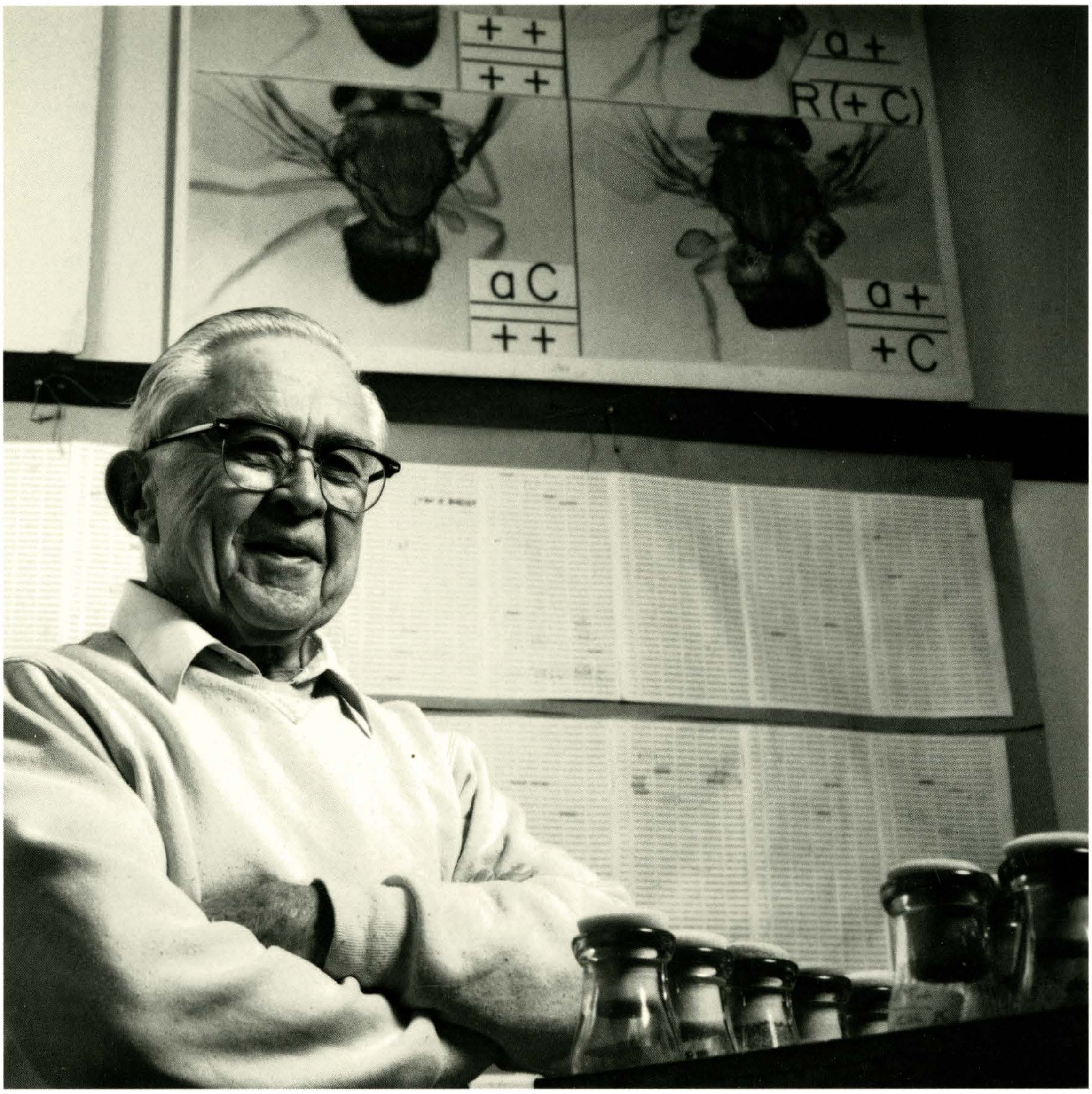
CALIFORNIA INSTITUTE OF TECHNOLOGY

1994–95 *Annual Report*



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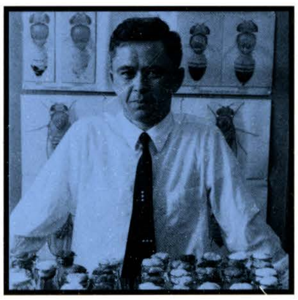


INSTITUTE ADMINISTRATIVE COUNCIL
(as of March 12, 1996)

On the Cover:

Edward B. Lewis, Thomas Hunt Morgan Professor of Biology, Emeritus, became Caltech's 22nd Nobel laureate in October 1995. He was awarded the prize in physiology or medicine for his research on fruit-fly genetics.

Dr. Lewis was also featured on the cover of *Engineering & Science* in 1957 (small photo), when he was engaged in earlier stages of the research for which he received the Nobel Prize. Many lines of basic research begun at Caltech decades ago are still under way in contemporary form.

A Message from the President and the Chair of the Board

Thomas E. Everhart, President, and Gordon E. Moore, Chair of the Board of Trustees.

As Caltech stands poised between a distinguished past and a challenging future, it seems fitting to reflect on the Institute's uniqueness in today's academic world. It is especially important now—when the entire American university system is undergoing change and the value of funding basic research is being questioned—to reemphasize those values which have undergirded our distinctive position. We are a small institution focused on science and technology. Our educational mission was stated by our trustees over 70 years ago: "To train the creative type of scientist or engineer urgently needed in our educational, governmental, and industrial development." We attract the most creative faculty and students by challenging them to work at the forefronts of knowledge. We remain small, and true to the words of our 1921 catalog, by "undertaking only a few lines of work and doing these well."

We try to select the best people we can find, be they students, faculty, or staff. We then provide them with the facilities and environment to accomplish their goals. Our students assume great responsibility as they live under our honor code. Our faculty assume great responsibility as they decide what research has the most potential, how best to teach and mentor students, how to invest their time. Our staff facilitate the research, teaching, and learning processes. We have consciously remained small to encourage interactions among people in different fields, interactions that are stimulating and can lead to novel approaches to science, to new discoveries, to new ways of visualizing problems.

Our vision of a small, focused, superlative institution continues to find its chief expression in our people. From the beginning, Caltech has selected and nurtured the brightest students. (Last year's incoming freshmen, for example, had SAT scores averaging 1405, and all of them came from the top 10 percent of their high school senior classes.)

We provide them the opportunity to learn and the resources they need to contribute top-quality work; they, in return, bring to the Institute the enthusiasm and open-minded approach of youth. To continue to offer our undergraduates the broadest possible scientific education, faculty review of the core curriculum has continued, yielding in the last year the recommendation that a course be required in biology and some choice be allowed in required core science courses. Opportunities for undergraduate research also remain high, through Summer Undergraduate Research Fellowships (SURFs) and school-year research in laboratories or at JPL.

The Institute also attracts superlative graduate students from all over the world. More than four thousand applications for graduate study were received last year, almost three thousand of them from international students. Of those four thousand applicants, 529 were admitted and 219 enrolled, including 104 international students. These graduate students, working with their faculty mentors, increase our knowledge of the natural world, and our ability to solve important problems.

Our 275 professorial faculty compare with the best anywhere. They are in great demand, but we attract them to Caltech by providing them with excellent facilities, colleagues, and students, and with many opportunities for cross-disciplinary interaction. (All 15 professorial positions offered last year were accepted.) The quality of our faculty was again validated last October, when Edward Lewis, Ph.D. '42, the Thomas Hunt Morgan Professor of Biology, Emeritus, became the 22nd Caltech faculty member or alumnus to win a Nobel Prize. Many other faculty awards are listed beginning on page 21.

Caltech's lean administration requires talented people to be successful. When Vice President and Provost Paul Jennings and Vice President for Business and Finance David Morrisroe stepped down last year after their distinguished contributions, we were fortunate to find eminently qualified people to succeed them. Steven Koonin, professor of theoretical physics, was named vice president and provost. John Curry, formerly chief financial officer at UCLA, joined the Institute as vice president for business and finance. Divisional leadership also changed last year, as Melvin I. Simon, the Anne P. and Benjamin F. Biaggini Professor of Biological Sciences, succeeded John Abelson, the George Beadle Professor of Biology, as chair of the Division of Biology. All are off to fine starts. Our 1,600 support staff have also shown themselves extraordinarily dedicated to keeping Caltech strong. Caltech people have high expectations of themselves and of each other, and the result is institutional excellence.

The decision to nurture a select group of faculty follows from an institutional concentration on a few, carefully chosen areas of research, a strategy that has been vindicated over the years by the many discoveries and innovations made by Caltech faculty. We intend to continue building on current research strengths, while entering new fields when the opportunity arises. Caltech's preeminence in astronomical observation was reinforced when construction of the second LIGO (Laser Interferometer Gravitational-Wave Observatory) facility began in Livingston Parish, Louisiana, last July. When completed, this observatory will work in concert with the LIGO facility in Hanford, Washington, and installations planned overseas. Yet another important astronomical research center will expand when the Keck II telescope is dedicated in Mauna Kea in May 1996.

Support for research in the biological sciences also remains a priority. A grant received last year from the Alfred P. Sloan Foundation has established the Center for Theoretical Neurobiology, which will complement the work of the Institute's pioneering computation and neural systems program. The Alzheimer's Forum held last May also helped focus attention on the impact of the work Caltech biologists are pursuing.

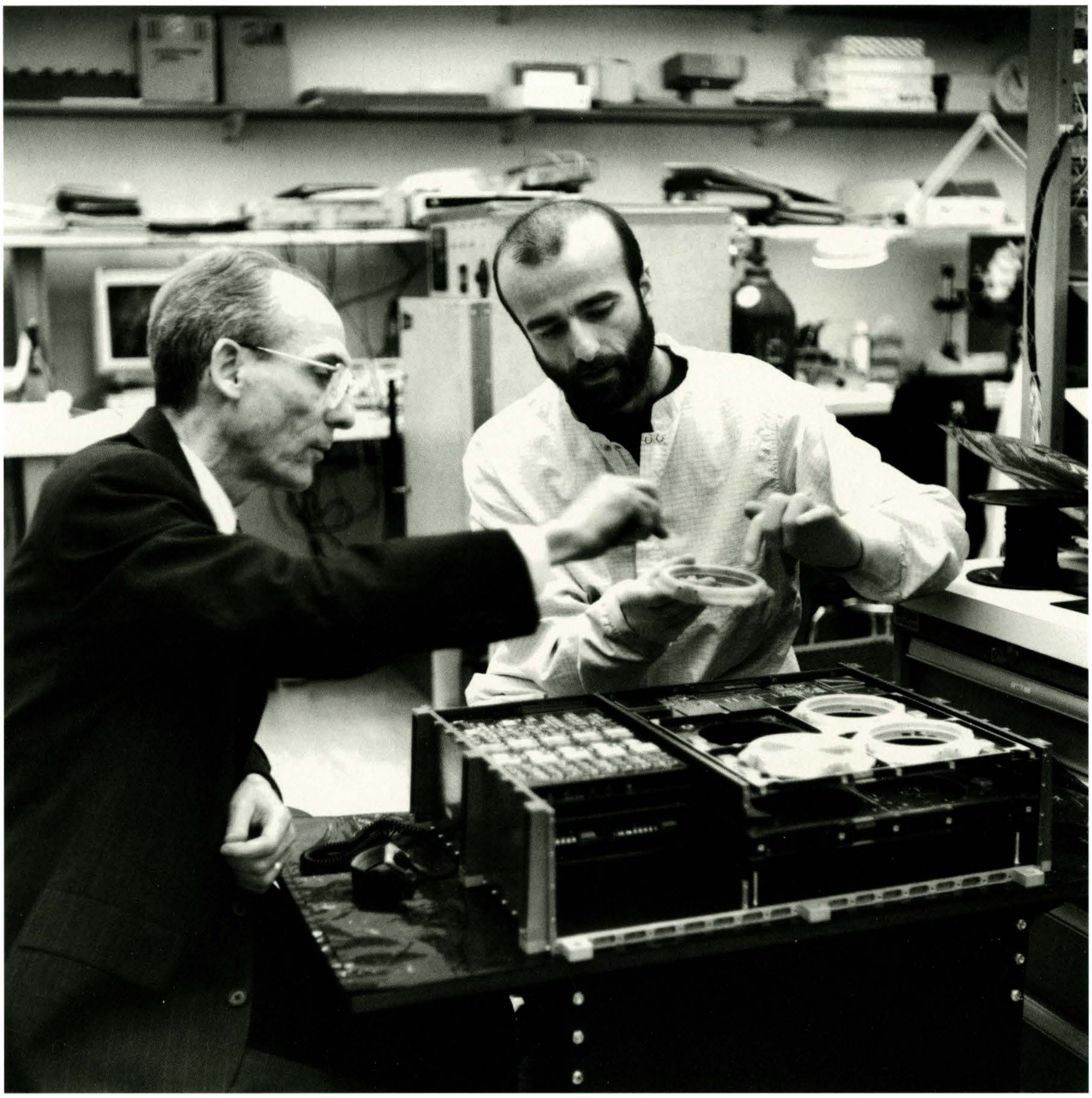
Innovative research proceeds much faster in up-to-date physical facilities. Accordingly, Caltech's commitment to excellence also finds expression in blueprints and at construction sites. The Gordon and Betty Moore Laboratory of Engineering was completed last fall, providing a home for many faculty and students, as well as for the new Center for Neuromorphic Systems Engineering. Construction of the Sherman Fairchild Library of Engineering and Applied Science is slated for completion in late 1996. Avery House, a residence for undergraduates, graduates, and faculty, should be ready for occupancy in September 1996. These facilities will improve our ability to fulfill our mission.

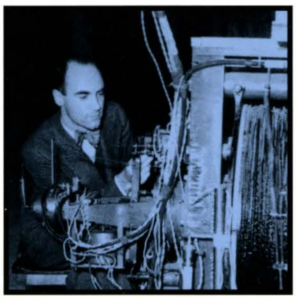
As fortunate as Caltech is in the generosity of its friends and alumni and the strength of its endowment, uncertain times dictate the wisest possible expenditure of resources, as well as creative approaches to increasing revenue. It is generally recognized that the Institute has less bureaucracy than most academic institutions of its size and repute; the innovative restructuring of Institute administrative systems begun in the past year will improve further this efficiency of operation. Our Office of Technology Transfer, established in December 1994, continues to explore ways of identifying and marketing Institute-based inventions with commercial potential. This office serves as liaison between faculty and companies that might be interested in licensing Caltech inventions. Their efforts will make scientific innovation more readily available to society, and through royalties, may bring additional funding to the Institute.

American research universities—with Caltech one of the vanguard—have helped bring our country to a prosperity unprecedented in human history. Research scientists and engineers have improved our lives with new products and processes, new cures for disease, faster modes of travel, and better means of communication. Graduates of research institutions have enriched our economy by founding major new companies and sometimes whole new industries. We take justifiable pride in our alumni. Leadership in science and technology is one of our nation's great assets; but keeping our lead depends on keeping institutions like Caltech strong. Our people—faculty, students, and staff—are working hard to see that the Institute's distinctive influence will be felt far into the next millennium.

Thomas E. Everhart
President

Gordon E. Moore
Chair of the Board of Trustees





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Building On Our Strengths

Fiscal year 1994–95 found Caltech building on its many strengths—among them instructional and research facilities, financial position, personnel, and academic reputation—to prepare itself for the dynamic times ahead. The Institute has been fortunate this past year to be able to expand its facilities and to support a variety of innovative programs through the generosity of individuals, corporations, and foundations.

Improvements and Investments

The newest addition to Caltech's architecture, the Gordon and Betty Moore Laboratory of Engineering, was completed in fall 1995 and dedicated in January 1996. The 90,000-square-foot building serves as headquarters to the Center for Neuromorphic Systems Engineering, one of 21 National Science Foundation Engineering Research Centers across the country. Besides providing advanced research facilities for communications, power electronics, signal processing, microwave electronics, micromachining, and nanofabrication, Moore Laboratory contains lecture halls and an entire floor devoted to instructional laboratories. It also features the first fiber-optic computer network on campus. Construction of the Moore Laboratory was made possible by a gift from alumnus and Chair of the Board of Trustees Gordon Moore and his wife, Betty.

Construction also moved ahead last year on the Sherman Fairchild Library of Engineering and Applied Science. When completed in late 1996, the library will house the latest in information-retrieval technology. Construction of the library has been made possible by a grant from the Sherman Fairchild Foundation.

Groundbreaking for a third new campus building, Avery House, took place last spring. The residence is designed to promote the interaction of undergraduate and graduate students, faculty, and special visitors. When ready for occupancy in September 1996, Avery House will offer resources pertaining to the theme of entrepreneurship—among them a gallery, a library, and special speakers and programs. A gift from R. Stanton Avery, founder chairman

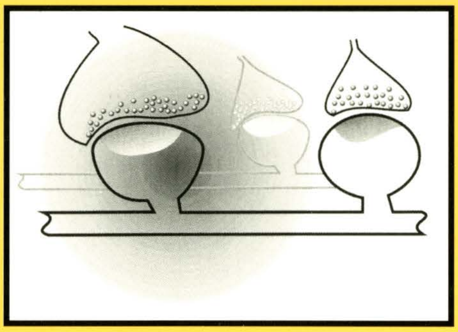
Learning the Language of Memory

What happens in the brain when we learn and remember things? Attempting to answer this basic question has led neuroscientists in the Division of Biology to study the function of cells in the hippocampus, a region of the brain known to play a key role in the formation of memories. This investigation of the brain's electrochemical "language" at the molecular level may one day contribute not only to a clearer understanding of memory formation, but to treatment strategies for Alzheimer's and other diseases that cause memory loss.

Nerve cells, or neurons, come in various shapes and sizes, but they share a common purpose: communication. Using a combination of electrical and chemical signals, neurons "talk" to each other at junctions called synapses. When a neuron receives a signal, it releases a chemical called a neurotransmitter that travels across the synapse to interact with specialized receptors in an adjoining "listening" cell. These receptors trigger an electrical impulse that stimulates the listening cell to release its own neurotransmitter, causing it to become a talking cell to the next neuron in line. When two neurons communicate repeatedly, the strength of the synaptic transmission increases—the neurons either "talk" more loudly or "listen" more acutely—and a long-lasting increase in neuronal communication results. This effect is known as long-term potentiation (LTP). It is thought that memories are encoded as patterns of associations between cells; LTP could be the mechanism by which cells "learn" to associate into the proper patterns.

To observe the molecular mechanisms of LTP, Caltech neuroscientists have been studying individual neurons in thin slices of rat hippocampus. These experiments are the first to show that neurotrophic factors—proteins that promote cell growth in the developing nervous system—can also change synaptic strength in the adult nervous system. A separate line of research has demonstrated that LTP in part depends on a listening cell's producing a gas, nitric oxide, when it is stimulated. Nitric oxide production is triggered by an enzyme called nitric oxide synthase (NOS).

Researchers know that NOS comes in three varieties, but it isn't clear whether one particular variety is responsible for stimulating neurons to release the gas. Recent work has therefore focused on developing a tool that will allow each "flavor" of the enzyme to be tested individually. The experimental tool exploits viruses' habit of taking over the protein-making machinery of cells they infect. The researchers remove the portion of the virus that makes cells sicken and die, but leave its other capabilities intact. The DNA for a specific protein—in this case, a dysfunctional version of one type of NOS—is then inserted into the virus. When injected into a neuron, the virus instructs the neuron to produce the mutant enzyme, which monopolizes the sites usually occupied by normal NOS. The researchers then stimulate the neuron. If nitric oxide isn't released, they have evidence that this variety of NOS controls nitric oxide production. Such viral tools could be adapted to test the workings of other molecules—neurotrophic factors or virtually any other substance thought to play a role in LTP—with unprecedented precision and control.



This diagram depicts the activity of three different synapses during long-term potentiation. When LTP is initiated in the lower right-hand cell, nitric oxide is generated. NO then diffuses out of the cell to influence nearby, but not distant, synapses. Through such diffusion, NO may coordinate the activity of many neurons that underlie a particular behavior.

(diagram: E. Schuman)

emeritus of Avery Dennison Corporation, and former chairman and life trustee of the Caltech Board of Trustees, has funded the project.

Capital improvements continued off-campus as well. In June 1995, ground was broken in Hilo, Hawaii, for the Georgina and William Gimbel Building, a facility that will support the Caltech Submillimeter Observatory located on Mauna Kea. The building will provide office and laboratory space for both permanent observatory staff and visiting astronomers. Gifts from Mr. and Mrs. Gimble, longtime members of the Caltech Associates, have underwritten the building.

In July 1995, construction began in Livingston Parish, Louisiana, on the second LIGO (Laser Interferometer Gravitational-Wave Observatory) facility. When completed, it will work with the first LIGO facility in Hanford, Washington, to detect the gravitational waves predicted by Einstein 80 years ago. LIGO is a joint project of Caltech and MIT, and is funded by the National Science Foundation.

The support of Caltech's donors has also made possible the updating of equipment in laboratories across campus, as well as the funding of scholarships, fellowships, and endowed professorships. Among the many generous contributions received this past year was a gift from Intel Corporation, which has provided new supercomputing equipment for the Center for Advanced Computing Research. The Intel Corporation also made a generous equipment contribution to the Moore Laboratory. In addition to contributing to the installation of the Moore Laboratory fiber-optic computer network, Bay Networks has supported the acquisition of equipment for the Center for Computational Biology and for the Campus Computing Organization. Funds from the Fletcher Jones Foundation have been used to renovate undergraduate biology laboratories. A grant from the Charles Lee Powell Foundation will make possible the purchase of new equipment for the Division of Engineering and Applied Science, and will support fellowships and faculty startup in that division as well. An additional gift from alumnus Craig SanPietro has expanded the SanPietro Undergraduate Scholarship, which has benefited two students to

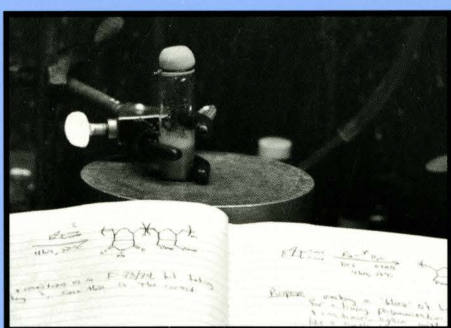
ROMPing into the Future

One day soon, physicians may treat heart disease with a low-fat diet, regular exercise—and synthetic polymers. The idea isn't as far-fetched as you might think, say scientists in Caltech's Division of Chemistry and Chemical Engineering. Their experiments with polymerization at the molecular level may soon result in, among many other products, drugs whose effect on the body can be fine-tuned to an unprecedented degree.

Although polymers—large molecules made up of smaller ones known as monomers—abound in nature, man has created them only since the early 1900s. In that relatively short time, a vast array of new substances has appeared, from nylon and styrofoam to plastics that conduct electricity. Until about nine years ago, the industrial sector developed most polymers; very little research was done in academia. Then, while studying chemical bonding in metal-containing ions, Caltech organic chemists discovered that some of these reactions could also produce polymers. Further work to understand the mechanisms of such reactions led to the development of a technique called ring-opening metathesis polymerization, or ROMP. In this process, chemists add a metal catalyst to the material being polymerized. The catalyst breaks carbon double bonds in the material's molecular rings, opening the rings and joining them end to end in one continuous reaction.

In the last three years, ROMP has become more sophisticated, thanks to the development of ruthenium-based catalysts that permit "living polymerization." In traditional catalysts, polymer chains fall off the catalyst—"die"—before all the monomer is consumed; the chains cannot be restarted later. But once a "living" catalyst has opened and joined all available molecular rings, it pauses until more rings are provided, then starts up again. Since chemists can add precise quantities of particular components to the reaction whenever they choose, they can more easily control a polymer's size, and consequently its properties. Ruthenium also makes polymerization easier because, unlike earlier catalysts, it isn't sensitive to air or water. Being able to ROMP in water has given chemists a convenient way to modify naturally occurring chains of amino acids called polypeptides.

Last year, Institute chemists began applying to drug synthesis what they had learned about making polypeptides. It had been observed in the past that conventional drugs based on polypeptides sometimes don't work because the body breaks them down before they get a chance to act. In some cases, the failure may occur because the drug contains a sulfur-to-sulfur bond that is easily dissolved by enzymes. To circumvent this problem, chemists are experimenting with making drugs by reverse ROMP—closing molecular rings rather than opening them. In one such drug, an anticoagulant, the two vulnerable sulfur atoms are replaced with carbon atoms, which can then be closed up into a ring containing a carbon double bond. The chemists predict that when the drug is ingested, enzymes that would ordinarily destroy the sulfur bond will be thwarted by the new carbon link. The drug's structure will therefore remain intact, allowing it to do its job.



One of the sophisticated—not to mention convenient—features of ROMPing with a ruthenium-based catalyst is that it doesn't require especially sophisticated equipment. "Living" polymerization can be carried out in small vials of water like this one.

(photo: Bob Paz)

date. A bequest from the Pearl Knapp Briscoe estate will increase the Robert T. and Pearl Knapp Fellowship fund, while a gift from the Margaret Pleasants estate will add to the J. Gibson Pleasants Scholarship fund. A bequest from the estate of Frank J. Gilloon has established the Elizabeth W. Gilloon Professorship.

The contributions of other friends and alumni have also helped ensure Caltech's future. Members of the Caltech Associates contributed more than $10.2 million to a variety of restricted and unrestricted areas. The endowment also benefited from many generous bequests and life income gifts. Notable among these are bequests from Thad W. Bryan and alumnus Mason A. Logan, and life income gifts from Jack E. Andrews, Jr., and alumnus Dr. William T. Russell. And, as in the past, Arnold O. Beckman provided generous support for a variety of campus projects.

The Board of Trustees

During fiscal year 1994–95, Caltech's Board of Trustees had the pleasure of welcoming six new members. Gayle Wilson, a longtime advocate for volunteerism, children's welfare, and science education, was elected to the board in May 1995. In June, Gordon M. Binder, Mike R. Bowlin, and Arthur L. Goldstein began their service as trustees. Gordon Binder is currently chairman and CEO of Amgen. Mike Bowlin is chairman, president, and CEO of Atlantic Richfield Company, Los Angeles. Arthur L. Goldstein is chairman, president, and CEO of Ionics, Inc., an international firm that manufactures and sells systems for the treatment, purification, and supply of water and other liquids. The Board also elected Philip M. Neches (BS '73, MS '77, PhD '83) and Louise Kirkbride (BS '75, MS '76) as Young Alumni Trustees, in June and September, respectively. Philip Neches is presently the group technical officer for the AT&T Multimedia Products and Services Group. Louise Kirkbride has extensive background in support management, software engineering, and marketing, and is founder and general manager of San Jose–based Answer Systems, Inc.

Going with the Flow

We can send men to the moon and spacecraft to Jupiter—but unless we pay Concorde prices, it still takes 12 hours to fly to Tokyo, much as it did in 1975. Why has affordable commercial supersonic flight eluded us for 20 years? One reason is that we still know too little about fluid turbulence and turbulent mixing. In the past, observation and experiment have often been inadequate to explain the technologically important phenomena that are hostage to the unruly dynamics of turbulent flow. But our understanding of these phenomena is growing, thanks to recent efforts by scientists in the Division of Engineering and Applied Science to describe the complex, unsteady surfaces where fluids like jet fuel and air mix.

Man has tried to characterize turbulent flow for centuries. Around 500 B.C., the Greek philosopher Herakleitos, noting the complexity of turbulence, remarked that it is impossible to step twice into the same river. Leonardo da Vinci sketched the eddies scientists now call vortices after studying flowing water. A mathematical definition of turbulence was the goal in the 19th century, when a system of nonlinear equations based on Newton's laws of motion was developed. Except in the simplest cases, however, these equations could not be solved; individual flows proved too complex and variable. For decades scientists described turbulence only in general, statistical terms.

Then, in a series of landmark experiments in the 1970s, Caltech researchers discovered that turbulence was not the random mess they had thought it was. When they observed that shear flows—the turbulent mixing of two streams of fluid moving in the same direction at different speeds—produced organized vortical motion, they realized that turbulence had considerable form and order. They captured that form on film using high-speed photography and, more recently, using laser-induced fluorescence. (In this technique, a laser illuminates a slice of the turbulent mixing zone and activates a special dye that labels one of the mixing fluids and tracks the mixing process.) The images of scalar isosurfaces—three-dimensional surfaces where mixing fluids attain a constant concentration—originally looked to many scientists like fractals—irregularly shaped objects, such as mountains or coastlines, that appear crinkly close-up as well as from a distance. They began to theorize that the then-new language of fractal geometry might be the key to describing isosurfaces.

Recently, however, Caltech scientists determined that scalar isosurfaces are not typical fractals. Their complexity increases with their scale; conventional fractal relations are not adequate to describe their more-complex geometry. The scientists' continuing work to extend the original fractal language in a "scale-dependent" way promises to make it equal to this task.

This image, produced with laser-induced fluorescence techniques, shows a jet-fluid concentration 275 jet-nozzle diameters downstream from the discharge nozzle. Black areas denote the fluid into which the jet is discharged. White indicates the region of highest concentration; regions of lesser concentration are gray.

(photo: P. Dimotakis/H. Catrakis)

The researchers expect that the correct description of turbulent mixing and the dynamics of scalar isosurfaces will bring increased understanding and, eventually, control of the processes that govern them. It will then be possible to manipulate things like fuel concentration and combustion rate in jet engines and many other combustion devices, as well as to understand better the dispersion of pollutants in the atmosphere, large- and small-scale flow in the oceans, and the dynamics of global warming.

Interdisciplinary research has long been an important part of Caltech's academic culture, and the opportunity for collaboration with researchers in related fields continues to attract world-class scholars to the Institute. Cross-disciplinary work is becoming ever more prevalent, and promises to reveal new approaches to problem solving in many areas.

The Center for Neuromorphic Systems Engineering—located, as mentioned earlier, in the new Moore Laboratory—is one site of interdisciplinary work on campus. Researchers at the center work with their counterparts in business and industry to design and develop "biological sensing machines"— devices that replicate one or more of the senses of sight, hearing, taste, touch, and smell. Their work builds on research under way for the last decade in Caltech's program for computation and neural systems, in which biologists, engineers, and computer scientists collaborate to design artificial neural networks.

Scientists in the new Center for Theoretical Neurobiology also work across disciplines. This program, established with a grant from the Alfred P. Sloan Foundation, is housed in the Mabel and Arnold Beckman Laboratories of Behavioral Biology. Its purpose is to study fundamental principles of brain function by cross-pollinating ideas from experimental and theoretical neurobiology with those from computation and neural systems. The center will offer a new "third track" to students of neuroscience, giving them the chance to receive both theoretical and experimental training, rather than having to choose one or the other.

Cross-disciplinary collaboration also was the impetus behind "Ideas, Instruments, and Innovation: the Interdisciplinary Migration of Technologies and Concepts," a conference cosponsored by faculty in the Beckman Institute and the Division of the Humanities and Social Sciences. The November 1994 symposium was designed to encourage dialogue between scientists and historians of science about such topics as the role of instrumentation in fostering interdisciplinary research, and the impact of cross-disciplinary approaches on the techniques and technology of modern science.

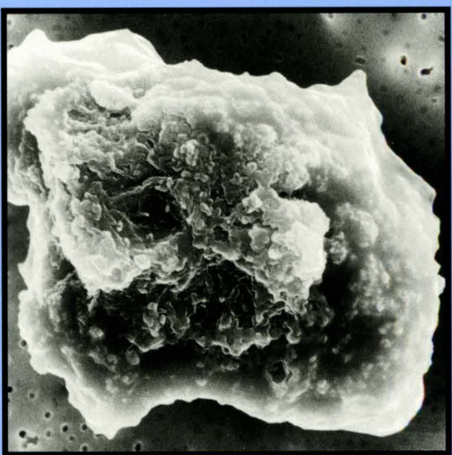
Dusting Off an Old Mystery

Is another ice age on the way? Or will Anchorage soon be as warm as Pasadena? The jigsaw puzzle of global climate is still far from assembled, but one elusive piece may have fallen from outer space. Geochemists in Caltech's Division of Geological and Planetary Sciences have discovered a possible correlation between the infall of interplanetary dust—the detritus of comets, asteroids, and such—and some major events in Earth's history, including one of the glaciation cycles of the current geologic period.

Initially, the researchers simply wanted to measure how much interplanetary dust falls to Earth each year. To minimize the amount of continental debris they would have to sift out, they examined a sediment core from the middle of the North Pacific Ocean. They needed a marker that would distinguish alien from home-grown dust, so they decided to test the sediments for helium 3. Although present when the planet accreted, ^{3}He is not produced on Earth, and most of Earth's original supply has returned to space. Unlike its heavier cousin, helium 4—a product of the radioactive decay of uranium and thorium—^{3}He comes from hydrogen-fusion processes like those in the sun. In space, the solar wind bombards the dust particles with ^{3}He, much of which remains embedded in the particles' surface after they fall to Earth.

Using a fairly straightforward but time-consuming lab technique to test small chunks—in this case, about a million years' worth—of the core at a time, the geochemists measured the ^{3}He content of sediments spanning 70 million years. The testing revealed three unexpected ^{3}He spikes, all of which coincided with major geologic events. The first spike occurred about 66 million years ago, when most experts agree a huge object collided with Earth, annihilating the dinosaurs. Dust also peaked at the end of the Eocene (about 35 million years ago), coincident with gradual species extinctions and the appearance of tektites—glassy rocks produced when large objects hit Earth hard enough to fling molten material skyward. The third is actually a series of peaks correlating with the 100,000-year cycle of glaciation characteristic of the last million years, and suggests that the glaciers recede when dust levels increase and advance when dust levels decrease.

Before concluding that cosmic dust clouds change the climate, however, more information is required. To find out whether the dust spikes occurred globally or were caused by local ocean currents, the geochemists are also examining cores from the North Atlantic and equatorial Pacific. Improved lab methods have made it possible to test these large samples in a fraction of the time the old process required—so results may be available in months rather than years. Scientists also need to understand better the relationship between dust infall and the many other variables—such as the location of mountains and the carbon dioxide content of the atmosphere—that influence climate. Linking interplanetary dust levels to the glaciation cycle won't complete the climate puzzle, but it could help fill in the background.



The interplanetary dust particle shown in this scanning electron photomicrograph was collected in the stratosphere by a U-2 aircraft. The particle is 12 micrometers across—about 1/25 the thickness of a piece of cellophane tape. Its chemical composition, which includes a rich supply of helium 3, gives away its extraterrestrial origin.

(photo: D. Brownlee)

Conference participants included scholars from universities in Norway, Greece, Australia, and England, and across the United States.

The growing prevalence of interdisciplinary scholarship underscores the importance of exposing undergraduates to a broad spectrum of scientific fields. To ensure that undergraduate study remains comprehensive and keeps pace with the changing character of science, faculty review of the core curriculum continues. Last year, the newly formed Core Curriculum Council recommended changing the pass/fail rules for the latter part of the freshman year. The council is also debating whether to reduce the number of required physics, math, and chemistry courses, to allow for the addition of "menu" courses in other areas of science. The choices that will appear on the menu have yet to be determined, but it is likely that the courses will come from such information-rich fields as the biological and earth sciences.

Expanding Our Community

Cognizant of the valuable role it can play in making science and technology more accessible to the nonscientific public, the Institute last year sponsored several programs and services of special interest to the Southern California community.

In April, a group of nationally recognized print and broadcast journalists gathered in Beckman Auditorium for a symposium entitled "Reporting Science: Fact, Skepticism, and Controversy." The program's purpose was to discuss how journalists bridge the gap between researchers and the public to help citizens better understand the contributions science and technology make to society. Before an audience comprising communications professionals from colleges, nonprofit organizations, corporations, hospitals, and research institutions, as well as local high school and college journalism and science students, a panel of journalists and Institute faculty explored such issues as how the public perceives animal research and how science stories are compiled for national network news broadcasts. Following the morning panel discussion, Robert

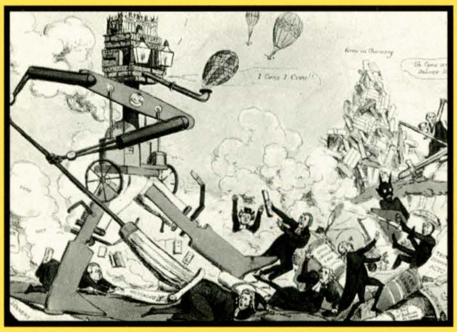
The Past As Prologue

We may be on the brink of the twenty-first century, but in some ways we're still Victorians—or so say scholars of nineteenth-century British history and literature in the Division of the Humanities and Social Sciences. Many of the assumptions and arguments that inform our current social policy and political and cultural debates were first articulated in nineteenth-century Europe, and particularly in Britain. We are still trying to work out, for example, to what extent government should be responsible for citizens' welfare; how to preserve the nuclear family in the wake of rapid social and technological change; what roles literature and the arts should play in public and private life; and which areas of human behavior should be subject to scientific investigation and explanation—all motifs of the 1800s.

To promote discussion of these kinds of issues, Caltech humanities faculty have launched an interdisciplinary seminar series called "The Long Nineteenth Century." The name reflects the idea that many of nineteenth-century Britain's most pressing concerns—like coping with the effects of the French and Industrial Revolutions—originated in the 1780s and persisted until World War I or beyond. The organizers of the series intend to seek out scholars whose work, like their own, crosses traditional academic boundaries, and who can speak to the connections between literary criticism, cultural history, and the history of science.

The series' inaugural lecture took place last May. It concerned women's involvement in social reform and religious movements in nineteenth-century England, a topic of particular interest to Institute faculty who study literary portrayals of gender roles. The subject of the second seminar, given in October, was Alfred Russel Wallace, a contemporary of Darwin's whose independently developed theory of natural selection predated the ***Origin of Species.*** Discussion centered on how the two men could produce similar theories despite different backgrounds, education, and social position. This talk engaged Caltech historians whose research explores ways that social and political issues influenced the practice of science in the 1800s. Future lectures will intersect with other areas of Caltech humanities research, such as the relationship between nineteenth-century publishing, social protest, and reform. Seminars are open to the public and will take place either at Caltech or at the Huntington Library, the cosponsor of the series and a longtime scholarly resource for Institute faculty.

The benefits of "The Long Nineteenth Century" have already been many. The process of compiling—and debating—the roster of speakers has helped make series organizers more aware of the work of like-minded scholars, as well as revealing previously hidden aspects of each others' research. The seminar series also furthers the integration of humanistic and scientific inquiry begun at Caltech by programs like Science, Ethics, and Society. And finally, working across disciplines has helped the researchers to understand better how scholarly methods changed during the nineteenth century. For as they point out, until the 1800s, rigid separation of academic fields was unknown, and science was as cultural as a novel.



This 1829 political cartoon, entitled "The March of Intellect," is a commentary on reform, one key motif of the nineteenth century. The steam-engine-like creature laying waste to the institutions of "old England" alludes to an apocalyptic monster in the Book of Revelation. The cartoon satirizes both conservatives, who feared that reform meant the end of the world, and reformers, who thought industrial and scientific inventions were the solution to all Britain's problems.

(cartoon reprinted by permission of Guildhall Library Corporation of London)

Bazell, chief science and medical correspondent for NBC News, delivered the keynote address.

A large public audience also attended "Alzheimer's Disease: Causes and Effects" in May. This symposium, jointly presented by the Institute and the *Pasadena Star-News*, featured talks by researchers from Caltech, USC, and UC San Diego. The scientists described current neurobiological and medical research that promises to shed light on the causes and possible treatment of the disease, covering such topics as how memories are formed and the genetic and cellular basis of aging. Other speakers offered perspectives on the family and social issues raised by Alzheimer's.

Beckman Auditorium again attracted a capacity crowd in October, when noted architect Frank Gehry presented "Current Work," the fourth in Caltech's James Michelin Distinguished Visitor lecture series. Playwright Tom Stoppard, artist David Hockney, and architectural historian Vincent Scully have previously lectured at the Institute as Michelin Distinguished Visitors.

Extending the definition of its "public" even further, Caltech continues to reach out to a global community via the Internet. Prospective students can explore the Institute on the World Wide Web (URL http://www.caltech.edu) and get information about admissions procedures, academic divisions and options, the student houses, and other aspects of campus life. Web surfers can also access Caltech's catalog, bookstore, libraries, personnel directory, and employment listings, as well as home pages for many support and service departments. Institute Web sites are a valuable source of information for many people, according to usage statistics kept over the past 18 months. In April 1994, when the tracking of "hits" on the Campus Computing Organization's Web server—one of many such computers at Caltech—began, the average number of information requests per hour was 56. By October 1994 that average had grown to 92.5. And for the same week one year later, Caltech Web pages averaged more than 533 requests per hour—an increase of nearly 500 percent.

The Institute has also shown itself to be a good neighbor by opening a recycling center that serves both the campus and

A Quantum Leap for Computing

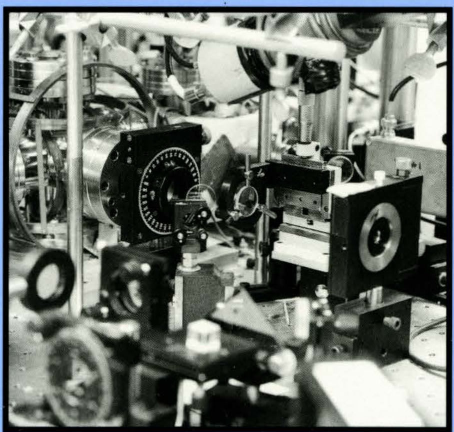
National security—and the privacy of citizens who bank or shop on-line—often depends on the codes that protect data sent between computers. Encryption codes are secure because they are based on huge numbers that even the most powerful computer cannot break down. Such codes may someday need replacing, however, if research by physicists in the Division of Physics, Mathematics and Astronomy continues along its current path. Over the last decade, they have studied the interactions between matter and light at the level of single atoms and photons—the "bundles" light comes in. This work has coincidentally allowed them to experiment with building one of the basic components of a quantum computer, which at least in theory could quickly perform such "impossible" tasks as factoring very large numbers.

Classical computers work by sending bits—the distinction between two alternatives, such as no or yes, 0 or 1—as pulses of electrical current through wires, transistors, and other components. At locations called logic gates, a bit is "flipped," or changed to its opposite state, if a specific combination of bits is present. A quantum computer would work by using the principles of quantum mechanics, which govern particles too tiny to obey the laws of classical physics. Quantum mechanics states that a particle can occupy many states at the same time. Since a collection of such quantum particles can exist in an exponentially large number of states simultaneously, a computer that "thinks" quantum mechanically could do many different calculations at once in a way that even the most sophisticated conventional computer could not.

In the mid-1980s, theorists proposed that a quantum computer created from atomic-scale components might have characteristics that would make it inherently more powerful than any classical machine. In 1994, research in quantum computation leaped forward when a scientist at Bell Labs proved that a quantum computer would be capable of efficiently factoring large numbers, a task thought to be intrinsically inefficient for classical computers. This factoring algorithm caught the attention of Caltech physicists, who thought their own quantum optics experiments might also be applied to quantum computation.

These experiments involved isolating a single atom in an optical cavity between two mirrors, one of which allowed partial transmission of light. Pairs of photons were shot through the cavity, with each photon polarized—that is, spinning as it traveled—either to the right or to the left. The researchers found that when two photons with opposite spins entered the cavity, they ignored the atom and exited unchanged; but when two right-spinning photons were shot into the cavity at once, they interacted strongly with the atom. The result was that each photon had a markedly different polarization coming out than going in. The physicists had in effect used their optical cavity as a rudimentary quantum logic gate. The individual photons were the "current" needed to carry quantum bits; changing the photons' polarization was analogous to bit flipping in conventional computers.

Their logic gate is a significant first step, but researchers must still solve many complex problems—how to make many such gates work together, for instance—before an entire computer can be designed. Our bank accounts are safe from quantum hackers—for now.



Physicists in the quantum optics group conduct their experiments by firing a laser through a tabletop maze of mirrors and lenses. The component made up of of shiny rings (center left, behind the black dial) houses the optical cavity where photons and single atoms interact.

(photo: Bob Paz)

Pasadena communities. The center accepts a variety of materials, including white, colored, and mixed paper; cardboard, newspapers, and phone books; and several varieties of plastic, metal, and glass containers. In 1994, the first year the center was open, it collected approximately 582,600 pounds of recyclable materials; in 1995, that quantity increased by more than 50 percent, to 913,000 pounds. According to Physical Plant, which operates the center, recycling over the past two years has reduced by 25 percent the amount of trash Caltech sends to local landfills, despite the growth the campus has experienced. Selling recycled materials has also raised almost $36,000, which will be used to support the recycling program in 1996. The state of California has recognized these results with Waste Reduction Awards in 1994 and 1995.

Caltech Graduates

Caltech's 101st commencement ceremony took place June 16, 1995 (despite threatened interruption by a highly unusual rainstorm). Chair of the Board Gordon E. Moore (PhD '54) made introductory remarks, and Mark S. Wrighton (PhD '72), former provost of MIT and the current chancellor of Washington University in St. Louis, gave the commencement address. The Institute awarded 491 degrees: 204 bachelor's, 117 master's, four engineer's, and 166 doctor's.

Half of the bachelor's degree recipients have entered graduate schools; another 26 percent have accepted positions with such companies as Applied Materials, First Quadrant, Microsoft, and Oracle. Of those receiving master's degrees, 78 percent planned to continue their graduate studies, while 14 percent have joined the work force. Fifty-six percent of PhD graduates accepted academic positions as postdoctoral scholars or assistant professors, and 36 percent were hired by business and industry, government, or not-for-profit organizations.

JPL Highlights

Knowledge of our solar system expanded significantly in 1995, courtesy of research at Caltech's Jet Propulsion Laboratory.

December was a historic month for planetary exploration, as the Galileo spacecraft arrived at Jupiter after a voyage of more than six years and 2.35 billion miles. After successfully separating from its atmospheric probe, the spacecraft crossed into Jupiter's huge, teardrop-shaped magnetic cocoon on December 1. As planned, the probe relayed data back to the orbiter on December 7 before vaporizing in Jupiter's clouds. Fifty-seven minutes of data from Jupiter's atmosphere were acquired, marking the first time that scientists had obtained in situ measurements of an outer planet.

Space exploration took yet another tack last year when JPL was awarded the Stardust project, the fourth mission of NASA's Discovery program. Stardust will gather and return samples of interstellar dust as it travels through the solar system on its way to a flyby of comet Wild-2 in 2004. The spacecraft will be launched in February 1999.

While planetary scientists extended our reach into the solar system, earth scientists examined our planet and its environs from space. Data from the ocean-observing TOPEX/Poseidon satellite allowed meteorologists to study El Niño, a climatic anomaly in the equatorial Pacific that warms the ocean and raises sea-surface elevation. El Niño has been known to trigger devastating storms in some parts of the world while bringing unusually warm winters to others. TOPEX/Poseidon, a joint program of NASA and the Centre Nationale d'Études Spatiales, the French space agency, uses a radar altimeter to measure sea-surface height precisely and produce global maps of ocean circulation.

JPL research cast new light on Earth's history as well as its climate. The Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar project continued to uncover signs of ancient civilizations. The project yielded, in one instance, extraordinarily clear images of the fabled Cambodian city of Angkor, a vast complex of more than 60 temples dating back to the ninth century. Data from another source—two flights of the space shuttle *Endeavour*—provided evidence that, millions of years before the reign of the dinosaurs, Earth was for a time dominated by one giant landmass.

Other Laboratory projects provided insights into fields such as fluids physics and deep-space communications. JPL's Drop Physics Module was flown for the second time aboard a space shuttle, allowing physicists to observe the interaction of fluids as free-floating drops in the microgravity environment of space. These experiments are expected to benefit pharmacology, industrial chemistry, and other ground-based industries. Also launched this year from California's Vandenberg Air Force Base was SURFSat, a student-built science payload developed as part of Caltech's Summer Undergraduate Research Fellowship (SURF) program. SURFSat's payload of low-power radio transmitters, originally designed to test the performance of deep-space communications in the 32-gigahertz frequency range known as Ka-band, has also been used to monitor a new set of Earth-orbit tracking stations.

This image (one frame of a computer-animation sequence) depicts Galileo arriving at Jupiter on December 7, 1995. The sequence shows the 49-minute engine burn that slowed the spacecraft so that it could be captured by Jupiter's gravity and begin orbiting the planet. The engine burn occurred after the probe had finished relaying data to Earth.

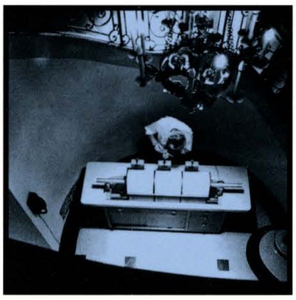
(photo: Jet Propulsion Laboratory)

At both the undergraduate and graduate levels, Caltech continues to be considered one of the country's preeminent institutions for science and engineering instruction and research.

U.S. News and World Report ranked Caltech seventh overall in its 1995 survey of the best national universities. In the "financial resources" category, Caltech ranked first; the Institute also had the best student-to-faculty ratio in the nation (6:1). Freshmen enrolling at Caltech in fall 1994 had the highest average SAT/ACT scores of any entering class in the United States.

According to *Research-Doctorate Programs in the United States* (the National Research Council's study of 3,600 doctoral programs in 41 fields at 274 universities), Caltech's overall graduate program places 14th in the nation. The study ranked 13 of the Institute's individual PhD programs in the top 10 for "effectiveness of program," "quality of faculty," or both, as follows:

Program	*Ranking*
Aerospace Engineering	#1
Astrophysics and Astronomy	#1
Cell/Developmental Biology	#1
Chemistry	#1
Geoscience	#1
Civil Engineering	#2
Mechanical Engineering	#4
Molecular and General Genetics	#4
Physics	#4
Electrical Engineering	#5
Biochemistry/Molecular Biology	#6
Chemical Engineering	#6
Neuroscience	#10



Caltech people have high expectations of themselves and of each other, and the result is institutional excellence."

National awards and honors

American Academy of Arts and Sciences, Fellow:
THOMAS J. AHRENS, *Professor of Geophysics*
PAUL C. JENNINGS, *Professor of Civil Engineering and Applied Mechanics*
ANTHONY C. S. READHEAD, *Professor of Astronomy*

American Association for the Advancement of Science, Fellow:
THOMAS K. CAUGHEY, *Richard L. and Dorothy M. Hayman Professor of Mechanical Engineering*

Department of the Interior, Meritorious Service Award:
THOMAS H. HEATON, *Professor of Engineering Seismology*

E. I. du Pont de Nemours & Co., Inc., Peter Debye Award in Physical Chemistry:
AHMED H. ZEWAIL, *Linus Pauling Professor of Chemical Physics and Professor of Physics*

National Academy of Engineering, Member:
ALLAN J. ACOSTA, *Richard L. and Dorothy M. Hayman Professor of Mechanical Engineering, Emeritus*
K. MANI CHANDY, *Professor of Computer Science*

National Academy of Sciences, Member:
ELLIOT M. MEYEROWITZ, *Professor of and Executive Officer for Biology*
ANTHONY C. S. READHEAD, *Professor of Astronomy*
ALEXANDER J. VARSHAVSKY, *Howard and Gwen Laurie Smits Professor of Cell Biology*

National Aeronautics and Space Administration, Outstanding Leadership Medal:
EDWARD C. STONE, Jr., *Vice President, Director of the Jet Propulsion Laboratory, and David Morrisroe Professor of Physics*

National Medal of Science, Recipient:
PETER M. GOLDREICH, *Lee A. DuBridge Professor of Astrophysics and Planetary Physics*

International awards and honors

Chemical Institute of Canada, Honorary Fellow:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

1995 E. Gordon Young Award:
MICHAEL R. HOFFMANN, *Professor of Environmental Chemistry*

Chinese Academy of Sciences, Institute of Science, Honorary Professor:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

State of Egypt, Order of Merit, First Class:
AHMED H. ZEWAIL, *Linus Pauling Professor of Chemical Physics and Professor of Physics*

Paul Ehrlich Foundation, Germany, Paul Ehrlich and Ludwig Darmstaedter Award, Corecipient:
PAMELA BJORKMAN, *Associate Professor of Biology and Associate Investigator, Howard Hughes Medical Institute*

European Association of Geochemistry, 1995 Urey Medal, Corecipients:
SAMUEL EPSTEIN, *William E. Leonhard Professor of Geology, Emeritus*
HUGH P. TAYLOR, JR., *Robert P. Sharp Professor of Geology*

European Association of Historical Economics, Gino Luzzatto Prize:
CAROLINE M. FOHLIN, *Assistant Professor of Economics*

European Physical Society, Special Prize, Corecipient:
HARVEY B. NEWMAN, *Professor of Physics*

French Chemical Society, Lavoisier Medal:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

Indian Academy of Sciences, Honorary Fellow:
ANATOL ROSHKO, *Theodore von Kármán Professor of Aeronautics, Emeritus*

International Society of Electrochemistry, Honorary Member:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

International Union of Geodesy and Geophysics, President:
PETER J. WYLLIE, *Professor of and Divisional Officer for Geology*

Karolinska Institute, Nobel Prize in Physiology or Medicine:
EDWARD B. LEWIS, *Thomas Hunt Morgan Professor of Biology, Emeritus*

Moët Hennessy–Louis Vuitton Foundation of France, Leonardo da Vinci Award of Excellence for 1995:
AHMED H. ZEWAIL, *Linus Pauling Professor of Chemical Physics and Professor of Physics*

Royal Society of Arts and Sciences in Sweden, Foreign Member:
HARRY B. GRAY, *Arnold O. Beckman Professor of Chemistry and Director of the Beckman Institute*

Local awards

Los Angeles Area Chamber of Commerce, 1995 Lifetime Achievement Award:
GEORGE W. HOUSNER, *Carl F Braun Professor of Engineering, Emeritus*

Awards and honors from professional societies

Acoustical Society of America, Science Writing Award:
MASAKAZU KONISHI, *Bing Professor of Behavioral Biology*

American Association of University Women, AAUW Recognition Award for Emerging Scholars:
ERIN M. SCHUMAN, *Assistant Professor of Biology*

American Astronomical Society, Helen B. Warner Prize and Warner Prize Lectureship:
E. STERL PHINNEY, *Associate Professor of Theoretical Astrophysics*

American Chemical Society, Southern California Section, Richard C. Tolman Medal:
JACQUELINE K. BARTON, *Professor of Chemistry*

American Choral Director's Association, Western Division, Chair, Women's Choirs, Repertoire and Standards Committee:
MONICA J. HUBBARD, *Director, Women's Glee Club*

American Institute of Aeronautics and Astronautics, Fluid Dynamics Award:
PHILIP G. SAFFMAN, *Theodore von Kármán Professor of Applied Mathematics and Aeronautics*

1995 Goddard Astronautics Award:
LEW ALLEN JR., *Senior Faculty Associate and Former Director of the Jet Propulsion Laboratory*

Space Science Award:
JAMES A. WESTPHAL, *Professor of Planetary Science and Director of Palomar Observatory*

American Physical Society, 1994 Tom W. Bonner Prize in Nuclear Physics:
FELIX H. BOEHM, *William L. Valentine Professor of Physics, Emeritus*

1995 Herbert P. Broida Prize:
AHMED H. ZEWAIL, *Linus Pauling Professor of Chemical Physics and Professor of Physics*

1996 Julius Edgar Lilienfeld Prize:
KIP S. THORNE, *Richard P. Feynman Professor of Theoretical Physics*

American Physical Society (Topical Group on Shock Compression of Condensed Matter), 1995 Shock Compression Science Award:
THOMAS J. AHRENS, *Professor of Geophysics*

American Society for Engineering Education, 1995 Frederick Emmons Terman Award:
P. P. VAIDYANATHAN, *Professor of Electrical Engineering*

American Society of Mechanical Engineers, J. P. Den Hartog Award:
THOMAS K. CAUGHEY, *Richard L. and Dorothy M. Hayman Professor of Mechanical Engineering*

Fellow:
WOLFGANG G. KNAUSS, *Professor of Aeronautics and Applied Mechanics*
ARES J. ROSAKIS, *Professor of Aeronautics and Applied Mechanics*

Association for Computing Machinery, Fellow:
ALAN H. BARR, *Associate Professor of Computer Science*

Electrochemical Society, Inc., Fellow:
FRED C. ANSON, *Elizabeth W. Gilloon Professor of Chemistry*

Geological Society of America, Arthur L. Day Medal and Life Fellowship:
THOMAS J. AHRENS, *Professor of Geophysics*

Microbeam Analysis Society Conference, Award for Best Invited Paper:
PAUL K. CARPENTER, *Manager, Division Analytical Facility in Geology*

Seismological Society of America, Medal:
CLARENCE R. ALLEN, *Professor of Geology and Geophysics, Emeritus*

Foundation awards

The Camille and Henry Dreyfus Foundation, Camille Dreyfus Teacher-Scholar Award:
ZHEN-GANG WANG, *Assistant Professor of Chemical Engineering*

John Randolph Haynes and Dora Haynes Foundation, 1995 Faculty Fellowship:
JEFFREY A. DUBIN, *Associate Professor of Economics*

David and Lucile Packard Foundation, Packard Fellowship in Science and Engineering:
ERICK M. CARREIRA, *Assistant Professor of Chemistry*

Pew Scholars Program in the Biomedical Sciences, 1995 Pew Scholar:
ERIN M. SCHUMAN, *Assistant Professor of Biology*

Searle Scholars Program, 1995 Searle Scholar Award:
RAYMOND DESHAIES, *Assistant Professor of Biology*

Alfred P. Sloan Foundation, Research Fellow:
JEHOSHUA BRUCK, *Associate Professor of Computation and Neural Systems and Electrical Engineering*

Stichting Havinga Foundation, 1995 Havinga Lecturer and Medalist:
JACQUELINE K. BARTON, *Professor of Chemistry*

University honors

Universities of Alberta, Calgary, and Regina, Canada, E. Gordon Young Distinguished Lecturer:
MICHAEL R. HOFFMANN, *Professor of Environmental Chemistry*

University of California, Berkeley, Engineering Alumni Society, Distinguished Engineering Alumni Award:
WILLIAM B. BRIDGES, *Carl F Braun Professor of Engineering*

Colorado State University College of Liberal Arts, Willard O. Eddy Lecturer:
PAUL C. JENNINGS, *Professor of Civil Engineering and Applied Mechanics*

Columbia University, Alumna of the Year Award:
JACQUELINE K. BARTON, *Professor of Chemistry*

Fudan University, China, Honorary Professor:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

Johns Hopkins Society of Scholars, induction:
DINAKAR RAMAKRISHNAN, *Professor of Mathematics*

Johnson Research Foundation of the University of Pennsylvania Medical School, 1994 Johnson Foundation Prize:
DOUGLAS C. REES, *Professor of Chemistry*

University College, Oxford, Honorary Fellow:
RUDOLPH A. MARCUS, *Arthur Amos Noyes Professor of Chemistry*

Phi Beta Kappa, Award in Science:
KIP S. THORNE, *Richard P. Feynman Professor of Theoretical Physics*

University of Pittsburgh's Chevron Science Center, 1994–95 Chancellor's Lecture Series Honoring Distinguished Women Scholars, Lecturer:
FRANCES H. ARNOLD, *Associate Professor of Chemical Engineering*

University of Southern California, Tyler Prize:
CLAIR C. PATTERSON, *Professor of Geochemistry, Emeritus*

Washington State University, Alumni Achievement Award:
JOHN N. ABELSON, *George Beadle Professor of Biology*

Western Kentucky University, Hall of Distinguished Alumni, Induction:
HARRY B. GRAY, *Arnold O. Beckman Professor of Chemistry and Director of the Beckman Institute*

Institute honors

Distinguished Alumni Awards:
GORDON P. EATON, *MS '53, PhD '57*
JERRY EARL NELSON, *BS '65*
ARATI PRABHAKAR, *MS '80, PhD '85*
CHARLES R. TRIMBLE, *BS '63, MS '64*
MAX L. WILLIAMS, JR., *MS '47, Eng '48, PhD '50*

Endowed Professorships:
FRED C. ANSON, *Elizabeth W. Gilloon Professor of Chemistry*
PAUL E. DIMOTAKIS, *John K. Northrop Professor of Aeronautics*
DAVID L. GOODSTEIN, *Frank J. Gilloon Distinguished Teaching and Service Professor*
PHILIP G. SAFFMAN, *Theodore von Kármán Professor of Applied Mathematics and Aeronautics*
DAVID J. STEVENSON, *George Van Osdol Professor of Planetary Science*
BRADFORD STURTEVANT, *Hans W. Liepmann Professor of Aeronautics*

Associated Students of the California Institute of Technology (ASCIT), Award for Teaching Excellence:
PAUL E. DIMOTAKIS, *John K. Northrop Professor of Aeronautics and Professor of Applied Physics*
BARBARA IMPERIALI, *Associate Professor of Chemistry*
JEREMY KAHN, *Assistant Professor of Mathematics*
DAVID B. RUTLEDGE, *Professor of Electrical Engineering*
JONAS ZMUIDZINAS, *Assistant Professor of Physics*

Honorable Mentions:
JAMES K. MCCARTHY, *Assistant Professor of Astronomy*
MOSHE SLUHOVSKY, *Instructor in History*
ALAN J. WEINSTEIN, *Associate Professor of Physics*

Richard P. Feynman Prize for Excellence in Teaching, Recipient:
ERIK K. ANTONSSON, *Associate Professor of Mechanical Engineering*

Graduate Student Council, 1995 GSC Teaching Awards:
YASER S. ABU-MOSTAFA, *Professor of Electrical Engineering and Computer Science*
CHRISTOPHER E. BRENNEN, *Professor of and Executive Officer for Mechanical Engineering*
GEORGE R. ROSSMAN, *Professor of Mineralogy*
EDWARD E. ZUKOSKI, *Professor of Jet Propulsion and Mechanical Engineering, Emeritus*

Outstanding Teaching Assistant Awards:
PATRICK Y.-S. CHUANG, *Graduate Student in Environmental Engineering Science*
SANJOY S. MAHAJAN, *Graduate Student in Physics*

Our people—faculty, students, and staff—are working hard to see that the Institute's distinctive influence will be felt far into the next millennium."

The California Institute of Technology continued its long history of robust financial performance in 1995. Support from federal research sponsors and private donors led the growth in revenues, a testimony to the singular quality of the Caltech faculty and the strategic focus of their teaching and research. Extraordinary equity and bond markets helped lift the endowment to a new high, and capital construction continued apace.

The following pages present a Balance Sheet, Statement of Changes in Fund Balances, Statement of Operating Expenditures, and Notes to the Financial Statements, along with analysis and commentary. Highlights are presented in the charts, while details are in Exhibits 1, 2, and 3.

The Balance Sheet

The balance sheet represents the cumulative financial history of Caltech. The first six charts highlight Exhibit 1 of the financial statements in horizontal slices by types of assets and liabilities. Looking first at *assets*, we see that

- *Investments*, primarily endowments, constitute Caltech's largest asset group. Investments increased from $649.2 million in 1994 to $694.3 million in 1995 (assets are recorded at cost).
- *Campus properties net of depreciation* increased from $460.7 million in 1994 to $494.6 million in 1995, due primarily to equipment acquisitions, as well as to substantial completion of the Moore Laboratory and Phase II of the W. M. Keck Observatory in Hawaii.

Looking next at *liabilities*, we see that

- *Accounts payable* and accrued expenses decreased from $240.3 million in 1994 to $224.6 million in 1995. Note that $216.4 million of these 1995 payables are offset by United States government receivables (see notes B and I).
- *Revenue bonds payable* increased from $48.1 million in 1994 to $77.1 million in 1995, reflecting the issuance of $30.0 million in new California Educational Facility Authority (CEFA) bonds for capital construction projects.

The difference between assets and liabilities is usually called net worth, but in fund accounting it is known as *fund balances*.

- *Fund balances* increased from $1,075.0 million in 1994 to $1,113.4 million in 1995.

The second set of six charts provides fund balances detail (Exhibit 1), first by fund group (current, endowment, plant, etc.), and then by fund categories, or degrees of restriction: unrestricted (spendable for any purpose); restricted (spendable only for purposes specified by sponsor or donor); and endowment principal (the corpus preserved and invested in perpetuity by law, with only yield and appreciation available for spending).

Looking at the balance sheet over the last 10 years, we see that net worth decreased in 1990. The details reveal that the decrease occurred in the plant fund, a consequence of introducing depreciation of campus facilities and equipment and recording the depreciation accumulated up to 1990 in a single year. Worthy of note is that the plant fund—net of annual depreciation—exhibits steady growth thereafter. Also of interest is that fund balances (net worth) have grown in 1994 and 1995, even though they were reduced by accrual of the full estimated cost of postretirement benefits in 1994. The fund balances understate Caltech's actual net worth because both financial and capital assets are stated on the original cost basis (Notes C and D).

The third set of charts summarizes Exhibit 2, the Statement of Changes in Fund Balances, commonly called the operating statement.

Statement of Changes in Fund Balances

Looking first at Sources of Funds (Revenues and Other Additions), we see that

- *United States government contracts and grants* (the sum of reimbursement of direct costs and recovery of indirect costs and management allowance) increased from $146.4 million in 1994 to $160.7 million in 1995, an increase of 9.8 percent.
- *Investment income* decreased from $30.7 million in 1994 to $29.8 million in 1995 because of a shift toward growth stocks in the endowment pool, while net gain on disposal of investments decreased from $51.3 million to $35.5 million. A portion of the extraordinary gain in 1994 was from discretionary funds temporarily advanced to the plant fund for major construction projects and subsequently refunded with 1994 CEFA bond proceeds. The charts portray the sum of investment income and net gain on disposal of investments as *investment return.*
- *Gifts and (other) grants and contracts* varied slightly, from $60.7 million in 1994 to $57.6 million in 1995.
- *Student tuition and fees* remained steady, changing from $30.9 million in 1994 to $32.0 million in 1995.
- *Campus properties and acquisitions* is a revenue item peculiar to fund accounting. It is paired with those expenses that are not consumed in the current fiscal year, but rather are capitalized as campus properties and subsequently depreciated over their useful lives. See campus property acquisitions and renewals and depreciation of campus properties under Expenditures and Other Deductions.

Turning now to Uses of Funds (Expenditures and Other Deductions, Exhibit 2), we see that

- *Campus operating expenditures* increased from $273.7 million to $280.8 million between 1994 and 1995—approximately at the rate of inflation.
- *Campus property acquisitions and renewals* grew from $46.2 million in 1994 to $57.1 million in 1995, or 23.6 percent, due primarily to large equipment purchases and to substantial completion of the Moore Laboratory and Phase II of the W. M. Keck Observatory.
- *Depreciation of campus properties* increased from $18.5 million in 1994 to $22.1 million in 1995, testimony to the increasing capital intensivity of Caltech research and teaching.

The next-to-bottom line of Exhibit 2 summarizes Caltech's financial performance for 1995:

- *Total fund balances* increased $38.4 million for the year. Contributors to the increase were endowment and similar funds ($26.4 million); plant funds ($9.8 million after depreciation); and life income and annuity funds ($5.5 million). Current unrestricted funds—that portion of current funds that the Institute budgets and manages directly—increased by $22.0 thousand while the current restricted funds decreased by $4.2 million, due primarily to the 1995 adjustment to the accrual of postretirement benefit costs.

Details of operating expenditures of $280.8 million for 1995 are shown in Exhibit 3.

Statement of Operating Expenditures

The exhibit and the three charts that go with it are self-explanatory. Worthy of special note are the direct costs of sponsored research at the Jet Propulsion Laboratory: they increased from $1,022.5 million in 1994 to $1,045.6 million in 1995. These costs are fully reimbursed by the United States government.

A look across all the 10-year review charts reveals a remarkable "stability of mix." For example, except for occasional spikes such as plant fund depreciation in 1990 and gifts in 1991, the various asset groups and revenue sources are maintaining their shares of overall balance sheet and operating statement "portfolios." Investments, properties, and federal receivables have grown at similar rates, as have federal research, investment return, gifts, and tuition.

There is one factor affecting asset values, however, that is not apparent in Exhibits 1, 2, and 3 or the charts. Note C to the Statements reveals that the carrying value of investments in 1995 is $694.3 million (as shown in Exhibit 1), whereas the market value is $914.0 million, a difference of $219.7 million. The next-to-the-last chart portrays the endowment share of Caltech investments; the 1995 market value of the endowment is $695.9 million. Not shown but of increasing importance is the 1995 value of life income and annuity funds: Exhibit 1 states their value at cost as $81.2 million, but they were worth $99.6 million at market on September 30, 1995.

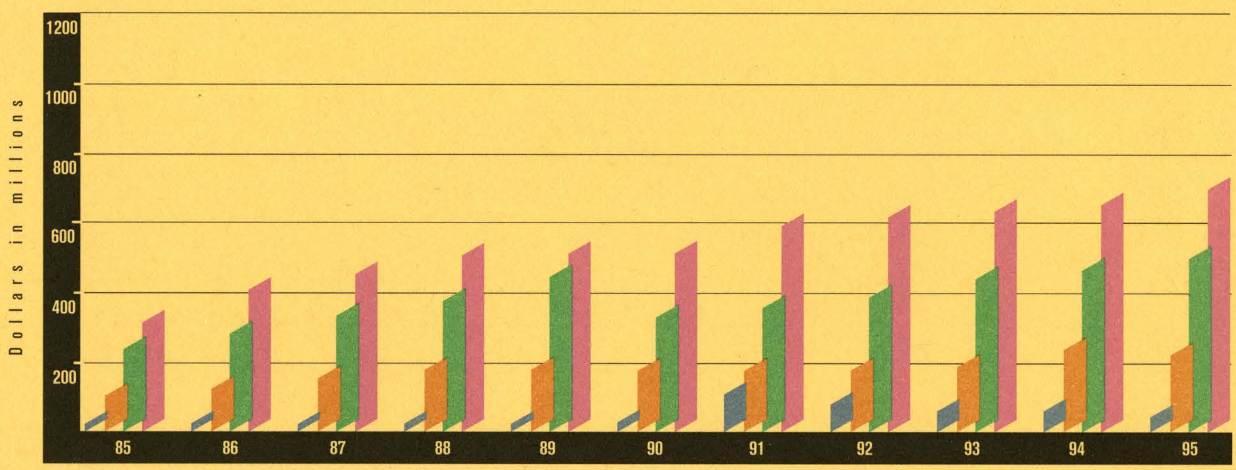
The California Institute of Technology maintains its accounts in accordance with the standards of the American Institute of Certified Public Accountants and the National Association of College and University Business Officers. Included with the Statements that follow is Price Waterhouse LLP's Report of Independent Accountants.

John R. Curry
Vice President for Business and Finance and Acting Treasurer

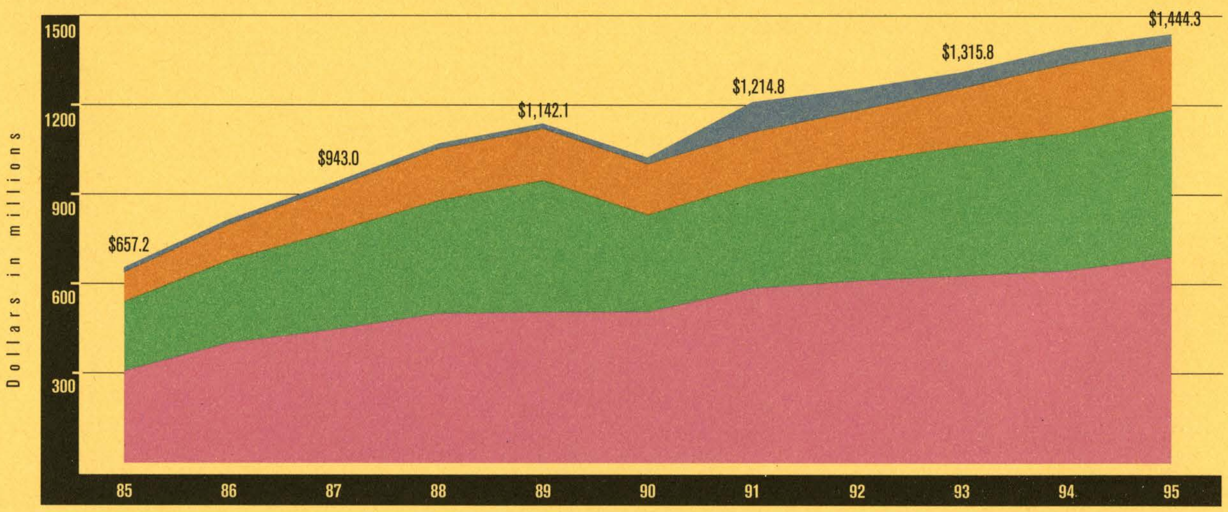
Assets

FY 1995

Ten Year Comparison FY 1985 - FY 1995

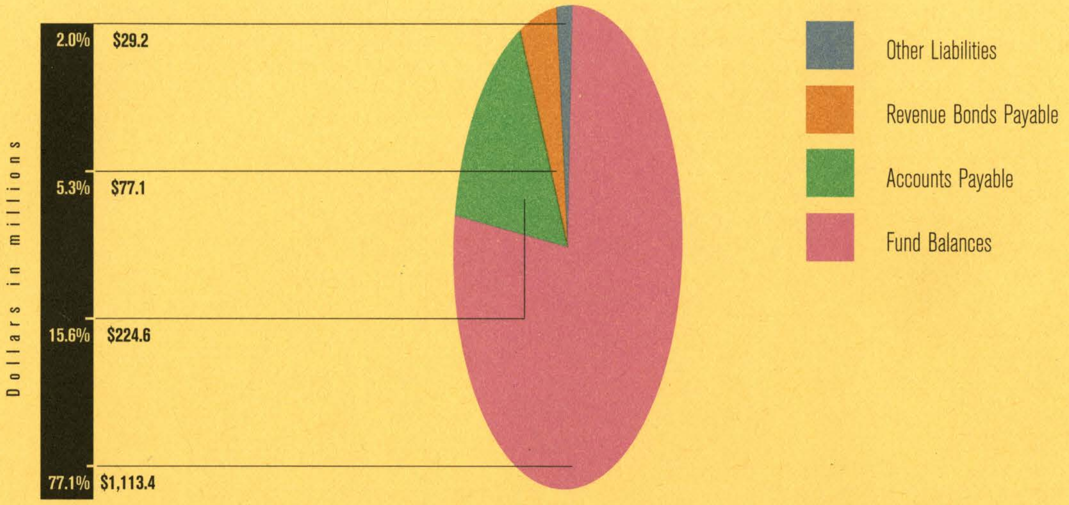


Ten Year Summary FY 1985 - FY 1995

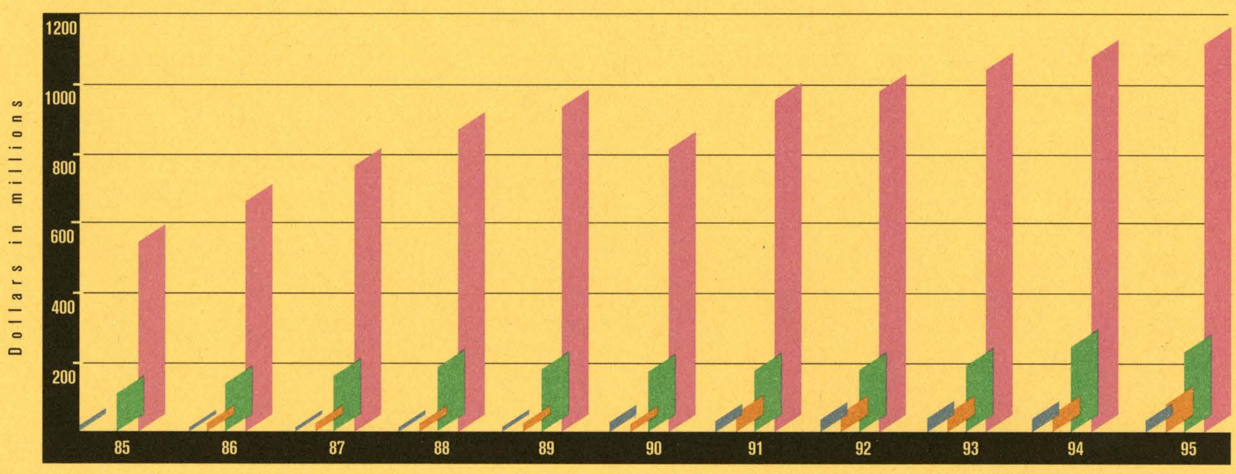


Liabilities and Fund Balances

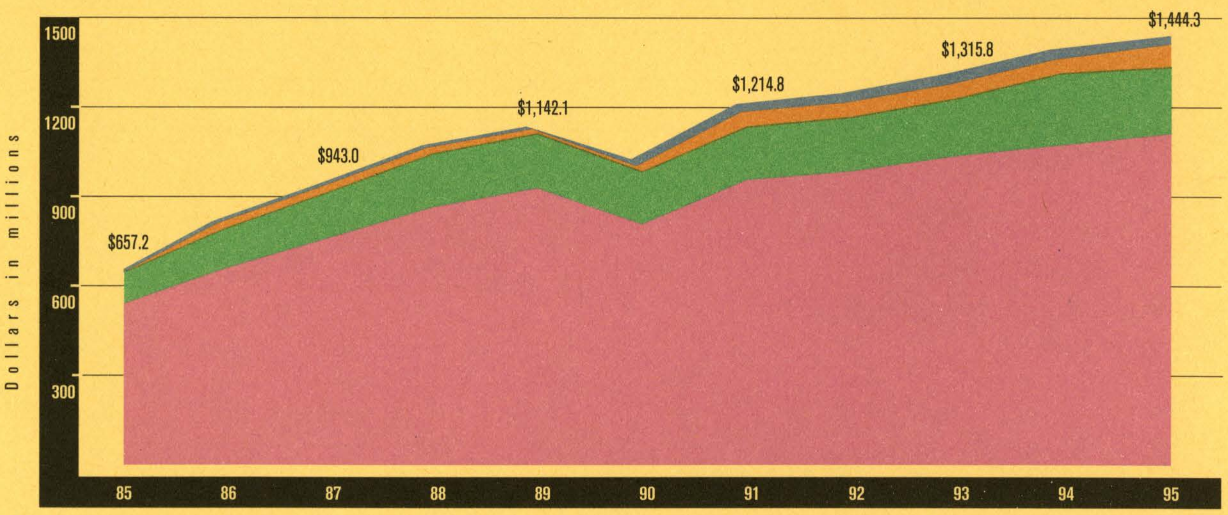
FY 1995



Ten Year Comparison FY 1985 - FY 1995



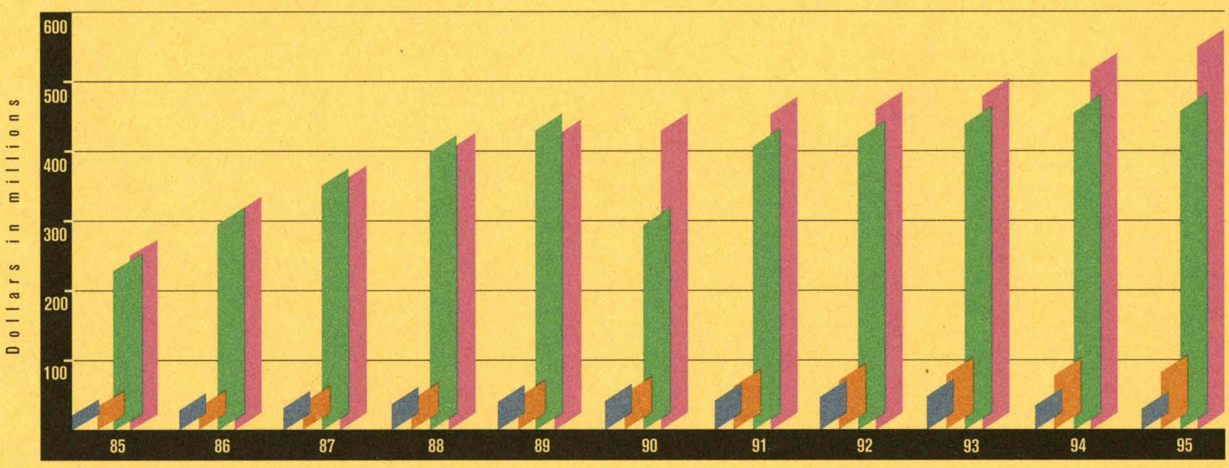
Ten Year Summary FY 1985 - FY 1995



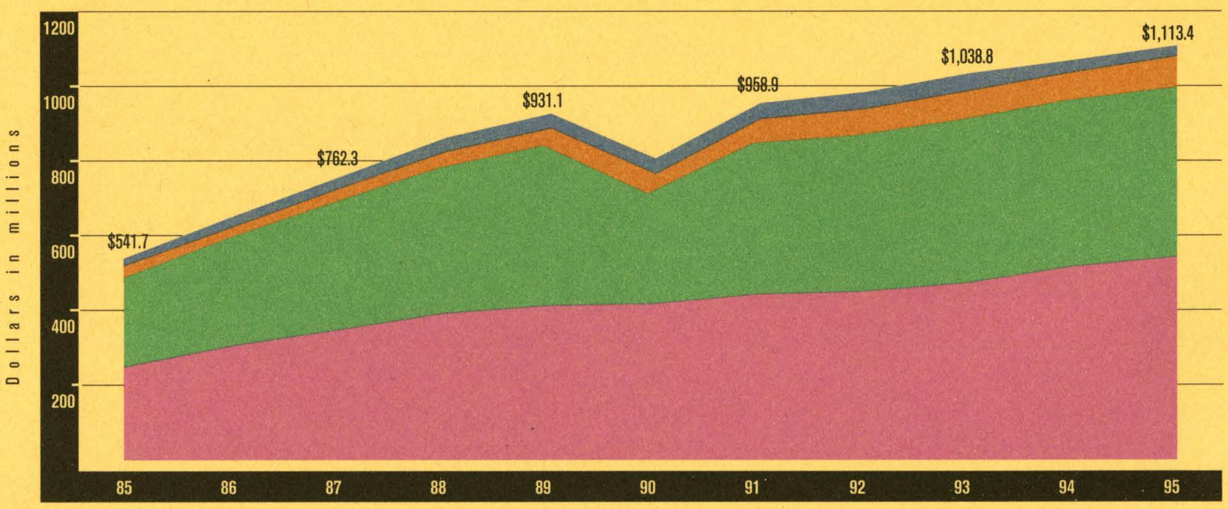
Fund Groups

FY 1995

Ten Year Comparison FY 1985 - FY 1995



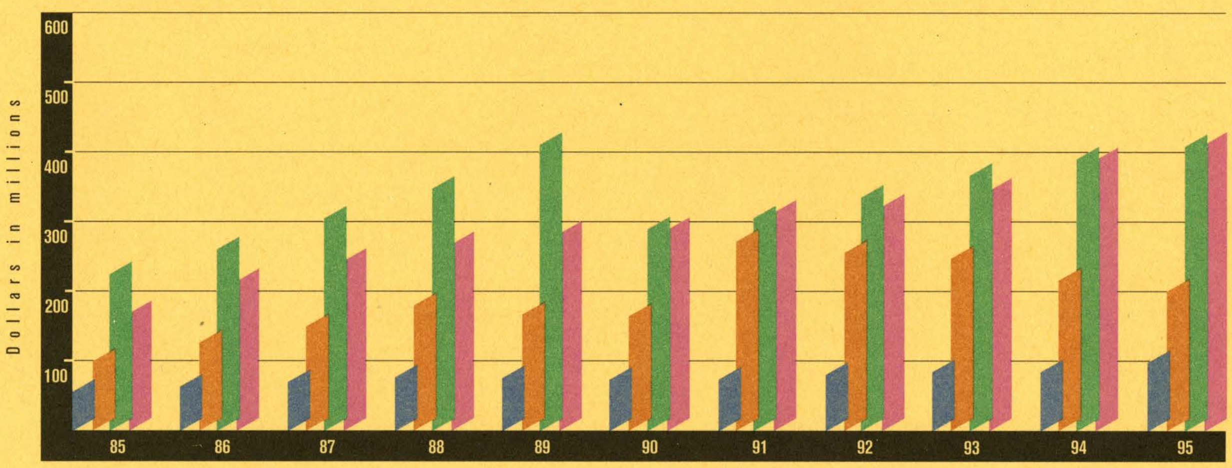
Ten Year Summary FY 1985 - FY 1995



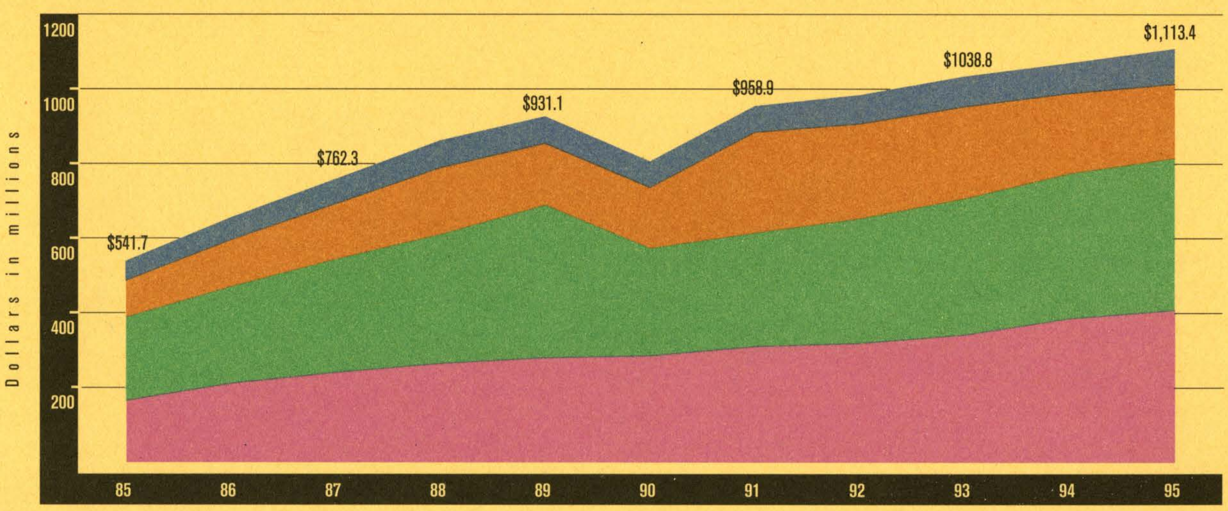
Fund Categories

FY 1995

Ten Year Comparison FY 1985 - FY 1995



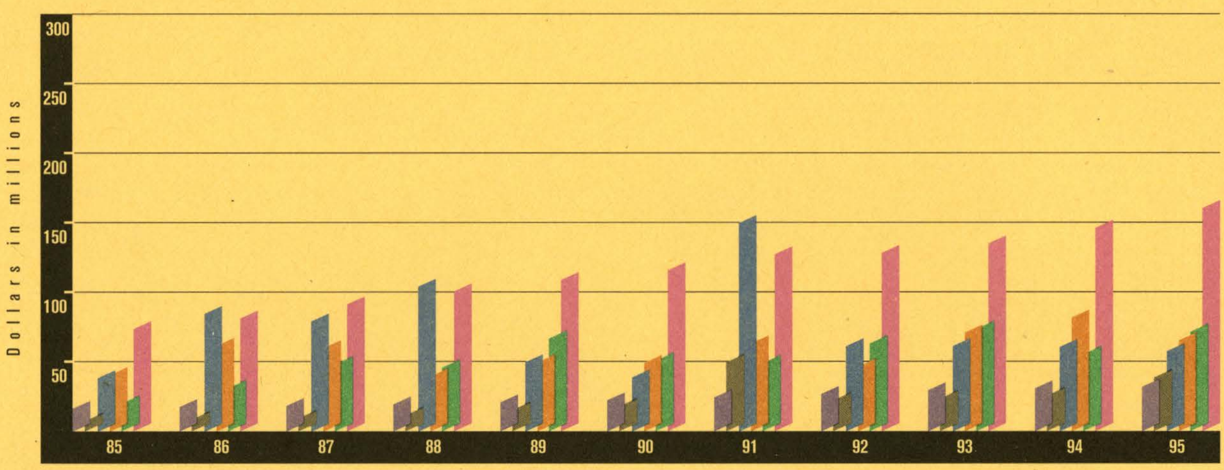
Ten Year Summary FY 1985 - FY 1995



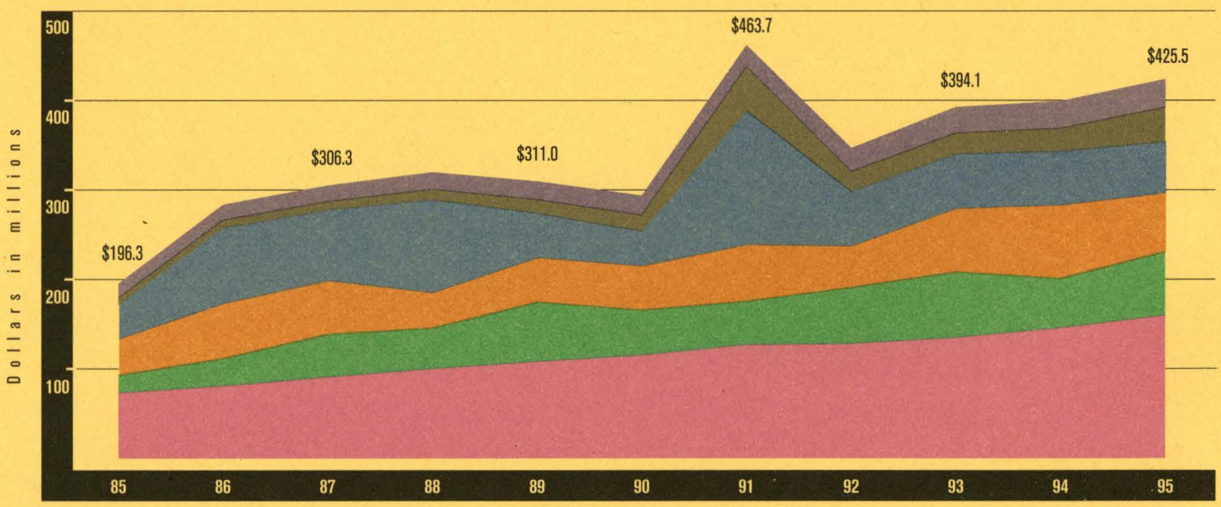
Sources of Funds

FY 1995

Ten Year Comparison FY 1985 – FY 1995

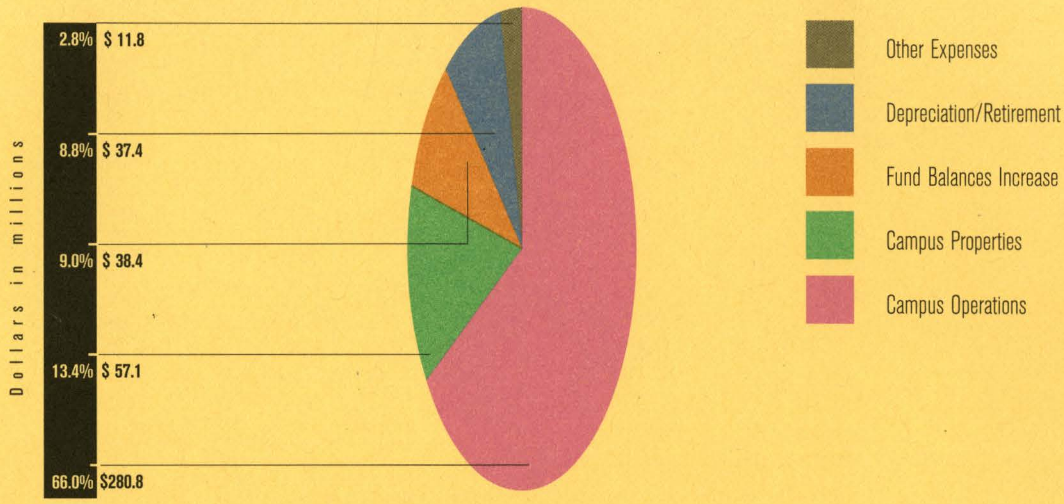


Ten Year Summary FY 1985 – FY 1995

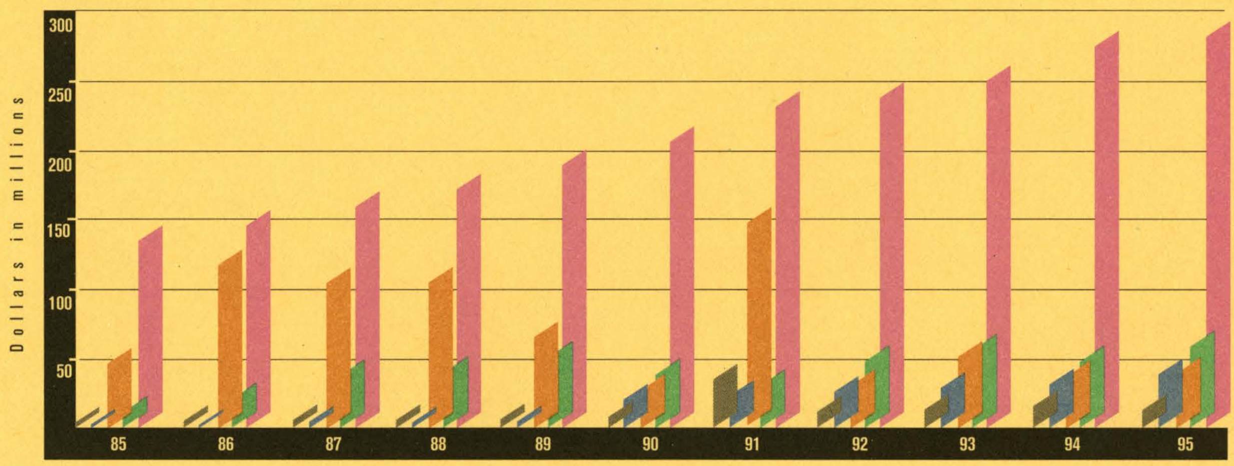


Uses of Funds

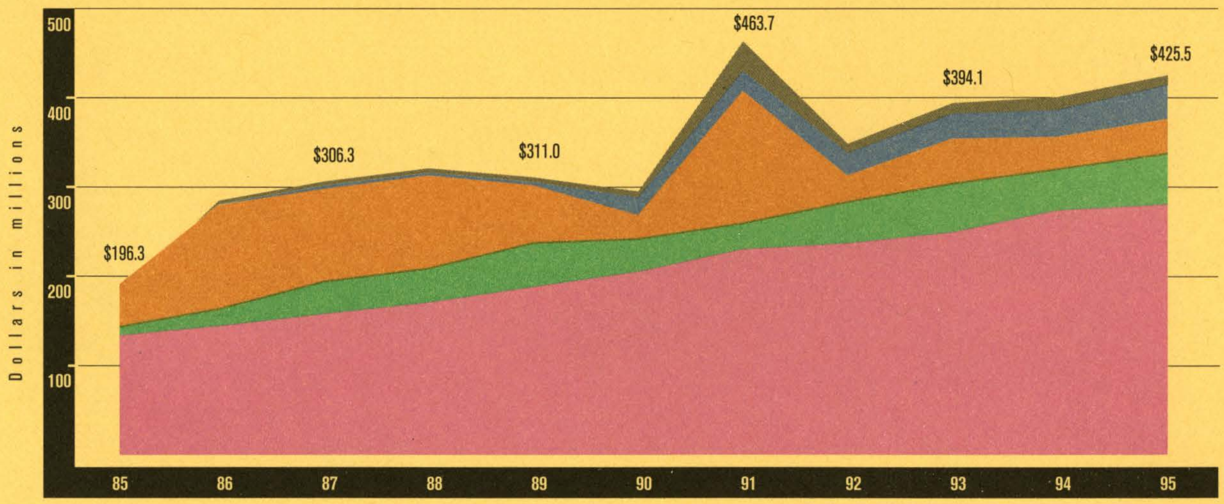
FY 1995



Ten Year Comparison FY 1985 - FY 1995



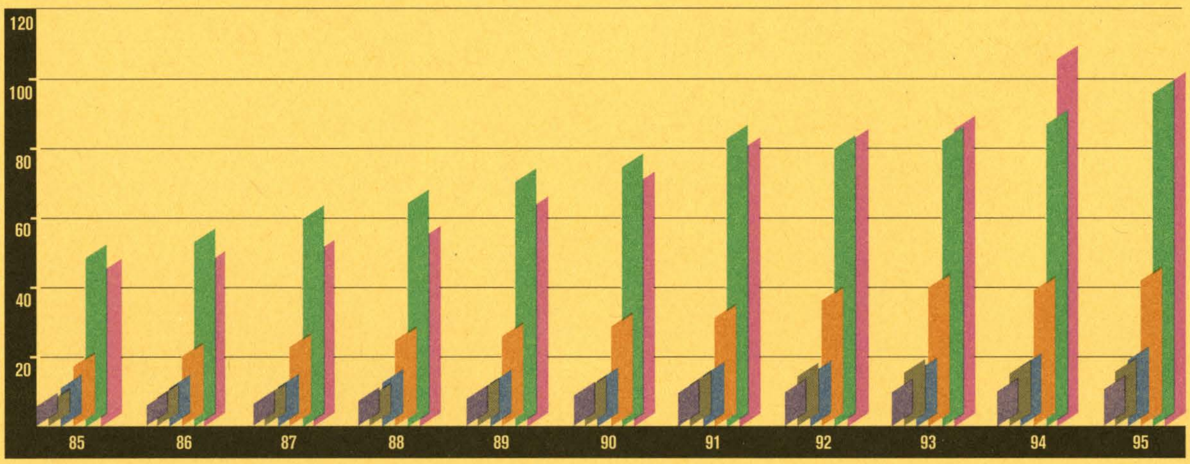
Ten Year Summary FY 1985 - FY 1995



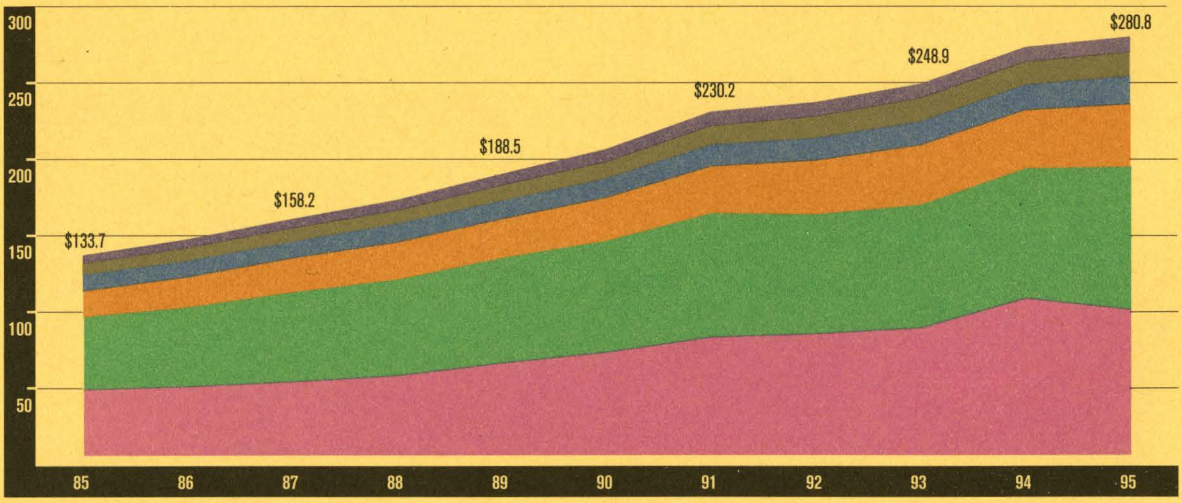
Campus Operations Detail

FY 1995

Ten Year Comparison FY 1985 – FY 1995

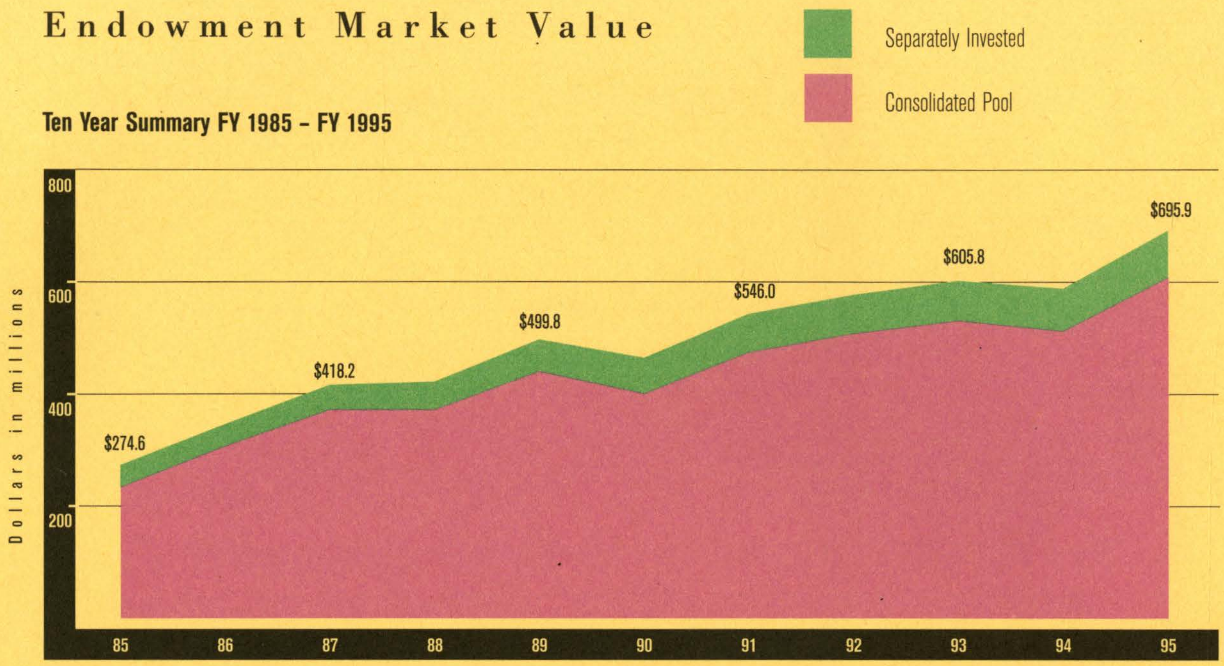


Ten Year Summary FY 1985 – FY 1995



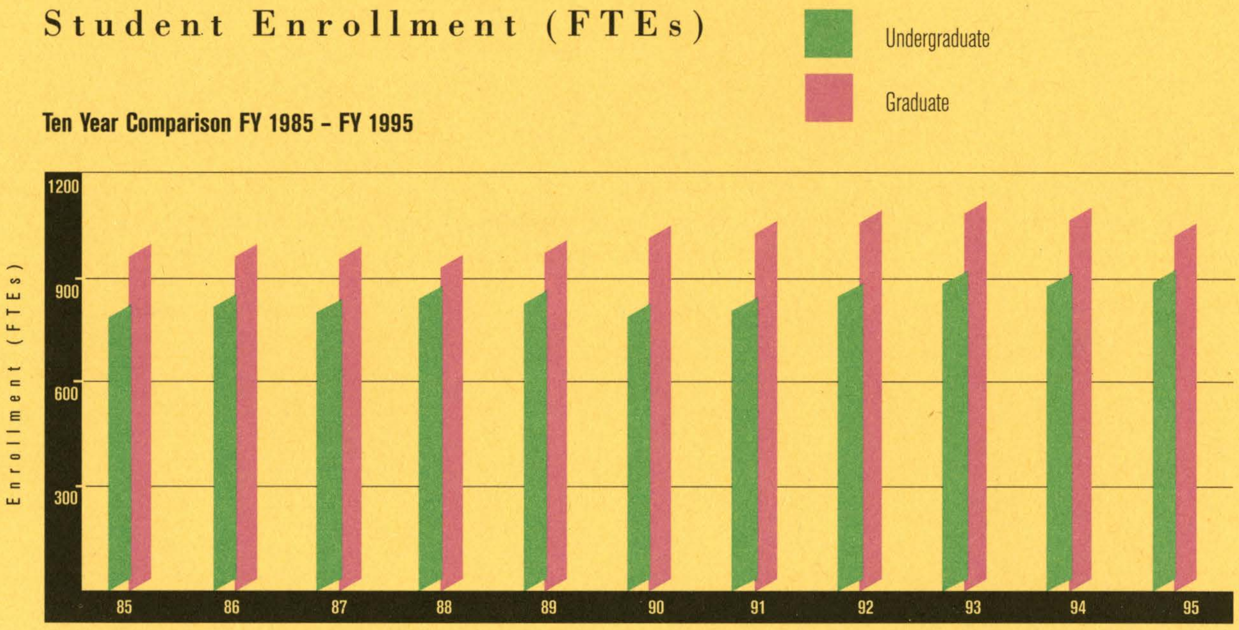
Endowment Market Value

Ten Year Summary FY 1985 - FY 1995



Student Enrollment (FTEs)

Ten Year Comparison FY 1985 - FY 1995



Balance Sheet *(in thousands)*

September 30, 1994

Exhibit 1

		Total All Funds
ASSETS		
Cash	$	1,250
Accounts receivable:		
United States government (notes B and I)		231,677
Pledges (note G)		20,975
Other		2,152
Student accounts and notes receivable		15,755
Investments (note C)		649,243
Interfund advances		
Prepaid expenses and other assets		15,862
Campus properties net of depreciation (note D)		460,689
Total Assets	**$**	**1,397,603**
LIABILITIES AND FUND BALANCES		
Accounts payable and accrued expenses (notes B and I)	$	240,269
Deferred student revenue		12,336
Revocable trust funds and agency funds (note E)		17,094
Annuities payable		4,854
Revenue bonds payable (note H)		48,100
Total Liabilities	**$**	**322,653**
Fund balances (Exhibit 2)		1,074,950
Total Liabilities and Fund Balances	**$**	**1,397,603**
Fund balances detail:		
United States government refundable	$	6,131
Institute funds:		
Unrestricted		18,543
Discretionary endowment:		
Unrestricted		64,623
Restricted		68,111
Endowment principal		387,911
Other restricted		140,037
Invested in plant		389,594
Total Fund Balances	**$**	**1,074,950**

See accompanying notes to financial statements

Total All Funds	Current Funds — Unrestricted	Current Funds — Restricted	Loan Funds	Endowment and Similar Funds	Life Income and Annuity Funds	Plant Funds	Agency Funds
$ 2,054	$ 1,015	$ 344	$ 243		$ 107		$ 345
216,421	3,840	212,581					
2,058	1,125	787			51		95
16,107	3,521	2	12,584				
694,256	5,915	22	2,343	$ 543,168	81,224	$ 58,978	2,606
		19,260		4,274		(23,534)	
18,736	12,382	1,472				4,871	11
494,626						494,626	
$1,444,258	**$27,798**	**$234,468**	**$15,170**	**$547,442**	**$ 81,382**	**$534,941**	**$3,057**

$ 224,626	$ 10,428	$ 210,124		$ 444	$ 90	$ 3,436	$ 104
12,543	12,435	108					
11,683					8,730		2,953
4,964					4,964		
77,050						77,050	
$ 330,866	**$22,863**	**$210,232**		**$ 444**	**$ 13,784**	**$ 80,486**	**$3,057**
1,113,392	4,935	24,236	$ 15,170	546,998	67,598	454,455	
$1,444,258	**$27,798**	**$234,468**	**$15,170**	**$547,442**	**$ 81,382**	**$534,941**	**$3,057**

$ 6,360			$ 6,360				
22,071	$ 4,935					$ 17,136	
74,489				$ 74,489			
61,955				61,955			
410,554				410,554			
130,237		$ 24,236	8,810		$ 67,598	29,593	
407,726						407,726	
$1,113,392	**$ 4,935**	**$ 24,236**	**$15,170**	**$546,998**	**$ 67,598**	**$454,455**	

Statement of Changes in Fund Balances *(in thousands)*

Exhibit 2

	Year ended September 30, 1994 Total All Funds
Fund Balances at Beginning of Year	**$1,038,836**
REVENUES AND OTHER ADDITIONS	
Student tuition and fees	$ 30,895
Investment income	30,670
Net gain on disposal of investments	51,289
Gifts	54,559
United States government grants and contracts:	
Reimbursement of direct costs	87,722
Recovery of indirect costs and management allowance	58,685
Other grants and contracts	6,168
Auxiliary enterprises revenues	11,620
United States government advances	448
Campus property acquisitions (including $25,056 in campus operating expenditures)	55,178
Retirement of indebtedness and internal advances	1,507
Other	11,915
Total Revenues and Other Additions	**$ 400,656**
EXPENDITURES AND OTHER DEDUCTIONS	
Campus operating expenditures (Exhibit 3)	$ (273,740)
Campus property acquisitions and renewals	(46,191)
Retirement of indebtedness and internal advances	(1,507)
Retirement and disposal of campus properties	(11,627)
Interest on advances for plant purposes	(2,102)
Interest on revenue bonds payable	(2,923)
Payment to life beneficiaries	(3,082)
Depreciation of campus properties	(18,534)
Other	(4,836)
Total Expenditures and Other Deductions	**$ (364,542)**
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	**$ 36,114**
Fund Balances at End of Year (Exhibit 1)	**$1,074,950**

See accompanying notes to financial statements

Year ended
September 30, 1995

Total All Funds	— Current Funds — Unrestricted	Restricted	Loan Funds	Endowment and Similar Funds	Life Income and Annuity Funds	Plant Funds
$1,074,950	**$ 4,913**	**$ 28,399**	**$14,202**	**$520,645**	**$62,109**	**$ 444,682**
$ 31,971	$ 31,954					$ 17
29,823	9,067	$ 15,767	$ 493		$ 3,156	1,340
35,547				$ 28,181	1,701	5,665
50,497	6,930	14,174	1	16,760	6,336	6,296
99,971		94,849				5,122
60,680	60,680					
7,100	1,739	5,361				
11,758	11,758					
427			427			
71,361						71,361
1,364						1,364
24,995	4,113	5,778	199			14,905
$ 425,494	**$ 126,241**	**$135,929**	**$ 1,120**	**$ 44,941**	**$11,193**	**$ 106,070**
$ (280,754)	$ (129,531)	$ (151,223)				
(57,088)						$ (57,088)
(1,364)						(1,364)
(15,344)						(15,344)
(2,286)						(2,286)
(3,799)						(3,799)
(3,588)					$ (3,588)	
(22,080)						(22,080)
(749)			$ (278)		(471)	
$ (387,052)	**$(129,531)**	**$(151,223)**	**$ (278)**		**$(4,059)**	**$(101,961)**
	$ (2,041)	$ (358)		$ 2,399		
	18,500	8,471		(26,971)		
	2,490	(2,490)				
	(11,631)	(20)		5,987		$ 5,664
		2		1,643	$ (1,645)	
	(4,006)	5,526	$ 126	(1,646)		
	$ 3,312	**$ 11,131**	**$ 126**	**$ (18,588)**	**$ (1,645)**	**$ 5,664**
$ 38,442	**$ 22**	**$ (4,163)**	**$ 968**	**$ 26,353**	**$ 5,489**	**$ 9,773**
$1,113,392	**$ 4,935**	**$ 24,236**	**$15,170**	**$546,998**	**$67,598**	**$ 454,455**

Statement of Operating Expenditures *(in thousands)*

Exhibit 3

	Year Ended September 30, 1994 Total	— Year Ended September 30, 1995 — Total	Unrestricted	Restricted
Educational and general:				
Instruction and departmental research	$ 88,700	$ 98,035	$ 56,379	$ 41,656
Organized research	86,995	95,791		95,791
Scholarships and fellowships	15,038	15,637	4,480	11,157
Institutional and student support	39,023	41,837	39,218	2,619
Plant operation, maintenance, and utilities	17,065	19,055	19,055	
Total Educational and General	**$ 246,821**	**$ 270,355**	**$119,132**	**$ 151,223**
Auxiliary enterprises	9,942	10,399	10,399	
Cumulative effect of change in accounting principle for postretirement benefits (note I)	16,977			
Total Campus Operating Expenditures (Exhibit 2)	**$ 273,740**	**$ 280,754**	**$129,531**	**$ 151,223**

Direct Costs of Sponsored Research at Jet Propulsion Laboratory (fully reimbursed by the United States government)	**$1,022,522**	**$1,045,621**		**$1,045,621**

See accompanying notes to financial statements

September 30, 1995

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 (note C) 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.

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 and management allowance 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 operating 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 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, 1995 and 1994, and in turn to accounts receivable from the United States government. Accounts payable and accrued expenses (and related receivables) for JPL amounted to approximately $172 million and $197 million at September 30, 1995 and 1994, 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 —*	
	1994	*1995*	*1994*	*1995*
Marketable securities:				
Debt securities	$ 222,708	$ 236,162	$ 218,673	$ 246,067
Equity securities	339,457	340,933	428,162	503,120
Total Marketable Securities	**$562,165**	**$577,095**	**$646,835**	**$749,187**
Short-term commercial obligations	32,467	65,158	32,994	64,949
Real estate, mortgages, notes, and other	54,611	52,003	94,949	99,857
Total Investments	**$649,243**	**$694,256**	**$774,778**	**$913,993**

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

	— September 30,—	
	1994	*1995*
Carrying value	$463,995	$484,520
Market value	$526,792	$624,092
Pool share value at market	$ 21.77	$ 25.64
Pool share annualized income earned	$ 0.81	$ 0.81

The Institute also manages a major foundation's investment portfolio with an approximate market value of $248 million at September 30, 1995. 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,—	
	1994	*1995*
Land and land improvements	$ 21,180	$ 21,600
Buildings, including construction in progress	306,627	345,598
Equipment	378,559	395,185
Campus Properties – cost	**$706,366**	**$762,383**
Less accumulated depreciation	(245,677)	(267,757)
Campus Properties – net	**$460,689**	**$494,626**

Depreciation has been calculated, using the straight line method, with life years of 20, 40, and a range of 3 to 15 (10 in fiscal 1994) for land improvements, buildings and equipment, respectively. Depreciation, including retirement and disposal of campus properties, of $37.4 million and $30.2 million was recorded for fiscal 1995 and 1994, respectively.

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 $21.8 million and $17.8 million at September 30, 1995 and 1994, respectively. The income derived from these funds amounted to approximately $741 thousand and $858 thousand for the years ended September 30, 1995 and 1994, 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 $8.7 million and $14.3 million at September 30, 1995 and 1994, 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 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. Non-academic staff were covered by a defined benefit pension plan terminated effective December 31, 1993. The Institute provided two plans effective January 1, 1994 for employees who were participants in the terminated defined benefit pension plan: (1) the defined contribution pension plan and (2) a successor defined benefit pension plan for participants who attained age 55 and had 10 or more years of service. Approximately 97% of the participants in the terminated defined benefit pension plan irrevocably elected to participate in the defined contribution pension plan.

Retirement benefits under the terminated defined benefit pension plan and the successor defined benefit plan are based on years of service and career average compensation and accrued 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.

The net pension cost for the year ended September 30, 1995 and funded status at September 30, 1995 for the terminated defined benefit plan and successor defined benefit plan are as follows (in thousands):

	Campus	*JPL*
NET PENSION COST		
Service cost – benefits earned during the year	$ 141	$ 413
Interest cost on projected benefit obligation	432	1,480
Actual return on plan assets	(555)	(1,390)
Amortization	138	(51)
Net pension cost	$ 156	$ 452
FUNDED STATUS		
Actuarial present value of accumulated benefit obligations (all vested)	$ 6,389	$ 22,136
Projected benefit obligation	$ 6,464	$ 22,560
Plan assets at fair value	(6,142)	(23,063)
Projected benefit obligation in excess of plan assets	$ 322	$ (503)
Unrecognized net gains/(losses)	(504)	(886)
Prepaid pension cost	$ (182)	$ (1,389)

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 7.25% (8.25% in 1994) and 5% (5% in 1994), respectively. The expected long-term rate of return on assets is 8%.

Pension costs for the defined contribution plan for the year ended September 30, 1995 were $8.3 million ($7.3 million in 1994) for the Campus, and $31.5 million ($26.7 million in 1994) 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 $31.2 million and $32.0 million at September 30, 1995 and 1994, 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 no recorded pledges remaining to be collected as of September 30, 1995.

At September 30, 1995, the Institute had additional pledges on hand (principally for restricted purposes), but not recorded, totaling approximately $73 million, of which $26 million is expected to be collected in fiscal year 1996. 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.

On October 27, 1994, the Institute issued $30 million in California Educational Facilities Authority Revenue Bonds for the purpose of financing and refinancing the acquisition, construction, and completion of additional educational facilities. The Series 1994 bonds are variable rate bonds maturing on January 1, 2024, repayable with interest from the general revenues of the Institute. Principal of and premium, if any, on the bonds is payable upon presentation.

Note I – POSTRETIREMENT AND POSTEMPLOYMENT BENEFITS OTHER THAN PENSIONS

The Institute provides certain health and life insurance benefits to retirees. Effective for fiscal 1994, the Institute adopted Financial Accounting Standard No. 106, "Employers' Accounting for Postretirement Benefits Other Than Pensions", which requires accrual of actuarially calculated postretirement benefit costs to the years during which employees render qualifying service. The Institute has elected to fully recognize the Campus obligation which is reflected in the financial statements, effective October 1, 1993.

The total postretirement benefit cost for fiscal 1995 is summarized as follows (in thousands):

	Campus	*JPL*
Service cost – benefits attributed to service during the year	$ 1,033	$ 2,837
Interest cost on accumulated benefit obligation	2,831	9,487
Amortization of transition obligation	1,683	5,523
Total	$ 5,547	$ 17,847

The accrued postretirement liability as of September 30, 1995 was as follows (in thousands):

Retirees	$24,438	$ 66,587
Fully eligible employees	10,609	45,595
Other active employees	7,886	26,388
Accumulated postretirement benefit obligation	$42,933	$138,570
Plan assets at fair value	—	—
Unrecognized net loss	(5,838)	(13,797)
Unrecognized transition obligation	(30,298)	(99,405)
Accrued postretirement liability	$ 6,797	$ 25,368

The Institute expects to recover approximately 52% for the Campus and will recover 100% for JPL of this postretirement obligation through future charges to United States government grants and contracts. The amount of campus recovery will be adjusted annually to reflect actual federal recovery rates. The Campus obligation of $42.9 million and the related recoverable amount of $22.3 million are included in Exhibit 1 as accounts payable and accrued expenses and United States government accounts receivable, respectively. The JPL postretirement obligation is excluded from the financial statements as only liabilities (and related assets) arising from current JPL operating activities are recorded.

A 7.25% (8.25% in 1994) discount rate and a 10% (12% in 1994) annual rate of increase in the per capita cost of covered health care benefits for retirees were assumed for 1995. This cost trend rate is assumed to decrease at a rate of 1% per year leveling off at a rate of 5% in 2001 and thereafter. The health care cost trend rate has a significant effect on the amounts reported. As of September 30, 1995, a 1% increase in the assumed cost trend rates in each year would increase the accumulated post retirement benefit obligation by $6.6 million and $19.9 million, and the net periodic postretirement benefit cost for the year by $0.9 million and $2.6 million for the Campus and JPL, respectively.

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 implementation of this standard did not have a material effect on the Institute's financial condition.

Note J – 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.

Report of Independent Accountants

Price Waterhouse LLP

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, 1995, 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 LLP

Los Angeles, California
January 12, 1996

California Institute of Technology
Pasadena, California 91125