Annual Report 1992-93

CALIFORNIA INSTITUTE OF TECHNOLOGY

This annual report is the last under my chairmanship of Caltech's Board of Trustees. I have known the Institute in various capacities during the last fifty years—as an undergraduate, a graduate student, an alumni volunteer, and a Board member—and I have continued to be impressed by the remarkable people who make up the Caltech community. It has been an honor and pleasure to serve an institution that has been so aptly acclaimed a "national treasure."

In the *1984–85 Annual Report* I wrote, "What an exciting time to become chairman of the Caltech Board of Trustees." From the appointment of President Tom Everhart in 1987, to the opening of the Beckman Institute in 1989, the dedication of the first of two 10-meter Keck Telescopes in 1991, and a continuing stream of world-class research and teaching on the campus, the last nine years have certainly proved that statement true. As chairman, I am grateful for the continued support of a diverse and talented Board. Due in large part to the Board's efforts, the Institute was able to reach another milestone—The Campaign for Caltech successfully concluded on December 31, 1993, significantly surpassing its $350 million goal.

During the past year, three new Trustees were elected: Eli Broad, the chairman and chief executive officer of SunAmerica Inc.; Mildred Dresselhaus, the Institute Professor of Electrical Engineering and Physics at MIT, and a recipient of the National Medal of Science; and Stephen A. Ross, co-chairman, Roll and Ross Asset Management Corporation, and Sterling Professor of Economics and Finance, Yale University. We welcome their active participation and wise counsel.

In the coming years Caltech will be faced with even greater opportunities for achievement and still greater challenges to maintaining its preeminence. I have no doubt that the Institute has the people and the resources to surpass its own high standards of accomplishment.

Ruben F. Mettler

Ruben F. Mettler
Chairman of the Board of Trustees
1985-1993

Ruben F. Mettler and Thomas E. Everhart

We at Caltech focus on pioneering research, taking risks, and working to make them pay off. We believe that we offer a superlative education to some 900 undergraduate and 1,100 graduate students annually. Thus, it should be a matter of satisfaction and pride to the entire Caltech community that the Campaign for Caltech—our effort to raise funds to support the Institute's work—has been successful. By the end of October, the campaign had exceeded our goal of $350 million; indeed, by the conclusion of the campaign—December 31, 1993—we had attained more than $394 million.

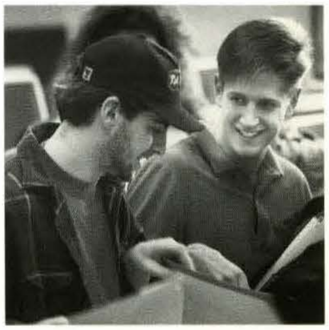
We set out to raise $100 million for endowment priorities and surpassed our goal by 18 percent. We exceeded our goal for endowed professorships—resulting in 18 new chairs—and for unrestricted endowment. We added seven new postdoctoral fellowships, 12 new graduate fellowships, and 50 new fully endowed undergraduate scholarships.

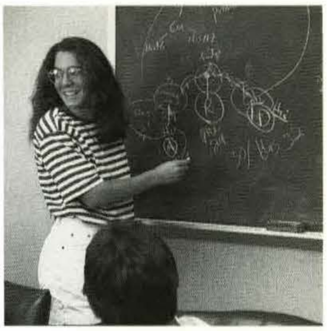
In addition, by the end of the campaign we had more than met our capital goal of $115 million. The second Keck telescope is well under way, and we will break ground for the Moore Laboratory of Engineering in March 1994. We have received partial funding for a Submillimeter Observatory headquarters building in Hawaii. In advanced planning is the Avery Center, the new undergraduate, graduate student, and faculty residence that will offer programs for developing the entrepreneurial spirit. Moreover, we are pleased to announce a commitment from the Sherman Fairchild Foundation for a new engineering library. (Although not part of the campaign, a parking garage and new central plant needed for the north campus area are nearing completion.) Finally, we surpassed our goal of $135 million for programs and current operations by almost $18 million, enhancing our research and teaching.

Additional funds still need to be raised to support endowed fellowships and scholarships, research initiatives/start-up funds, and laboratory modernization. We will continue to raise funds for these purposes in the coming months.

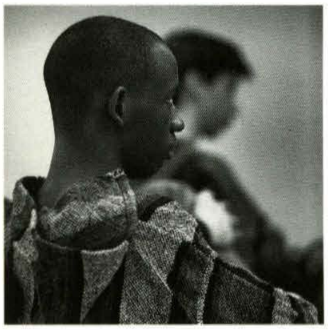
I want to take this opportunity to express the deep appreciation of everyone at Caltech for the support received during the campaign. In particular, I wish to acknowledge the major role played in the campaign's success by the Caltech Board of Trustees, especially the late alumnus James W. Glanville, MS '46, Eng '48, more recently William F. Kieschnick, and, finally, the Board's recently retired chairman, alumnus Ruben F. Mettler, BS '44, MS '47, and PhD '49. As chairman, Rube Mettler has been an energetic leader and a generous friend. We are indeed fortunate to welcome another alumnus and longtime supporter, Gordon E. Moore, PhD '54, as the new chairman.

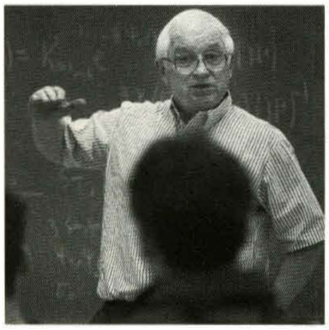
As we celebrate the campaign's success, we reaffirm its purpose: to enhance Caltech's strength as a research and teaching institution. In light of this, we are pleased to announce that Professor of Physics Charles W. Peck, PhD '64, became the new chair of the Division of Physics, Mathematics and Astronomy on October 1. He succeeds Howard Hughes Professor and Professor of Physics Gerry Neugebauer, PhD '60, who has stepped down after five effective years in the position.





The quality of our 275 professorial faculty remains superb. Sixty-four are members of the National Academy of Sciences, and 27 are members of the National Academy of Engineering. Thirteen have been named California Scientist of the Year, the most recent being Hiroo Kanamori, the John E. and Hazel S. Smits Professor of Geophysics and the director of Caltech's Seismological Laboratory, who received the award in 1993. Also in 1993, Seymour Benzer, the James G. Boswell Professor of Neuroscience, Emeritus, received the Royal Swedish Academy of Science's Crafoord Prize, for his work in neurogenetics. In addition, Hans W. Liepmann, the Theodore von Kármán Professor of Aeronautics, Emeritus, received the National Medal of Technology. He had received the National Medal of Science in 1986, so this latest honor makes him one of only 11 Americans to win both awards. (Another is Board Chairman Emeritus Arnold O. Beckman, PhD '28.) Our junior faculty are distinguished, too. Forty-one have been National Science Foundation Young Investigators (formerly called Presidential Young Investigators), and seven have won Packard Fellowships.





Looking at student life at the Institute, there have been significant changes. Our undergraduates include a greater number of women. We have made some progress in admitting more minority students, but further efforts are needed. A diverse student body helps provide our students with an education that will prepare them for the global village they will enter. It is worth noting that the 1993 Commencement awarded degrees to the largest number of graduates ever—220 bachelor's, 160 master's, four engineer's, and 158 doctor's degrees, for a record total of 542. The overall plans of the BS graduates this year are similar to previous years in terms of choice of employment or further education; 61 percent are going directly into a graduate program, with 13 graduates having been accepted to MD or MD/PhD programs.

The quality of instruction and research at Caltech will be increasingly important in the years ahead. In addition to rapid changes in science and technology, our nation faces uncertainties in foreign policy, economic policy, and health policy. All are bound to have an impact on universities, directly or indirectly. For example, the allocation of scientific research funds and the public's expectations for research are changing. Today, the public has far less trust in the allocation process. Congress, reflecting the public mood, is more divided; some members are negative toward universities; all allocations in these tight budget years are constantly being questioned.

The public wants research to result in new industries and new jobs. They look at recent examples of new industries founded on a scientific or technological base—the integrated-

circuit industry, for example, did not exist in 1960; today, it is a $65 billion industry. Communications and information technologies are undergoing explosive growth and change, presenting both challenges and opportunities. Research universities must meet new expectations to continue to merit public research funding.

A faculty discussion of the undergraduate core curriculum has been undertaken this past year, to ensure that Caltech offers the best possible curriculum to our talented students. We certainly will continue emphasizing the fundamentals of science, technology, and the humanities. However, other areas—such as foreign languages and cultures, and entrepreneurship—may receive more attention. Likewise, as we add new faculty, we need to think about which areas of what fields will have the greatest payoff for Caltech and for society. Choosing superb people in important—often emerging—fields is how we have made an impact in the past, and is our surest pathway to continued success. Such people define the future and teach others how to make it a reality.

Thomas E. Everhart

Thomas E. Everhart
President

Caltech's research accomplishments—in areas as varied as astronomy, molecular chemistry, communication theory, and political science, as the following highlights will show—complement and enhance its effectiveness as a teaching institution. Central to excellent teaching and research is the recruitment of new faculty. This recruitment process at Caltech is characterized—and constrained—by high standards, our continuing emphasis on experimental research in the physical sciences and engineering, and limits imposed by the high costs of modernizing laboratories and adding needed computing power and support personnel.

Nevertheless, a significant number of new faculty have been recruited in recent years. Most of them are outstanding junior faculty who will help Caltech maintain its position as both a premier research university and a first-rate teaching institution.

Computer modeling and simulation are increasing in importance in science and engineering, and Caltech continues to be a leading institution in high-performance computing. This success is a result of our growing community of student, staff, and faculty researchers adept in the use of parallel supercomputers, and our acquisition—in cooperation with JPL—of state-of-the-art parallel computers, including the Intel Delta, an Intel Paragon, and a Cray T3D.

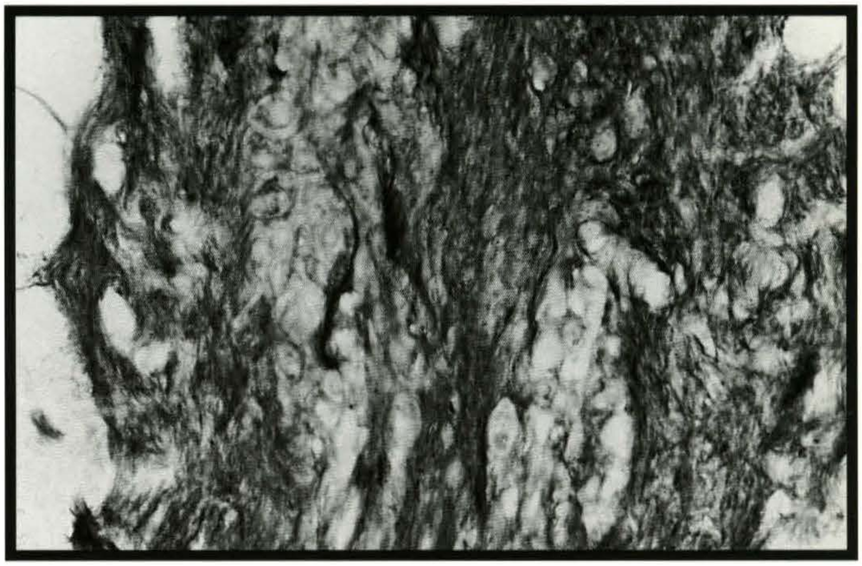
In regard specifically to teaching, a new graduate option has been established in the area of control and dynamical systems, and a major effort is under way to change and modernize the undergraduate core curriculum.

Finally, I would like to mention the negative national perception of research universities that has developed over the past few years, a perception that I believe is in large part unjustified. All of us at Caltech—faculty, staff, and students—have a role to play in demonstrating to the public that leading-edge research is not only compatible with effective teaching, but essential to it, and is not only relevant but vital to solving our societal problems.

Paul C. Jennings

Paul C. Jennings
Vice President and Provost

Shown is a rat brain treated to elicit Parkinson's disease-like symptoms. The picture is a high-power view of a graft containing adrenal cells placed into this brain. Also grafted here were skin cells genetically engineered to secrete a protein that converts the adrenal cells into nerve cells. Thus, the animal's own cells were used to produce new nerve cells inside the damaged brain.



The best laid cells of mice and men often go awry. When they are brain cells, going awry can lead to neurodegenerative diseases such as Alzheimer's, Parkinson's, and amyotrophic lateral sclerosis (Lou Gehrig's disease). By studying the survival, growth, and development of nerve cells in the brains of mice and rats, Caltech biologists are beginning to understand what causes these cells to go awry and die. This research may contribute to a better understanding of why nerve cells die in human brains, particularly during neurodegenerative diseases, and after traumatic injury.

In the past few years, the Caltech group and other researchers around the world have succeeded in identifying a new family of proteins (called neuropoietic cytokines) that not only controls the kinds of nerve cells that develop, but also can rescue dying cells after injury.

The Caltech research team obtained their initial results with nerve cells growing in tissue culture, but recent studies have involved new strains of mice, called "knockout mice." Certain genes in these mice have been mutated, or "knocked out," so that they are inactive and don't produce the protein that they code for.

In a recent study of mice in which a gene for one of the neuropoietic cytokines was mutated to an inactive form, so that the mice lacked the cell-rescuing protein, the Caltech group found that the brains of these mice were altered in striking ways, confirming the important role the protein plays in proper development: the brains of the knockout mice have a shrunken and sick hippocampal region, and the appearance of nerve cells in the visual cortex is altered. The hippocampus controls learning and memory, so the Caltech group plans to test the learning ability of these mutant mice. Since memory deficits are key features of Alzheimer's dementia, the neuropoietic cytokine discovered in these studies could potentially be important for future therapeutic uses in this disease.

In a further confirmation of the protein's importance, when the nerves of these mutant mice are injured, their regeneration response differs from that of normal mice. In a normal mouse, when a neuron is injured, it changes the pattern of proteins it produces, and these changes are important for nerve regrowth and for the immune response following injury. In the knockout mice, however, injured neurons behave as though they are intact; they continue to produce the same proteins in the same amounts. Future tests will look at the rate of regrowth in normal and knockout mice.

Because this protein appears to be important, the biologists are developing new methods for delivering the protein to the site of the injured or dying neurons in animal models of Alzheimer's and Parkinson's disease.

Probing the DNA "wire"

The fluorescent glow in a test tube at Caltech's Noyes Laboratory may be a beacon for important scientific discoveries. Set upon an ultraviolet light table, a solution of DNA mixed with a synthetic complex shows a pinkish-orange glow, then loses it when another synthetic complex is added. By studying the absence or presence of this vibrant color, Caltech researchers have devised a way to see whether an electric current is flowing through the DNA.

In a series of experiments completed in fall 1993, Caltech chemists used light to initiate a flow of electric current through a short piece of DNA. This is the first time a DNA double helix has been demonstrated to act as a "molecular wire."

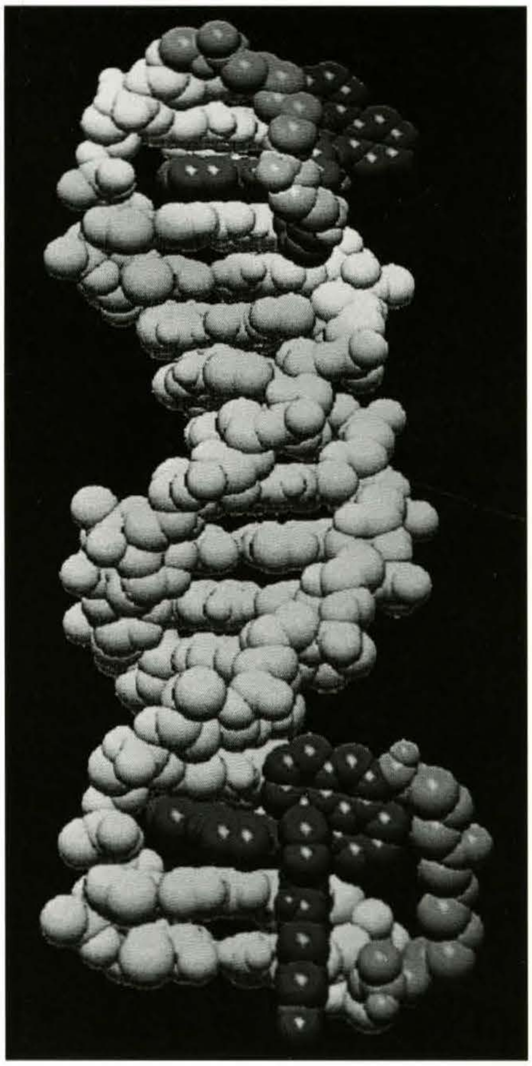
For more than 40 years, scientists have known that DNA is a polymer composed of two strands that wind around each other in a double helix. Each segment of the twin spirals is called a base pair, and in each human cell there are about three billion base pairs which encode the genetic information that makes us what we are. The Caltech researchers have shown that clouds of electrons at each base pair, layered like a stack of pennies, create a path for the flow of electrons.

The key to this finding is two modified DNA strands made in the laboratory, each containing a short (15 base) strand of DNA with a complex of ruthenium or rhodium attached to the end. In one experiment, when a single strand with no metal attached and a ruthenium-labeled strand were mixed in solution and intertwined, the resulting double helix glowed when excited with ultraviolet light. But in a separate test, when a strand of DNA with ruthenium attached interacted with a rhodium-labeled strand, so that the resultant double helix had one metal at each end, the glow was turned off.

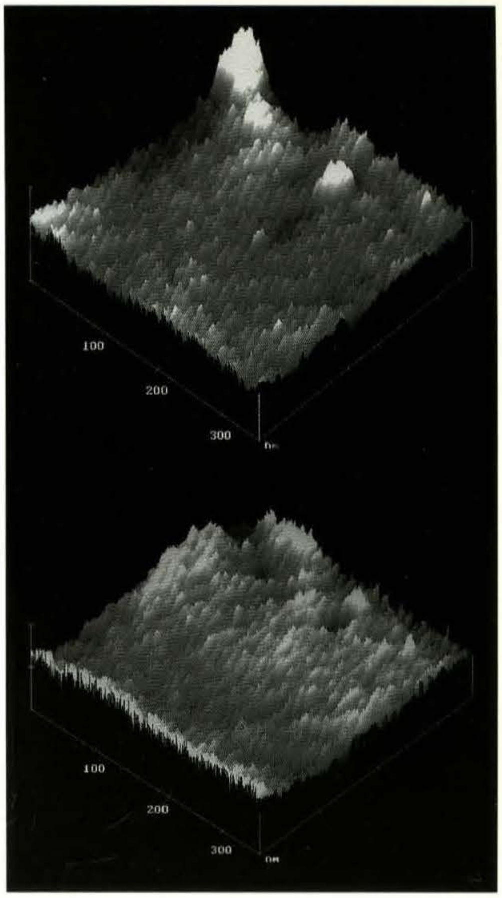
The metal complexes, stacked near each end of the DNA double helix, are separated by 40 angstroms, which in molecular dimensions is a large distance for the electron to travel—so large that the researchers concluded the DNA double helix must serve as a "wire" between them. The scientists believe that when the ultraviolet light excites a ruthenium atom, it shoots an electron down the electron-cloud stacks to the other end where the rhodium atom then acts as an electron acceptor, and turns off the glow.

The next question is whether or not this is a reaction nature has taken advantage of, or maybe needs to protect against. The Caltech group's efforts to answer such questions may create a whole new approach to the design of DNA-based diagnostics. Such efforts may also help build a better understanding of DNA structure and its reactions.

Pictured is a computer-generated macromolecular assembly of the DNA double helix. The actual modified DNA strands were made in the Noyes Laboratory, and each contained a short (15 base) strand of DNA with a complex of ruthenium or rhodium (metal complex) attached to each end.



Revolutionizing electronics for the 21st century



The top image, pictured on the atomic scale, shows a surface of gold deposited on a silicon wafer. The bottom image demonstrates the electrical current fluctuation of the gold-silicon interface.

The engineering of structures on the atomic scale promises to be the cornerstone of electronics and electro-optical devices of the 21st century. Scientists at Caltech are developing new solid state diodes that emit light in the blue and green, new materials ideal for detecting and emitting light at wavelengths below the visible, and a whole new set of electronic devices that may extend the wonders of the electronic revolution of the 1990s well into the next century. Extending the available colors of light sources from the red only to the green and blue will allow applications as diverse as stop lights and CD players, in addition to television sets, computer monitors, and film recorders.

The 1990s may be the decade of the "incredible shrinking device." Today's electronic devices, based largely upon silicon semiconductors, have been shrinking in size dramatically, leading to a rapid expansion of the electronics industry. If this microdevice revolution is to continue into the next century, when many industry analysts predict a new technology will have to come into place, it will open paths to even greater size reduction.

Scientists at Caltech are leading the "evolution" of this new technology by developing novel microdevices—many of which do not use silicon. More than 10 new devices have been developed. These microdevices perform feats from enabling a camera to "see" three-dimensional objects, to recording ultra-high-resolution color images on film, to allowing a computer to store a thousand times more data in its memory than any existing silicon-based RAM.

Such microdevices do not yet exist in the commercial realm. However, to illustrate the usefulness of microdevices, Caltech researchers this past spring made significant advances by creating a prototype transistorless computer memory (known as Static Random Access Memory, or S-RAM). Current computer memories use millions of transistors, with roughly 10 million transistors on a single chip. The transistorless S-RAM is now patent pending. These same researchers are also developing a version of non-silicon based chips that can allow a machine to "see." These chips can handle images with hundreds of times more detail than their silicon counterparts. The scientists' goal is to create microdevices, which can be made as small as 1/100th the size of the standard transistors, and to develop devices that can replace many transistors.

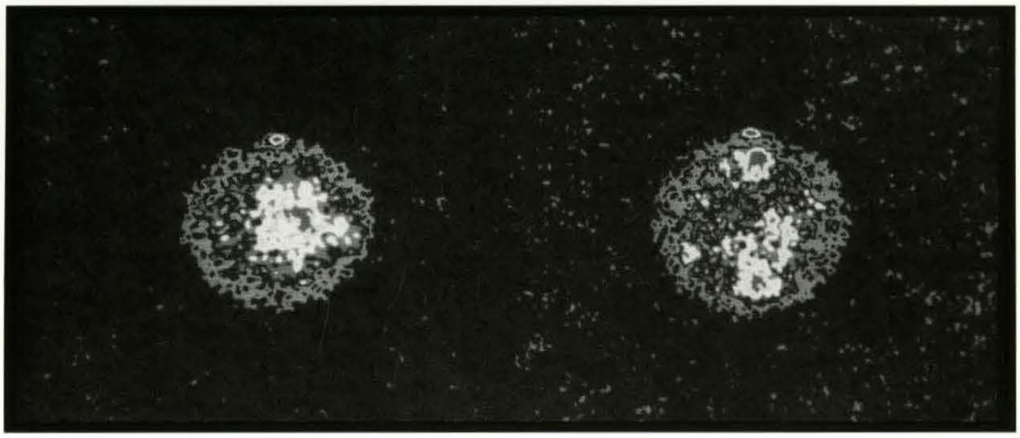
The turning point for creating such unusual technology came when researchers introduced "exotic" substances, such as gallium arsenide and gallium antimonide, cadmium selenide, and zinc teluride. These semiconductors enable a wide variety of microstructures to be grown. This large catalog of microstructures allows the engineering of very specific device structures that will continue to provide the new wonders of electronics.

Ice discovered on scorching-hot planet

Ice is common in our solar system, especially far from the sun on the cold moons of Jupiter and the other outer planets. But a team of scientists from Caltech and JPL has found evidence of ice on the small, rocky planet nearest the sun, where equatorial temperatures are hot enough to melt a soda-pop can. Using radar to study the planet's surface, the team has shown that it is possible for water to migrate to Mercury's poles, and that water ice is stable and will remain there for billions of years.

Icy surfaces can exist on scorching-hot Mercury because the planet has no seasons and a very thin atmosphere. The tilt of the Earth's axis alternately exposes its north and south poles to warming sunlight. But because Mercury's axis is perpendicular to its orbital plane, the sun is always overhead at the equator and on the horizon at the poles. Therefore, the slightest depression in the ground near the poles is in permanent shadow. Mercury's surface temperatures at the poles may be as cold as 125 kelvins (-235° Fahrenheit). That is clearly cold enough to retain frozen water, but where would water come from on this parched planet? Scientists theorize that some has accumulated from space matter (asteroids and comets), which contains water molecules and has been bombarding Mercury for billions of years. In addition, gases in the sparse atmosphere could freeze and "snow" onto the ground, where the snow could remain for the lifetime of the solar system.

Radar images of Mercury made with the Very Large Array (VLA). The image on the right was made after Mercury had rotated about 100 degrees. The brightest feature in both images lies on the planet's north pole and has been interpreted as arising from ice deposits in permanently shadowed craters.



The Caltech–JPL scientists used a radio technique called *earth rotation synthesis,* which uses radar waves as a flashlight to "light up" shadowed areas that cannot be photographed in visible light. These scientists examined sections of Mercury that were missed when the Mariner 10 spacecraft mapped about half the surface in the mid-1970s. In their study, the radio astronomers noted the existence of highly radar-reflective regions near both poles of Mercury. The scientists proposed that, based on the details of radio waves reflected, these are most likely composed of water ice. Their study also found three large, moderately reflective areas at lower latitudes, which are not ice formations, but rather "backscatter," or "radar basins." The research team interpreted these large splotches as possible impact craters. The rough ground in a crater would reflect radar better than the smooth surrounding surface.

The researchers hope these findings will encourage extensive investigation into the radar properties of cold, icy surfaces, and have scheduled an observation with the Very Large Array near Socorro, New Mexico, for March 1994 to look at the south pole of Mercury. They continue to study ice caps on Mars and to explore further Saturn's largest icy moon, Titan.

Southern California — a social research lab?

With its rich blend of cultures and races, Southern California is considered by many authorities to be a harbinger of 21st-century civilization. But surprisingly little is known about the political, racial, and cultural dynamics of this complex region. To bridge the gap in knowledge, Caltech professors last fall founded the Race, Politics, and Region (RPR) Program.

The interdisciplinary program consists of three main components—research, education, and community interaction—and supports visiting scholars from a variety of disciplines, including political science, history, sociology, and anthropology. RPR's objective is to bring scholarly research to bear on local problems, not only as a means of better understanding race relations and ethnic politics in Southern California, but also as a way of discerning broader social and political trends in modern America.

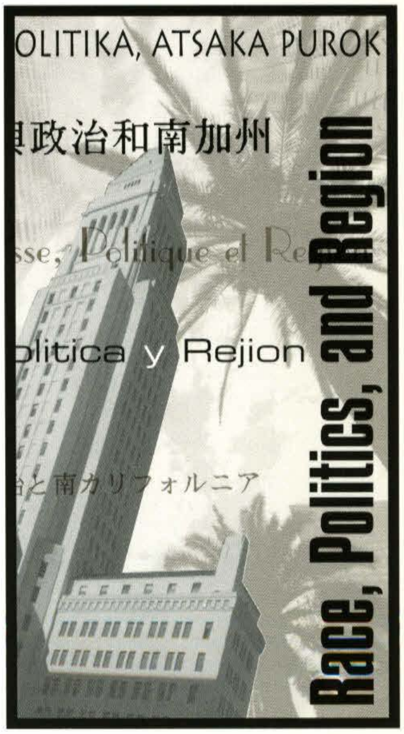
Initially, RPR will concentrate on Southern California as its social research laboratory, and will place particular emphasis on political developments. In this way, RPR organizers hope to build a program that can speak directly to the concerns of their local region and be a model for similar programs throughout the United States.

One of the most visible aspects of the program is the RPR seminar series. This series brings together academic researchers, public officials, and the larger Southern California community. Speakers have included internationally recognized scholars in race relations, as well as such notable political figures as Los Angeles County Supervisor Gloria Molina and Congressman Esteban Torres. Open to the public, the RPR seminars have attracted large and enthusiastic audiences.

The origin of RPR stems in part from remarks made by Caltech's President Everhart at the 1992 commencement exercises, held shortly after the riots in Los Angeles. Dr. Everhart said that the Institute had a responsibility to address the social, economic, and political problems that fueled such destruction. These comments prompted discussions among Humanities and Social Sciences faculty, which resulted in the formation of RPR.

RPR is now planning a major new research initiative on ethnic political representation in Southern California. Researchers will explore the political participation of minority ethnic groups in the past, and the set of new issues surrounding minority political representation that have been raised by recent changes in federal voting rights laws and by recent legal cases. The RPR directors also plan to hold symposia on politics and race, and to expand the Institute's curriculum in ethnic studies.

Caltech's "Race, Politics, and Region" Program name is translated into a sampling of the multitude of languages spoken in Southern California—a region that many authorities believe reflects the increasingly multiracial and urban Western world of the future.



Keck captures image of farthest galaxy known

Modern cosmologists believe the universe started about 15 billion years ago with the Big Bang, but the exact cause of that event, plus much of what happened following it, remains a mystery. This past spring, Caltech scientists came closer to seeing into the dawn of the cosmos than ever before, while conducting the first scientific test of the 10-meter Keck Telescope. In this maiden run, the most powerful optical and infrared telescope in the world enabled astronomers to take a picture of the most distant known galaxy, as well as several previously unseen "clumps" around it that may be a cluster of other galaxies. In capturing this image, astronomers saw matter as it appeared about 3 billion years after the Big Bang.

Caltech scientists estimate that the light we now see from galaxy 4C41.17 left it when the universe was only 10–25 percent of its current age. By analyzing the galaxy's spectrum, they determined that it has a redshift of 3.8; this translates into a "look-back time"—and distance from Earth—of about 12 billion light-years, or 72 trillion billion miles.

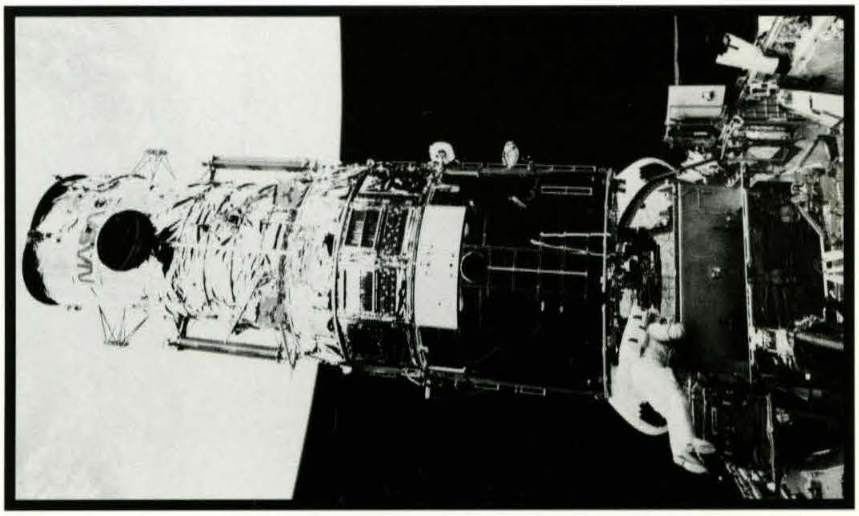
Galaxies have been studied for a long time, but no telescope—until Keck—had been able to capture the details of extremely faint, faraway ones in a reasonable amount of time. With its "outstanding combination of telescope and camera," Keck was able to record the previously unseen objects near the galaxy in only half an hour.

At the heart of the telescope is the high-tech mirror and instrument. Keck's mirror is a revolutionary mosaic design made up of 36 hexagonal segments, all computer-controlled to act as one. This sort of mirror has never been used before in an optical telescope. The instrument that recorded the images—the near-infrared camera (NIRC)—is the first scientific instrument to have been mounted on the Keck. Designed and built at Caltech, and using a state-of-the-art infrared sensor provided by Santa Barbara Research Center, the camera has high spatial resolution. Its sensitivity is vastly greater than any of its predecessors.

The NIRC had a successful "commissioning" run on the Keck Telescope in November 1993, and nearly all the capabilities that were built into the instrument were tested. As of January 1994, the NIRC became the second instrument to be used on a regular basis on the Keck Telescope. The first instrument, a high-resolution optical spectrograph, began regular observations in November 1993. The observations with the NIRC and the other focal plane instruments will be crucial in furthering our understanding of the early universe.

On its first scientific run, Keck Telescope enabled astronomers to undertake the most ambitious exploration of the outer limits of our universe—capturing an unprecedented image of the most distant known galaxy.

Shown outside the Hubble Space Telescope is a member of the team of astronauts from the space shuttle Endeavour. The team installed JPL's Wide-Field and Planetary Camera II , a second-generation camera for the Hubble.



The year 1993 proved to be challenging for the Jet Propulsion Laboratory, with a number of projects marking important milestones.

In December, spacewalking astronauts installed JPL's Wide-Field and Planetary Camera II, a second-generation camera for the Hubble Space Telescope. WFPC II incorporates special optics designed to compensate for the spherical aberration in the Hubble telescope's main mirror.

The Jupiter-bound Galileo spacecraft, meanwhile, met another objective with its August flyby of the asteroid Ida. Galileo previously flew by another asteroid, Gaspra, in 1991. Launched in 1989, the spacecraft is due to enter Jupiter orbit in December 1995 and deliver a descent probe into the giant planet's turbulent atmosphere.

After a highly successful orbital tour making radar maps of the surface of Venus, the Magellan spacecraft embarked on a new scientific direction when its orbit was lowered beginning in May, so that the spacecraft could study the planet's gravity field. The lower orbit allowed Magellan to measure Venus's gravity more accurately at higher northern and southern latitudes.

The joint U.S.–European Space Agency spacecraft Ulysses, launched in 1990, progressed toward its 1994 encounter of the sun's southern polar region. In 1995 the spacecraft will encounter the region of the sun's north pole.

The long-lived Voyager mission to the outer planets returned new results in 1993 when scientists reported that the two spacecraft had detected the first evidence of the long-sought-after heliopause—the boundary that separates the solar system from interstellar space. The evidence was in the form of intense radio emissions that scientists believe were caused by the interaction of plasmas, which flow from the sun, and cold interstellar gas beyond the heliopause.

The joint U.S.–French TOPEX/Poseidon spacecraft was also keeping researchers busy as its mission studying ocean sea-level changes from Earth orbit continued following its August 1992 launch. In 1993 scientists affiliated with the mission released findings of a recurrence of the El Niño phenomenon in the Pacific Ocean.

One difficult note in the year was the Mars Observer mission. Following a launch in September 1992, contact was lost with the spacecraft shortly before it was to enter Mars orbit in August 1993. As the year ended, JPL planners were studying possible future missions for achieving Mars Observer's science objectives.

Before that loss, however, the Mars Observer spacecraft was able to participate with Galileo and Ulysses in a three-mission experiment to search for signs of gravitational waves. For three weeks in March and April, researchers looked for slight changes in the frequency of radio signals sent to the trio of spacecraft. Any such frequency shift could be caused by a passing gravitational wave emitted by a collapsing black hole or other distant celestial event.

National awards and honors

American Academy of Arts and Sciences, Fellow:
Roger D. Blandford, *Richard Chace Tolman Professor of Theoretical Astrophysics and Executive Officer for Astronomy*
Ahmed H. Zewail, *Linus Pauling Professor of Chemical Physics*

American Association for the Advancement of Science, Fellow:
Dennis A. Dougherty, *Professor of Chemistry*
Paul W. Sternberg, *Associate Professor of Biology and Associate Investigator, Howard Hughes Medical Institute*
Edward C. Stone, *Vice President; Director of JPL; Professor of Physics*
Rochus E. Vogt, *R. Stanton Avery Distinguished Service Professor and Professor of Physics; Director, Laser Interferometer Gravitational-wave Observatory Project*

Department of Energy, Enrico Fermi Award:
Harold Brown, *President Emeritus and Trustee*

National Academy of Engineering, Member:
Manfred Morari, *Ross McCollum–William H. Corcoran Professor of Chemical Engineering and Executive Officer for Engineering and Applied Science*
Fredric Raichlen, *Professor of Civil Engineering*

National Academy of Sciences, Member:
Richard D. McKelvey, *Professor of Political Science*

National Academy of Sciences,
Arthur L. Day Prize and Lectureship:
Hiroo Kanamori, *John E. and Hazel S. Smits Professor of Geophysics and Director of the Seismological Laboratory*

National Medal of Technology, Recipient:
Hans W. Liepmann, *Theodore von Kármán Professor of Aeronautics, Emeritus*

National Science Foundation,
Presidential Faculty Fellow:
Gilles J. Laurent, *Assistant Professor of Biology and Computational and Neural Systems*

State honors

California Museum of Science and Industry,
Scientist of the Year:
Hiroo Kanamori, *John E. and Hazel S. Smits Professor of Geophysics and Director of the Seismological Laboratory*

International awards and honors

Association François-Xavier Bagnoud,
François-Xavier Bagnoud Aerospace Prize:
William H. Pickering, *Professor of Electrical Engineering, Emeritus*

Geological Society, Wollaston Medal:
Samuel Epstein, *William E. Leonhard Professor of Geology, Emeritus*

Indian Academy of Sciences, Raman Chair:
Anatol Roshko, *Theodore von Kármán Professor of Aeronautics*

Royal Astronomical Society, Gold Medal:
Peter M. Goldreich, *Lee A. DuBridge Professor of Astrophysics and Planetary Physics*

Royal Society, Fellow:
David J. Stevenson, *Professor of Planetary Science and Chairman of the Division of Geological and Planetary Sciences*

Royal Society of Canada, Foreign Fellow:
Rudolph A. Marcus, *Arthur Amos Noyes Professor of Chemistry*

Royal Swedish Academy of Science,
Crafoord Prize, Corecipient:
Seymour Benzer, *James G. Boswell Professor of Neuroscience, Emeritus*

Wolf Foundation Prize in Chemistry, Recipient:
Ahmed H. Zewail, *Linus Pauling Professor of Chemical Physics*

Awards and honors from professional societies

American Academy of Achievement, Gold Plate Award:
Rudolph A. Marcus, *Arthur Amos Noyes Professor of Chemistry*

American Association for Aerosol Research,
David Sinclair Award:
Richard C. Flagan, *Professor of Chemical Engineering*

American Association of University Women,
Recognition Award for Emerging Scholars:
Julia A. Kornfield, *Assistant Professor of Chemical Engineering*

American Chemical Society,
1993 Arthur C. Cope Award:
Peter B. Dervan, *Bren Professor of Chemistry*

American Chemical Society,
1994 Arthur C. Cope Award:
John D. Roberts, *Institute Professor of Chemistry, Emeritus*

American Chemical Society, Willard Gibbs Medal:
Peter B. Dervan, *Bren Professor of Chemistry*

American Chemical Society (New York Section),
Nichols Medal:
Peter B. Dervan, *Bren Professor of Chemistry*

American Physical Society, Fluid Dynamics Prize:
Theodore Yao-Tsu Wu, *Professor of Engineering Science*

American Physical Society, Earle K. Plyler Prize:
Ahmed H. Zewail, *Linus Pauling Professor of Chemical Physics*

American Society for Engineering Education,
Fellow Member:
Thomas E. Everhart, *President; Professor of Electrical Engineering and Applied Physics*

American Society for Engineering Education,
Curtis W. McGraw Research Award:
John F. Brady, *Professor of Chemical Engineering and Executive Officer for Chemical Engineering*

American Society for Information Science,
James M. Cretsos Leadership Award:
Vivian A. Hay, *Library Systems Administrator*

American Society of Mechanical Engineers,
Pi Tau Sigma Medal:
Melany L. Hunt, *Assistant Professor of Mechanical Engineering*

Genetics Society of America,
Thomas Hunt Morgan Medal:
Ray D. Owen, *Professor of Biology, Emeritus*

Geological Society of America, Arthur L. Day Medal:
Hugh P. Taylor, Jr., *Robert P. Sharp Professor of Geology and Executive Officer for Geology*

***Hadassah Magazine*,** Harold U. Ribalow Prize:
Merrill Joan Gerber, *Lecturer in Creative Writing*

Institute of Electrical and Electronics Engineers, Fellow:
David B. Rutledge, *Professor of Electrical Engineering*

Institute of Electrical and Electronics Engineers,
Medal of Honor:
Karl J. Åström, *Sherman Fairchild Distinguished Scholar*

***The Journal of Economic History*,** Arthur H. Cole Prize:
Philip T. Hoffman, *Associate Professor of History and Social Science*

Pasadena Area Youth Music Council,
Music Educators of the Year:
Delores Bing, *Director of Chamber Music*
William Bing, *Director of Instrumental Music*

The Society for Experimental Mechanics,
Hetényi Award:
Ares J. Rosakis, *Professor of Aeronautics and Applied Mechanics*

Foundation awards

Rita Allen Foundation, Scholar Award:
Stephen L. Mayo, *Assistant Professor of Biology*

Arnold and Mabel Beckman Foundation,
Young Investigator Award:
Erick M. Carreira, *Assistant Professor of Chemistry*

Camille and Henry Dreyfus Foundation,
New Faculty Award:
Konstantinos P. Giapis, *Assistant Professor of Chemical Engineering*

Camille and Henry Dreyfus Foundation,
Teacher-Scholar Award:
Barbara Imperiali, *Assistant Professor of Chemistry*

John Randolph Haynes and Dora Haynes Foundation,
Faculty Fellowship:
Douglas Flamming, *Assistant Professor of History*

David and Lucile Packard Foundation,
Faculty Fellowship:
Stephen L. Mayo, *Assistant Professor of Biology*

Alfred P. Sloan Foundation, Research Fellow:
Barbara Imperiali, *Assistant Professor of Chemistry*
Tomasz S. Mrowka, *Associate Professor of Mathematics*

University honors

University of Alabama, Madison Marshall Award:
Jacqueline K. Barton, *Professor of Chemistry*

University of California, Los Angeles;
Professional Achievement Award:
Thomas E. Everhart, *President; Professor of Electrical Engineering and Applied Physics*

University of Chicago,
Distinguished Alumni Award for Public Service:
Edwin S. Munger, *Professor of Geography, Emeritus*

Cornell University, Philip Taft Labor History Prize:
Douglas Flamming, *Assistant Professor of History*

University of Wisconsin, Whitewater;
Outstanding Recent Alumni Award:
Richard A. Leske, *Research Fellow in Physics*

Institute honors

Distinguished Alumni Awards:
Trent R. Dames '33, MS '34
Philip Mwangi Githinji, MS '61, Eng '63
Thomas Hudspeth '41
John McCarthy '48
William W. Moore '33, MS '34
Stephen A. Ross '65
Alvin V. Tollestrup, PhD '50

Endowed Professorship:
John E. Bercaw, *Centennial Professor of Chemistry*
Mark E. Davis, *Warren and Katharine Schlinger Professor of Chemical Engineering*
James H. Strauss, *Ethel Wilson Bowles and Robert Bowles Professor of Biology*

Associated Students of the California Institute of Technology (ASCIT),
Award for Teaching Excellence:
William F. Deverell, *Visiting Assistant Professor of History*
Marcia B. France, *Graduate Student in Chemistry*
Glen A. George, *Lecturer in Computer Science and Electrical Engineering*
Henry A. Lester, *Professor of Biology*
Mary E. Lidstrom, *Professor of Applied Microbiology*
Anthony C. S. Readhead, *Professor of Astronomy*
Sima Setayeshgar, *Graduate Student in Physics*
Hunter S. Snevily, *Bateman Research Instructor in Mathematics*
Edward E. Zukoski, *Professor of Jet Propulsion and Mechanical Engineering*

Graduate Student Council,
Awards of Excellence in Teaching:
James K. Knowles, *William R. Kenan, Jr., Professor and Professor of Applied Mechanics*
Charles W. Peck, *Professor of Physics and Chairman of the Division of Physics, Mathematics and Astronomy*
David J. Stevenson, *Professor of Planetary Science and Chairman of the Division of Geological and Planetary Sciences*
P. P. Vaidyanathan, *Professor of Electrical Engineering*

This financial report of the California Institute of Technology has been prepared from the Institute's accounting records. It reflects the Institute's financial position as of September 30, 1993, and the results of its operations for the year then ended. These statements have been reviewed by the Audit Committee of the Board of Trustees, whose members are designated by an asterisk in the list of board members in the back of this report. The California Institute of Technology maintains its accounts in accordance with the guidelines suggested by the American Institute of Certified Public Accountants and the National Association of College and University Business Officers.

The Institute maintained its strong financial position during fiscal year 1993 despite the current national economic environment. Caltech owes this strength to a substantial endowment fund and sound investment policies. The exceptional quality of its teaching and research programs continues to generate strong support from private donors and government funding agencies. The following are highlights of fiscal year 1993.

■ Individuals, foundations, and corporations have continued to generously support the Institute. Contributions received through the Campaign for Caltech during fiscal year 1993 totaled $55.9 million. At the conclusion of the campaign in December 1993, total contributions raised, including pledges, amounted to more than $394 million, substantially exceeding the campaign goal of $350 million.

■ United States government contracts and grants at the campus totaled $111.2 million, as compared with $106.1 million in fiscal year 1992. Of that amount, $81.7 million was for costs that directly relate to specific research projects. The balance of $29.5 million was recovery of indirect costs, such as facilities operation and maintenance, utilities, libraries, and support staff that cannot be directly attributed to specific research projects. Caltech continued to experience moderate growth in this area despite significant reductions in the overall growth rate of federal research budgets and increasing competition for these limited funds.

(in millions)

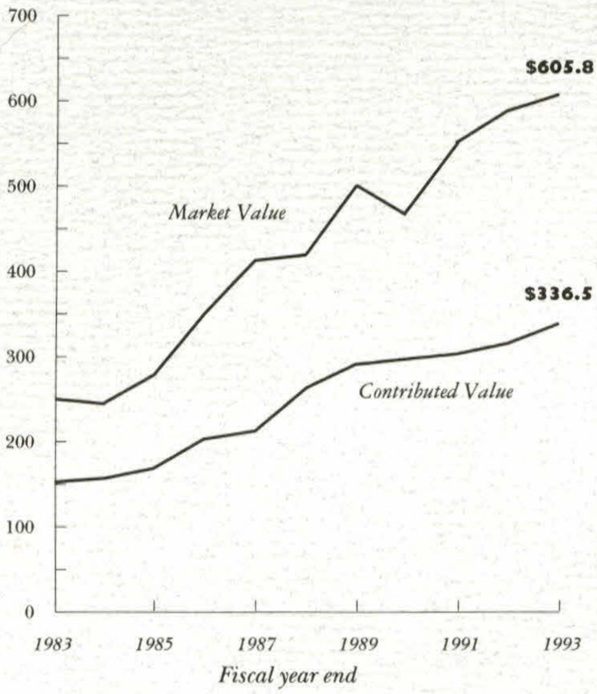
	1983	1988	1993
Operating expenditures			
Instruction and departmental research	$ 37.7	$ 52.4	$ 85.6
Organized research	36.8	65.7	82.5
Scholarships and fellowships	5.1	8.4	15.3
Institutional and student support	14.3	24.7	39.9
Plant operation, maintenance, and utilities	9.6	12.6	16.0
Total educational and general	$ 103.5	$ 163.8	$ 239.3
Auxiliary enterprises	4.5	7.1	9.6
Total campus	$ 108.0	$ 170.9	$ 248.9
Inflation adjusted (1983 dollars)	$ 108.0	$ 143.5	$ 173.8
Jet Propulsion Laboratory direct expenditures	$ 425.2	$1,019.3	$1,086.1
Endowment and Similar Funds			
Market value	$ 248.3	$ 424.0	$ 605.8
Total return (5 year average)	13.6%	11.8%	11.4%
Campus Properties			
New construction	$ 2.4	$ 31.5	$ 34.4
Renovations and alterations	4.3	9.6	15.6
Maintenance and repairs	3.0	3.6	4.8
Gifts, Grants, and Bequests			
For current operations	$ 18.1	$ 30.3	$ 24.2
For endowment	3.0	41.2	12.5
For facilities	2.9	30.5	10.8
For life income and annuity	1.0	3.7	8.4
Student Information			
Tuition rate (in thousands)	$ 7.5	$ 11.1	$ 15.0
Enrollment (first term)			
Undergraduate	874	859	912
Graduate	936	963	1,109
Total	1,810	1,822	2,021
Grant aid as a percentage of total costs for undergraduate students	41.0%	47.7%	52.7%
Student loans granted	$ .7	$ 1.0	$ 2.2
Student loans outstanding	4.7	7.0	11.0
Degrees granted			
B.S.	205	184	220
M.S.	154	123	160
Eng.	1	—	4
Ph. D.	136	146	158
Total	496	453	542

■ The market value of Caltech's endowment at September 30, 1993, was $605.8 million, compared to $580.5 million at September 30, 1992. The fund is sizable for a small institution such as Caltech with a current undergraduate and graduate student body of just over 2,000.

The following graph shows the growth in endowment over the last ten years:

ENDOWMENT

Millions of dollars



Income from endowment totaled $21.8 million, of which $15.0 million was derived from restricted and $6.8 million from unrestricted funds.

The endowment investment policy of the Institute is to: 1) provide income to support Institute operations, 2) achieve long-term appreciation of assets, and 3) preserve endowment principal. With this policy, the Institute endeavors to provide a stream of investment return which, after inflation, will strike a fair balance between current and future support of its instruction and research programs.

■ The market value of the life income and annuity funds was $104.8 million at September 30, 1993, compared with $93.4 million at September 30, 1992, a 12 percent increase. Life income and annuity agreements are a source of meaningful additions to the Institute's endowment and other funds. This form of deferred giving has proved attractive to many donors who wish to support the activities of the Institute. Donors receive income on their gifts during their lifetime while also obtaining a charitable tax deduction for their gifts.

Year ended September 30, 1993
(in thousands)

Additions
(Excluding Reimbursement of Direct Costs at the Jet Propulsion Laboratory)

United States Government Grants and Contracts	Reimbursement from various government agencies for direct costs of research, instruction, and student support.	$ 81,676
Plant Acquisitions	Additions to campus plant for land, buildings, and equipment, and retirement of indebtedness.	74,785
Gifts and Nongovernment Grants	Includes gifts and grants from private sources for education and research, and physical facilities.	61,448
Indirect Costs and Management Allowance	Recovery of indirect costs and management allowance under federally sponsored programs at the campus and the Jet Propulsion Laboratory.	53,484
Realized Gains	Net realized gains on investments sold.	38,627
Investment Income	Endowment income and investment income of other funds, including earnings from short-term investments.	32,522
Tuition and Fees	Tuition and fees assessed students.	29,539
Auxiliary Enterprises	Revenues from sales by food services, student housing, and bookstore.	11,350
Other	Income from sales and services, and other miscellaneous revenue.	10,639
Total Additions		$ 394,070

Deductions
(Excluding Direct Costs at the Jet Propulsion Laboratory)

Instruction	Expenditures for activities that are part of the instructional program, including departmental research.	$ 85,589
Research	Expenditures for activities specifically organized to produce research outcomes supported by federal and private sponsors.	82,481
Plant Fund	Expenditures for buildings, equipment, and renewals, plus retirement of plant assets.	59,944
	Payments on revenue bonds and advances for plant purposes, including interest.	6,274
	Depreciation of campus properties.	22,618
Institutional and Student Support	Expenditures for business and financial affairs, student services, Institute relations, and general administration.	39,912
Plant Operations	Expenditures, including utilities, for the operation and maintenance of the campus grounds and facilities.	15,992
Scholarships and Fellowships	Awards made to students enrolled in formal course work with no requirement that they perform services or repay the awards.	15,303
Auxiliary Enterprises	Expenditures, including maintenance, of auxiliary enterprises.	9,672
Other	Includes payments to life beneficiaries with life income and annuity agreements, and miscellaneous other charges.	5,889
Total Deductions		$ 343,674
Increase in Fund Balances		50,396
Total		$ 394,070

■ Total net assets increased from $988.4 million to $1,038.8 million due primarily to increases in endowment principal and Phase II construction of the W.M. Keck Observatory in Hawaii, scheduled for completion in 1996.

■ Caltech provided $15.3 million in scholarships and fellowships, a 7 percent increase over the previous year. The cost of a Caltech education would be beyond the means of many qualified students without grant and loan assistance. Of the total spent for student aid at Caltech, 28 percent came from government sources and 72 percent came from Caltech funds. Caltech's contribution permits the Institute to continue its policy of admitting students based on their merit and promise rather than on their ability to pay. Increasing endowment for student aid and fellowships continues to be a major objective for Caltech.

The following pages present a Balance Sheet, Statement of Changes in Fund Balances, and Statement of Operating Expenditures, along with Notes to Financial Statements, which comprise the Institute's formal financial statements. They provide more detail about the status at fiscal year-end and transactions during the fiscal year. Also included is Price Waterhouse's Report of Independent Accountants.

David W. Morrisroe
Vice President for Business and Finance and Treasurer

BALANCE SHEET

September 30, 1992

(in thousands)

Exhibit 1

		Total All Funds
ASSETS		
Cash	$	369
Accounts receivable:		
United States government (note B)		172,196
Pledges (note G)		47,550
Other		1,386
Student accounts and notes receivable		14,667
Investments (note C)		613,660
Interfund advances		
Prepaid expenses and other assets		11,156
Campus properties net of depreciation (note D)		390,119
Total Assets	**$**	**1,251,103**
LIABILITIES AND FUND BALANCES		
Accounts payable and accrued expenses (note B)	$	181,018
Deferred student revenue		11,275
Revocable trust funds and agency funds (note E)		17,642
Annuities payable		2,728
Revenue bonds payable (note H)		50,000
Total Liabilities	**$**	**262,663**
Fund balances (Exhibit 2)		988,440
Total Liabilities and Fund Balances	**$**	**1,251,103**
Fund balances detail:		
United States government refundable	$	5,387
Institute funds:		
Unrestricted		16,071
Discretionary endowment:		
Unrestricted		63,114
Restricted		68,773
Endowment principal		320,980
Other restricted		179,920
Invested in plant		334,195
Total Fund Balances	**$**	**988,440**

See accompanying notes to financial statements

September 30, 1993

Total All Funds	— Current Funds — Unrestricted	Restricted	Loan Funds	Endowment and Similar Funds	Life Income and Annuity Funds	Plant Funds	Agency Funds
$ 550	$ 67	$ 180	$ 12		$ 108		$ 183
194,631		194,631					
24,975		6,750				$ 18,225	
1,220	820	133	3		146		118
14,701	3,883	10	10,808				
630,186	12,528	1,100	2,253	$ 471,689	84,559	55,687	2,370
		19,315		4,387		(23,702)	
13,912	7,125	3,692				3,087	8
435,672						435,672	
$ 1,315,847	**$ 24,423**	**$ 225,811**	**$ 13,076**	**$ 476,076**	**$ 84,813**	**$ 488,969**	**$ 2,679**
$ 192,545	$ 7,424	$ 183,074		$ 355	$ 318	$ 1,341	$ 33
12,218	12,132	86					
18,627					15,981		2,646
4,521					4,521		
49,100						49,100	
$ 277,011	**$ 19,556**	**$ 183,160**		**$ 355**	**$ 20,820**	**$ 50,441**	**$ 2,679**
1,038,836	4,867	42,651	$ 13,076	475,721	63,993	438,528	
$ 1,315,847	**$ 24,423**	**$ 225,811**	**$ 13,076**	**$ 476,076**	**$ 84,813**	**$ 488,969**	**$ 2,679**
$ 5,798			$ 5,798				
18,666	$ 4,867					$ 13,799	
64,448				$ 64,448			
67,210				67,210			
344,063				344,063			
172,918		$ 42,651	7,278		$ 63,993	58,996	
365,733						365,733	
$ 1,038,836	**$ 4,867**	**$ 42,651**	**$ 13,076**	**$ 475,721**	**$ 63,993**	**$ 438,528**	

STATEMENT OF CHANGES IN FUND BALANCES

Exhibit 2

(in thousands)

	Year Ended September 30, 1992 *Total All Funds*
Fund Balances at Beginning of Year	**$ 958,898**
REVENUES AND OTHER ADDITIONS	
Student tuition and fees	$ 26,868
Investment income	35,515
Net gain on disposal of investments	10,933
Gifts	56,506
United States government grants and contracts:	
Reimbursement of direct costs	77,762
Recovery of indirect costs and management allowance	50,618
Other grants and contracts	4,879
Auxiliary enterprises revenues	11,180
United States government advances	447
Campus property acquisitions (including $23,095 in campus operating expenditures)	62,988
Retirement of indebtedness and internal advances	473
Other	9,946
Total Revenues and Other Additions	**$ 348,115**
EXPENDITURES AND OTHER DEDUCTIONS	
Campus operating expenditures (Exhibit 3)	$ (236,634)
Campus property acquisitions and renewals	(46,656)
Retirement of indebtedness and internal advances	(473)
Retirement and disposal of campus properties	(4,266)
Interest on advances for plant purposes	(1,752)
Interest on revenue bonds payable	(3,006)
Payment to life beneficiaries	(3,281)
Depreciation of campus properties	(20,631)
Other	(1,874)
Total Expenditures and Other Deductions	**$ (318,573)**
TRANSFERS AMONG FUNDS	
Gifts allocated	
Investment gains and discretionary endowment allocated	
Investment income allocated	
Allocations for plant purposes	
Terminated trust and annuity agreements	
Other	
Total Transfers Among Funds	
Increase for the Year	**$ 29,542**
Fund Balances at End of Year (Exhibit 1)	**$ 988,440**

See accompanying notes to financial statements

Year Ended
September 30, 1993

Total All Funds	*— Current Funds — Unrestricted*	*Restricted*	*Loan Funds*	*Endowment and Similar Funds*	*Life Income and Annuity Funds*	*Plant Funds*
$ 988,440	**$ 4,830**	**$ 41,473**	**$ 12,234**	**$452,867**	**$ 58,152**	**$418,884**
$ 29,539	$ 29,522					$ 17
32,522	9,462	$ 15,817	$ 350		$ 3,420	3,473
38,627				$ 28,051	1,624	8,952
55,935	7,383	16,815	6	12,545	8,370	10,816
81,676		81,378				298
53,484	53,484					
5,513	1,331	4,182				
11,350	11,350					
447			447			
73,402						73,402
1,383						1,383
10,192	2,548	7,002	180			462
$ 394,070	**$ 115,080**	**$ 125,194**	**$ 983**	**$ 40,596**	**$ 13,414**	**$ 98,803**
$ (248,949)	$ (123,036)	$ (125,913)				
(54,713)						$ (54,713)
(1,383)						(1,383)
(5,231)						(5,231)
(1,919)						(1,919)
(2,972)						(2,972)
(3,420)					$ (3,420)	
(22,618)						(22,618)
(2,469)			$ (187)		(2,282)	
$ (343,674)	**$ (123,036)**	**$ (125,913)**	**$ (187)**		**$ (5,702)**	**$ (88,836)**
	$ (1,601)	$ (139)		$ 1,740		
	16,495	4,088		(20,583)		
	3,781	(3,781)				
	(9,042)	138		(773)		$ 9,677
				1,871	$ (1,871)	
	(1,640)	1,591	$ 46	3		
	$ 7,993	**$ 1,897**	**$ 46**	**$ (17,742)**	**$ (1,871)**	**$ 9,677**
$ 50,396	**$ 37**	**$ 1,178**	**$ 842**	**$ 22,854**	**$ 5,841**	**$ 19,644**
$1,038,836	**$ 4,867**	**$ 42,651**	**$ 13,076**	**$475,721**	**$ 63,993**	**$438,528**

STATEMENT OF OPERATING EXPENDITURES

Exhibit 3

(in thousands)

	Year Ended September 30, 1992 Total	*Year Ended — September 30, 1993 — Total*	*Unrestricted*	*Restricted*
Educational and general:				
Instruction and departmental research	$ 81,666	$ 85,589	$ 53,832	$ 31,757
Organized research	79,929	82,481		82,481
Scholarships and fellowships	14,296	15,303	4,192	11,111
Institutional and student support	36,125	39,912	39,348	564
Plant operation, maintenance, and utilities	15,034	15,992	15,992	
Total Educational and General	**$ 227,050**	**$ 239,277**	**$ 113,364**	**$ 125,913**
Auxiliary enterprises	9,584	9,672	9,672	
Total Campus Operating Expenditures (Exhibit 2)	**$ 236,634**	**$ 248,949**	**$ 123,036**	**$ 125,913**
Direct Costs of Sponsored Research at Jet Propulsion Laboratory (fully reimbursed by the United States government)	**$ 1,124,305**	**$ 1,086,082**		

See accompanying notes to financial statements

September 30, 1993

NOTE A – SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Basis of Accounting and Reporting – The financial statements of the California Institute of Technology (the "Institute"), a not-for-profit educational organization, have been prepared in accordance with the principles of accrual basis fund accounting for colleges and universities. Under these principles, Institute resources are accounted for by use of separate funds so that visibility and control are maintained for the benefit of the Institute and its sponsors. Funds that have similar objectives and characteristics have been combined into fund groups. Within each fund group, fund balances restricted by outside sponsors for specific purposes are so indicated and distinguished from unrestricted funds available for use in achieving any Institute objective.

Investments – Institute investments are stated at their approximate market value at date of gift, or at cost if purchased by the Institute, less applicable amortization and depreciation of real estate, unless there has been an impairment of value not considered temporary (note C).

All investments of endowment and similar funds are carried in an investment pool unless special considerations or donor stipulations require they be held separately. Pool share values are computed periodically based upon the total market value of the investment pool and total number of pool shares invested.

Income on investments of endowment and similar funds is recorded as current fund revenues for the purposes specified by the donor. Such income is supplemented, where necessary, by transfers of additional amounts so as to result in a total return from the investment pool equivalent to 5% of the average market value of the pool over a three-year period. This total return concept is authorized by the California Uniform Management of Institutional Funds Act, which allows the prudent use of realized appreciation on investments, thus permitting greater flexibility in formulating investment strategies.

Campus Properties and Plant Funds – Campus properties are recorded at cost of construction or acquisition, or at appraisal value at date of gift, less accumulated depreciation, computed on a straight-line basis over the estimated useful lives (note D). The Institute provides for the renewal and replacement of its campus properties from funds designated for this purpose. Expenditures for maintenance and repairs are generally charged to current unrestricted funds as plant operation and maintenance expenditures.

Annuities – Annuities payable to certain donors of the Institute are recorded at the present value of the liability calculated under an actuarial method which takes into account the life expectancies of the recipients.

Jet Propulsion Laboratory – The Institute manages and operates the Jet Propulsion Laboratory (JPL) under a cost reimbursable contract with the National Aeronautics and Space Administration. JPL land, buildings, and equipment are owned by the United States government and excluded from the Institute's financial statements. However, liabilities arising from JPL activities are those of the Institute and reflected in its financial statements as are receivables arising from such activities (note B). The volume of activity at JPL is reflected in the Statement of Operating Expenditures (Exhibit 3).

Tax-Exempt Status – The Institute is a tax-exempt educational organization under federal and state income, gift, estate, and inheritance tax laws.

NOTE B – UNITED STATES GOVERNMENT CONTRACTS

The Institute has many contracts with the United States government that provide for reimbursement of costs incurred at JPL and the Campus. These contracts gave rise to a substantial portion of the accounts payable and accrued expenses in the current funds at September 30, 1993 and 1992, and in turn to accounts receivable from the United States government. Accounts payable and accrued expenses (and related receivables) for JPL amounted to approximately $181 million and $169 million at September 30, 1993 and 1992, respectively.

NOTE C – INVESTMENTS

Institute investments, at carrying (note A) and market (note J) values, comprise the following (in thousands):

	— September 30, —			
	— Carrying Values —		— Market Values —	
	1992	*1993*	*1992*	*1993*
Marketable securities:				
Debt securities	$ 244,218	$248,130	$ 260,286	$269,495
Equity securities	260,102	282,889	387,338	415,458
Total Marketable Securities	**$ 504,320**	**$531,019**	**$ 647,624**	**$684,953**
Short-term commercial obligations	46,161	38,722	43,741	38,767
Real estate, mortgages, notes, and other	63,179	60,445	101,664	102,340
Total Investments	**$ 613,660**	**$630,186**	**$ 793,029**	**$826,060**

Investments shown above include the consolidated investment pool assets as follows (in thousands, except per share values):

	— September 30, —	
	1992	*1993*
Carrying value	$ 401,436	$423,818
Market value	$ 523,373	$546,567
Pool share value at market	$ 23.02	$ 23.63
Annualized income earned per pool share	$ 0.95	$ 0.84

The Institute also manages a major foundation's investment portfolio with an approximate market value of $226 million at September 30, 1993. These investments are not included in the amounts shown above.

NOTE D – CAMPUS PROPERTIES AND PLANT FUNDS

Campus properties consist of the following (in thousands):

	— *September 30,* —	
	1992	*1993*
Land and land improvements	$ 20,761	$ 20,899
Buildings	311,721	279,277
Equipment	262,162	362,639
Campus Properties – cost	**$ 594,644**	**$ 662,815**
Less accumulated depreciation	(204,525)	(227,143)
Campus Properties – net	**$ 390,119**	**$ 435,672**

Depreciation has been calculated, using the straight line method, with life years of 20, 40, and 10 for land improvements, buildings, and equipment, respectively. Depreciation of $20.6 million was recorded for fiscal 1992 and $22.6 million for fiscal 1993.

In 1991, the W. M. Keck Foundation awarded the Institute $74.6 million toward the construction of a second telescope at the W. M. Keck Observatory in Hawaii. As of September 30, 1993, $56.4 million has been received and approximately $44.8 million expended and included in campus properties. The unexpended portion of $11.6 million is included in plant funds investments. The pledge balance of $18.2 million is shown as a receivable (note G).

NOTE E – FUNDS HELD IN TRUST

The Institute is the income beneficiary of certain funds, recorded at a nominal value, which are held in trust by others and had current market values, estimated by the Institute, of approximately $18.6 million and $18.5 million at September 30, 1993 and 1992, respectively. The income derived from these funds amounted to approximately $893 thousand and $796 thousand for the years ended September 30, 1993 and 1992, respectively. This income has been included as investment income in the Statement of Changes in Fund Balances (Exhibit 2).

In addition, the Institute is the trustee for several revocable trusts, valued at trustor's basis at date of establishment, or at cost, if purchased by the Institute, totaling $16.0 million and $15.1 million at September 30, 1993 and 1992, respectively, in which it has a remainder interest and makes income payments for life to the grantors of the trusts.

NOTE F – RETIREMENT PLANS

The Institute has three retirement plans covering substantially all of its employees that are funded by periodic transfers to the respective insurance companies. Academic and senior administrative staff are covered by a defined contribution pension plan, while non-academic staff are covered by two defined benefit pension plans. Retirement benefits under these defined benefit pension plans are based on years of service and career average compensation and accrue partially on a fixed dollar basis, and partially on a variable dollar basis. The Institute's defined benefit plan funding policy is to contribute amounts sufficient to maintain retirement plan assets at levels adequate to cover all accrued benefit liabilities. In addition, the Institute's defined benefit plans will be converted to new defined contribution plans effective January 1, 1994.

The net pension cost for the year ended September 30, 1993 and funded status at September 30, 1993 for the defined benefit plans are as follows (in thousands):

	Campus	*JPL*
NET PENSION COST		
Service cost – benefits earned during the year	$ 2,945	$ 12,486
Interest cost on projected benefit obligation	3,522	16,531
Actual return on plan assets	(4,045)	(19,006)
Net amortization and deferral	497	2,515
Net pension cost	**$ 2,919**	**$ 12,526**
FUNDED STATUS		
Actuarial present value of accumulated benefit obligations, including vested benefits of $72.4 million and $358.0 million, respectively	$ 73,725	$364,193
Projected benefit obligation	$ 79,300	$387,771
Plan assets at fair value	(71,973)	(353,356)
Projected benefit obligation in excess of plan assets	**$ 7,327**	**$ 34,415**
Unrecognized net gains/(losses)	(6,868)	(24,515)
Unrecognized net assets at October 1, 1987, being amortized over 16 and 18 years, respectively	53	539
Accrued pension cost	**$ 512**	**$ 10,439**

The weighted-average discount rate and assumed rate of increase in future compensation levels used in determining the actuarial present value of the projected benefit obligation are 6.5% (7.25% in 1992) and 5% (6% in 1992), respectively. The expected long-term rate of return on assets is 8%.

Pension costs for the defined contribution plan for academic and senior administrative staff for the year ended September 30, 1993 were $5.3 million for the Campus, and $19.8 million for JPL.

All pension costs for JPL are included in direct costs of sponsored research.

Deferred Compensation Plan – The Institute has an inactive deferred compensation plan whereunder eligible employees elected to defer a portion of their normal salary, generally until retirement. The Institute's liability for future benefits payable to employees under this plan, which approximated $31.8 million and $31.6 million at September 30, 1993 and 1992, respectively, is matched by Institute investments in an annuity contract with a major insurance company. It is expected that any payments by the Institute to employees would be matched by payments from the insurance company to the Institute. The amounts representing future benefits payable and the matching investments are not reflected in the financial statements.

NOTE G – PLEDGES

The Institute records as a receivable and as gift revenue in plant funds, unconditional pledges received with respect to funding of major construction projects approved by the Board of Trustees and deemed fully collectible. The Institute had $25.0 million in recorded pledges remaining to be collected as of September 30, 1993.

At September 30, 1993, the Institute had additional pledges on hand (principally for restricted purposes), but not recorded, totaling approximately $40.6 million, of which $12.8 million is expected to be collected in fiscal year 1994. It is not practicable to estimate the net realizable value of these pledges.

NOTE H – REVENUE BONDS PAYABLE

On May 29, 1991, the Institute issued $50 million in California Educational Facilities Authority Revenue Bonds for the purpose of financing and refinancing the acquisition, construction, and completion of certain educational facilities, and to advance refund the outstanding principal amount of the Institute's Series 1985 bonds. The Series 1991 bonds are repayable with interest, from the general revenues of the Institute over a 30-year period. Interest rates vary from 4.8% to 6.4%. Required principal and interest payments are approximately $4 million a year for the fiscal years 1992 through 2005, approximately $3 million a year for fiscal years 2006 through 2016, and approximately $2 million a year thereafter until 2021, when the bonds will be fully redeemed.

NOTE I – POSTRETIREMENT AND POSTEMPLOYMENT BENEFITS

The Institute provides certain health and life insurance benefits to retirees. In December 1990, the Financial Accounting Standards Board issued Standard No. 106, "Employers' Accounting for Postretirement Benefits Other Than Pensions." The standard is effective for the Institute's fiscal year 1994 and requires the accrual basis of accounting for recognizing the cost of postretirement benefits other than pensions. Based on the available actuarial evaluation, the Institute's unfunded accumulated postretirement obligation will approximate $47 million for the Campus and $156 million for JPL, of which it expects to recover approximately 50% and 100%, respectively, through future charges to United States government grants and contracts.

The Institute also provides certain benefits to former or inactive employees after employment. In November 1992, the Financial Accounting Standards Board issued Standard No. 112, "Employers' Accounting for Postemployment Benefits." The standard is effective for the Institute's fiscal year 1995 and requires the accrual basis of accounting for recognizing the cost of postemployment benefits. The Institute does not believe that implementation of this standard will have a material effect on its financial condition.

NOTE J – DISCLOSURES ABOUT FAIR VALUE OF FINANCIAL INSTRUMENTS

In December 1991, the Financial Accounting Standards Board issued Standard No. 107, "Disclosures about Fair Value of Financial Instruments." For those financial instruments for which it is practical, the following methods and assumptions were used to estimate the fair value:

Cash – The carrying value is the fair value.

Student Accounts and Notes Receivable – Due to the nature and terms of these financial instruments, which can be subject to significant restrictions, it is not practical to estimate their fair value.

Investments – The fair value of marketable securities and short-term commercial obligations is estimated based on quoted market prices for those or similar financial instruments. The fair value of real estate, mortgages, notes, and other investments is estimated by professional appraisers or Institute management.

Revenue Bonds Payable – The fair value of revenue bonds payable is estimated based on the quoted market prices for the bonds or similar financial instruments, and approximates the carrying value.

NOTE K – CONTINGENCIES

The Institute is a defendant in various legal actions incident to the conduct of its operations. The Institute's management does not expect that liabilities, if any, for these legal actions will have a material effect on the Institute's financial position.

Price Waterhouse

To the Board of Trustees of the
California Institute of Technology

In our opinion, the accompanying balance sheet and the related statements of changes in fund balances and of operating expenditures (Exhibits 1 through 3) present fairly, in all material respects, the financial position of the California Institute of Technology (the "Institute") at September 30, 1993, and the changes in fund balances and the operating expenditures for the year then ended, in conformity with generally accepted accounting principles. These financial statements are the responsibility of the Institute's management; our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit of these statements in accordance with generally accepted auditing standards which require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements, assessing the accounting principles used and significant estimates made by management, and evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for the opinion expressed above.

Price Waterhouse

Los Angeles, California
December 29, 1993

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