staff member in Carnegie's Department of Embryology, was awarded the 2006 Albert Lasker Award for Special Achievement in Medical Science in recognition of his amazingly productive 57-year career. The Lasker Award, sometimes called the American Nobel, acknowledges Joe's role as "a founder of modern cell biology and the field of chromosome structure and function."[1] Through his study of exceptionally large chromosomes in amphibian eggs, termed lampbrush

Department of Terrestrial Magnetism (DTM) staff take a break from installing a Sacks-Evertson borehole strainmeter on the Greek island of Trizonia in 2002. Strainmeters consist of a metal tube filled with liquid that, when buried in the ground, detects minute changes in the strain of surrounding rocks. They have been installed in seismically and volcanically active regions around the world. Shown from left are Alan Linde, Pascal Bernard (l'Institut de Physique du Globe de Paris), Brian Schleigh, Nelson McWhorter, a local driller, and Selwyn Sacks.

chromosomes, Joe was able to show that each chromosome is composed of a single DNA double helix and that the chromosome loops are made of genes that are copied into RNAs that are stored for use in fabricating a new individual—a core component of the molecular machinery of life.

Joe also developed the technique of in situ hybridization. This technique allows scientists to pinpoint the locations of specific RNA or DNA sequences in the cell and determine whether a gene has been turned on in a developing embryo. His methodology became one of the most widely used techniques in cell biology and remains a standard method for gene mapping.

With over five decades at the bench, Joe is still exploring the mysteries of biology. He now is studying a structure in the nucleus called the Cajal body, which he believes may be critical for processing messenger RNAs. It has been observed that "Gall's legacy has already permeated cell biology textbooks and will reach far into the future through the biological problems and people he has touched."[1]

Indispensable Instruments

People are clearly the most important part of the equation for successful scientific research, but advanced equipment is also essential. As a result, Carnegie seeks not only to provide a home for exceptional individuals but also to nurture their efforts to develop instruments with new and exciting capabilities. A few examples follow.

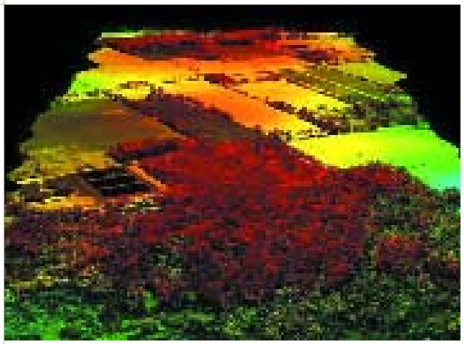
Strainmeters. Selwyn Sacks of our Department of Terrestrial Magnetism (DTM) developed a very sensitive borehole strainmeter (in collaboration with Dale Evertson of the University of Texas and DTM staff instrument maker Mike Seemann) in order to overcome the limited sensitivity of previous seismic instruments. These strainmeters are filled with hydraulic fluid and, by measuring flow of the fluid from one chamber to another, can detect otherwise imperceptible movements in the host rock. Such strainmeters are now used by geophysicists around the globe and have demonstrated that earthquake faults can move slowly as well as quickly and destructively, among other unexpected results.

Strainmeters are deployed in earthquake-prone areas around the globe, such as along the San Andreas Fault in California. In fact, a major effort is now under way to deploy thousands of these strainmeters across the United States. Funded by the National Science Foundation and supported by the U.S. Geological Survey, this network will foster a deep understanding of how the Earth redistributes geologic stresses.

DTM's Alan Linde uses these same devices to monitor the pressure and movement of fluids in magma chambers, thereby providing insights into the "plumbing" of volcanoes. Sacks and Linde have recently used strainmeters to show that environmental changes, such as the drop in atmospheric pressure from a typhoon, can bring about changes in geologic stress. In short, these versatile instruments are now a standard for seismic studies into various Earth processes.

Ecological Measurements. Greg Asner and his team at Carnegie's Department of Global Ecology designed and built the Carnegie Airborne Observatory (CAO) with financial support from Carnegie trustee Will Hearst and the W. M. Keck Foundation. This instrument, which can be flown on a variety of aircraft, employs high-fidelity imaging spectroscopy (HFIS) to measure biochemical indicators, and scanning-waveform light detection and ranging (LiDAR) to map the physical structure of vegetation. Together, the instruments provide quantitative insights into ecosystem physiology, biogeochemistry, and hydrology on a regional basis.

The CAO promises to open a new, high-resolution window on the changing composition of our land and ocean environments. Greg has already employed other remote sensing tools to monitor desertification in the American Southwest, the intrusion of invasive species in Hawaii, and the wide-scale prevalence of selective logging in the Amazon. The CAO will no doubt prove to be an essential tool for monitoring ecological threats.

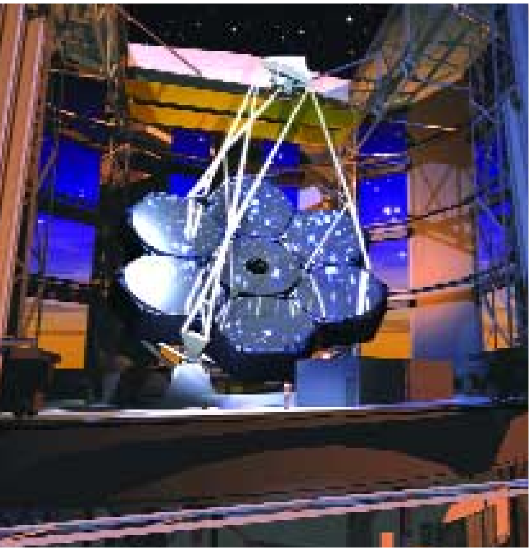


(TOP) Global Ecology's Greg Asner and team designed and built the Carnegie Airborne Observatory (CAO), which includes instruments for high-fidelity imaging spectroscopy (HFIS) to measure biochemical indicators and scanning-waveform light detection and ranging (LiDAR) to map the physical structure of vegetation. This is a LiDAR image of forests and pasturelands on the Big Island of Hawaii. *(Image courtesy Greg Asner.)*

(BOTTOM) The Geophysical Laboratory's Jake Maule (left) and colleague Norm Wainwright test the Lab-on-a-Chip in zero gravity aboard NASA's C-9 parabolic aircraft. *(Image courtesy Reduced Gravity Office, NASA Johnson Space Center.)*

Detection of Life. Humankind has always wondered if there is life beyond Earth. Andrew Steele and his colleagues at the Geophysical Laboratory and DTM are developing instruments to look for current or past life on Mars, one of the most probable additional havens for life in our solar system. Their small, rugged, "Lab-on-a-Chip" devices are designed to detect and analyze the proteins, lipids, and sugars indicative of living things.

Following exhaustive laboratory testing, Steele's instruments are field-tested in taxing environments, such as the Arctic (as part of the Artic Mars Analogue Svalbard Expedition), the Arizona desert, and in zero-G simulations. One instrument flew to the International Space Station aboard the space shuttle *Discovery* in December 2006, and three of the group's instruments are slated to fly on NASA's *Mars Science Lander* in 2009.



The Giant Magellan Telescope is slated for completion around 2016. It will consist of seven 8.4-meter primary mirrors arranged in a hexagonal pattern. The telescope's primary mirror will have a diameter of 80 feet (24.5 meters) with more than 4.5 times the collecting area of any current optical telescope and 10 times the resolution of the Hubble Space Telescope.

(Image courtesy Todd Mason and The Carnegie Observatories.)

Telescopes. Some of the most astonishing scientific results of the first half of the 20th century were the result of studies conducted with the progressively larger telescopes sponsored by Andrew Carnegie and others. Carnegie astronomer Edwin Hubble, for example, showed that the Milky Way was just one of millions of galaxies. He then demonstrated that the universe was expanding—an observation that helped to corroborate the Big Bang theory. The key to these discoveries was the availability of telescopes of increasing size to collect more light, thereby enabling astronomers to peer ever deeper into space.

Today, astronomers at the Carnegie Observatories, along with some intrepid colleagues at a group of sister institutions, are proceeding with plans to build a telescope with the resolving power of a 24.5-meter (80-foot) primary mirror—far larger than any other telescope ever built. It will be constructed of seven mirror segments, each 8.4 meters in diameter. The fabrication and testing of one of the off-axis mirrors, a major technical challenge, is now under way. The telescope will provide an enormous leap in capability—it will allow images up to 10 times sharper than those produced by the Hubble Space Telescope—and is likely to reveal cosmological surprises that are beyond imagining.

It is challenging to limit myself to only these few examples, as every corner of the institution reveals exciting research. The accomplishments of our staff scientists, postdoctoral researchers, and graduate students serve as proof, if proof were needed, that Andrew Carnegie's original vision of finding exceptional scientists and providing them with the means to express their brilliance is a timeless recipe for success. I look forward to sharing more stories of extraordinary achievement with you next year.

Richard A. Meserve

[1]Evelyn Strauss, 2006 Albert Lasker Award for Special Achievement in Medical Science, at http://www.laskerfoundation.org/awards/library/2006special.shtml.